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Effect of Thiodan on Survival, Behaviour and Predatory Performance of a Spider, *Plexippus paykulli* (Savigny et Audouin, 1827)

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Abstract.- *Plexippus paykulli* (Savigny et Audouin, 1827) is a jumping spider that has great potential to suppress insect pests of agricultural crops. In the present study effects of Thiodan (insecticide) on the survival, locomotion, insecticide avoidance behaviour and predation rate of *P. paykulli* were investigated. Thiodan caused 40% mortality at the recommended field rate concentration (5µl of insecticide /400 µl of water). *P. paykulli* did not avoid the surface treated with the Thiodan (1/4th of recommended field rate). Calculated LD_{50} value was 8.23 µl (SE± 2.01). There was also no difference in resting time of Thiodan treated and control spiders. However, predation rate of Thiodan treated spiders was significantly reduced (up to70%) compared to the control spiders. We also observed change in the locomotory pattern and speed of the treated spiders. It is concluded that Thiodan affect locomotory pattern and reduces the predatory performance of studied species, so before recommending this insecticide for the IPM programme in the study area, its affects on the other beneficial organisms should be investigated.

Keywords: Thiodan, *Plexippus paykulli,* locomotory behaviour.

INTRODUCTION

Natural enemies play crucial role in the regulation of insect pests of agricultural crops (Lang *et al.,* 1999; Marc *et al.,* 1999; Tahir and Butt, 2009). Insecticides, although effective but have negative impact on the natural enemies of insect pests, human health and environment. Insecticides can kill the natural enemies directly or affect them indirectly by eliminating their hosts and causing starvation (Devine *et al.,* 2007). Aim of current biological researchers is to use selective insecticides in agro-ecosystems that have potential to suppress the populations of phytophagous insects but cause no or least damage to the population of natural enemies of insect pests.

Spiders are one of the most abundant predatory arthropods in agricultural fields. An ideal biological control agent must have potential to tolerate synthetic insecticides (Sankari and Thiyagesan, 2010). Although spiders are more sensitive to insecticides than insects (Ravi *et al*., 2008) but some spiders not only tolerate the harmful effects of pesticides but also show resistance to them (Toft and Jenson, 1999; Yardim and Edwards, 1998; Marc *et al.,* 1999; Tanaka *et al.,* 2000).

As the main objective of Integrated Pest Management programme is to introduce selective pesticides, that efficiently affect target organisms but cause minimum damage to non target organisms and environment, it is therefore necessary to know the side effects of a pesticide on natural enemies such as spiders before including it into IPM programme (Pekar, 2002).

Thiodan is a chlorinated hydrocarbon insecticide and widely used in agro-ecosystem of Pakistan to control insect pests including whiteflies, aphids, leafhoppers and cabbage worms on cotton, oil seeds, vegetables, cereals, plants (*e.g.,* apples, citrus etc) and other crops. The aim of our study was to study the impacts of Thiodan on the survival and behaviour of spiders. The model species of spiders selected in this study was *Plexippus paykulli* (Savigny et Audouin, 1827). *P. paykulli* is cosmopolitan in distribution and found in many agricultural crops and orchards (Skinner, 1974; Muma, 1975; Mansour *et al.,* 1981). The adults and immature *P. paykulli* can be found throughout the year in different agricultural fields (Edward, 1979). *P. paykulli* has been reported to suppress insect pests of agricultural crops in Bangladesh (Maih *et al.,* 1986) and India (Rao *et al.,* 1981). *P. paykulli* is known from the literature as a polyphagous predator feeding on a wide variety of insect orders including

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Odonata, Orthoptera, Hornoptera, Lepidoptera, Diptera, Hymenoptera and other Araneae (Muma, 1975; Edwards, 1979; Miah *et al.*, 1986). They also significantly control the populations of some important vectors (*i.e.* muscoid flies, mosquitoes etc.) of human and domestic animal diseases (Edward, 1979). The objective of the present study was to determine the effects of Thiodan on the survival, locomotion and predatory performance of *P. paykulli.*

MATERIALS AND METHODS

Study area

Study was conducted during the period November 2011 through May 2012. For the experiment live specimens of spiders were collected from the lawns and ornamental plants (*Polyalthia longfolia,* and *Durananta repens*) of University of Sargodha by jarring method. During sampling a large white cloth sheet was spread below the plant on the ground. The spiders fell down on white cloth sheet within 3 min during jerking were collected in separate wide mouthed glass jars (5cm diameter, 13cm length) and transported to the laboratory for the experiment.

In the laboratory each spider was transferred to separate small opaque glass bottles (2cm diameter, 5.3cm length) containing wet sand for moisture at the bottom. Each container was covered with mesh cloth and maintained at room temperature and humidity (75- 85) and a light: dark cycle of 10:14 h. The spiders were fed with larvae of *Drosophila* cultured in the laboratory.

Bioassays

Bioassays were performed against three concentrations of Thiodan 35EC *viz.*, 2.5, 5.0 and 10.0µl of insecticide /400 µl of water. Filter papers (6x12 inches) were dipped in insecticide solution and then dried at room temperature. Spiders (n=20) were exposed to Thiodan treated filter papers for 1 h and then transferred to the clean glass bottles individually. Control spiders (n =10) were exposed to the filter papers dipped in tap water. We did not use one spider in more than one trial. Spiders were not provided any food during the experiment. Responses of the spiders (*i.e.*, unaffected, affected, paralyzed or dead) were assessed both in the treated and control group 2, 4, 8, 16, 24 and 48 h after the exposure. The experiment was replicated thrice. The criteria to record the spider's responses after insecticide treatment was the same as described by Tahir *et al.* (2012).

Avoidance behaviour

To record the avoidance behaviour, round Whatman's filter papers were cut into two equal halves (by drawing a line in the centre of the filter paper). One half of the filter paper was dipped in the recommended field concentration of insecticide 5µl of insecticide /400 µl of water while the other half in the tap water. Filter papers were dried at room temperature. After drying the filter papers, both halves of them were joined together by using scotch tape and were placed in a petri dish (8 cm diameter, 4 cm height). A single spider was released in each petri dish and the time spent by each spider on insecticide or water treated part was recorded by using stopwatch. For each spider reading was recorded for 30 min. A total of thirty spiders were used in this experiment. Spiders were allowed to acclimatize for 15 min before recording the data.

Locomotory behaviour

To study the effect of Thiodan (1/2 of recommended field concentration) on locomotory activity of *P. paykulli*, two spiders of almost same size and sex were selected and numbered as spider 1 and spider 2. Similarly two untreated Watman's filter papers were placed in the petri dishes which were also numbered as petri dish 1 and petri dish 2. Spider 1 was released onto the filter paper in the petri dish 1 and spider 2 onto the filter paper in the petri dish 2. The time spent by both spiders in moving and remaining still was recorded by stopwatch till half an hour. After this both spiders were removed from the petri dishes and shifted to the labeled glass vials separately. Filter paper in petri dish 1 was treated with tap water while filter paper in the petri dish 2 with the insecticide solution. Both filter papers were air dried and again placed in their respective petri dishes. Spider 1 was now released on to the filter paper treated with tap water (control) in the petri dish 1 and spider 2 on to the insecticide treated filter paper in petri dish 2.

Again the time spent by both spiders in moving and remaining still was recorded till half an hour. The difference in the time spent by both the spiders in moving or remaining still before or after the treatment was compared. Same experiment was repeated ten times.

Predatory behaviour

To investigate the effect of Thiodan (1/4th of field rate concentration) on the predatory performance of study species, 20 adult female spiders were taken and divided into two groups, each 10 spiders. To standardized the hunger level of spiders of group 1 and 2 all spiders were first fed on the *Drosophila* larvae up to the satiation level and than starved for two days before using them in the experiment. Each spider of group 1 was offered with same sized immature spider of genus Lycosa (as prey) in a clean separate glass jars having wet mesh cloth on their mouth. The predation was recorded after 24 h. The spiders of group 2 were exposed to insecticide (Thiodan) treated filter paper for 1 h and than placed in the separate glass jars. The predation rate of spiders of group 1 and group 2 was compared.

Statistical analysis

Data was analyzed using t-test and analysis of variance (ANOVA). LD_{50} was calculated using Probit analyses. Statistical analyses were performed consulting SPSS (version 16) and Minitab 13.2.

RESULTS

Survival

Mortality rate of *P. paykulli* at the half field rate concentration was 30% after 48 h of insecticide exposure. Figure 1A shows that initially there was 10% mortality 4 h after insecticide exposure which increased up to 20% after 8 h. At 24 h mortality increased up to 30% and remained the same till 48 h. Along with the 30% dead specimens, 20% specimens were paralyzed after 48 h. At the recommended field concentration mortality increased up to 40% (Fig. 1B), which went upto 50% mortality occurred at double field concentration (Fig. 1C). Calculated LD_{50} value was 8.23±2.01 µl. Lower and upper Fiducial CI limits were 5.63 and 26.99, respectively.

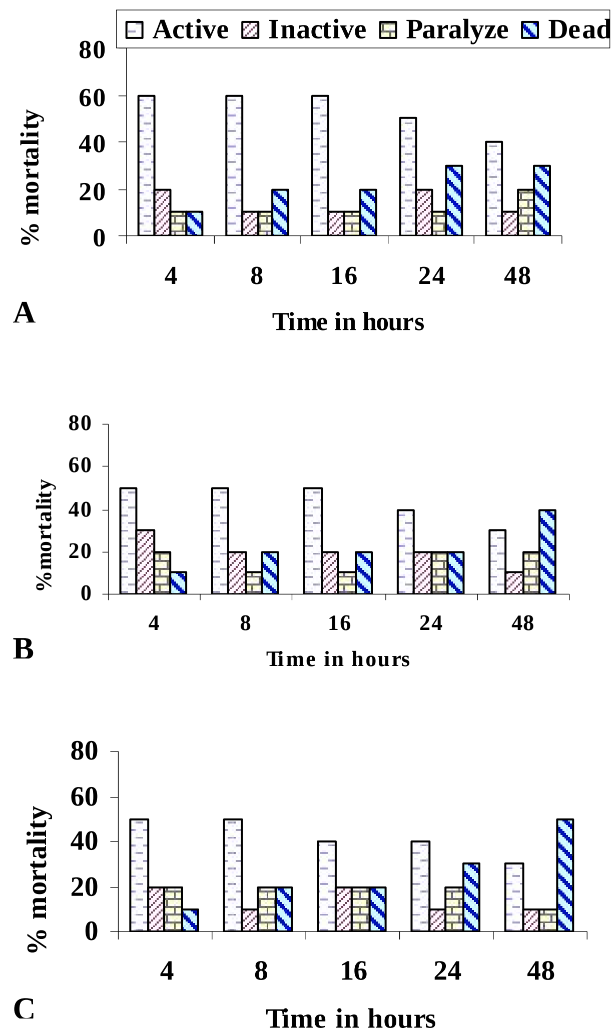

Fig. 1. Response of *Plexippus paykulli* to different concentrations of Thiodan *viz.*, 2.5µl/400 µl of water (A), 5µl/400 µl of water (B) and 10µl/400 µl of water (C) at different time intervals.

There was no difference in the mortality rates of males and females at the recommended field concentration ($t = 1.41$; $P = 0.22$). When the mortality rates of *P. paykulli* were compared at various time interval significant differences were observed ($df = 4, 14$; $F = 96.26$; $P < 0.001$ for half field rate; $df = 4, 14$; $F = 112.53$; $P < .001$ for recommended field concentration and $df = 4, 14$; $F = 113.62$; $P < .001$ for double field rate).

Avoidance behaviour

It was observed that *P. paykulli* spent more time on the water treated part of the filter paper (16.73± 1.19 min) compared to the insecticide treated part (13.40± 1.23) but statistically there was no significant difference (t =1.38; P = 0.178, Fig. 2).

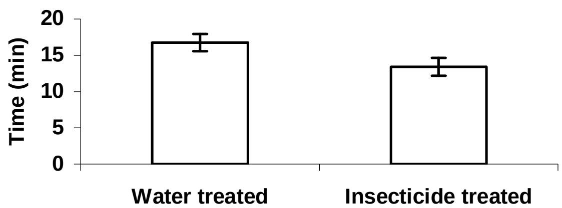

Fig. 2. Time (±SE) spent by *P. paykulli* on the insecticide-treated or water-treated part of the filter paper.

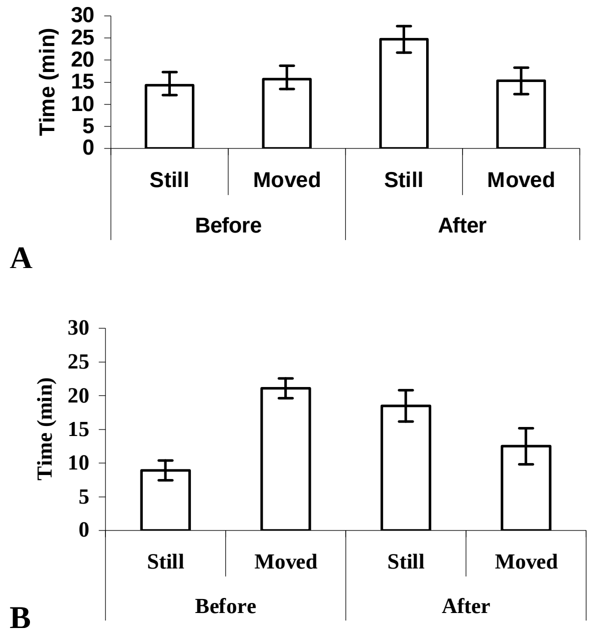

Fig. 3. Time spent (±SE) by *Pl. paykulli* in locomotory activity or still position before and after water (A) or insecticide (B) treatment.

Locomotory behaviour

In the control group there was no difference in the non locomotory time (still time) of spiders before and after water treatment (t = - 0.15; P = 0.882). However, non locomotory time was significantly increased after the Thiodan treatment in experimental group (t = - 3.52; P = 0.006) (Fig.3). We also observed change in the speed and pattern of movements of spiders after exposure with insecticide.

Predatory behaviour

When the predation that of spiders of control group was compared with the treated group, highly significant reduction (70-80%) was observed in the predation rate of treated group (t = 25; P = 0.002, Fig. 4).

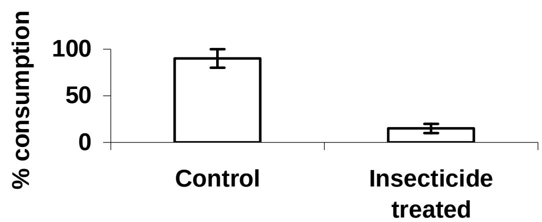

Fig. 4. Percent consumption of offered prey by *P. paykulli*.

DISCUSSION

Spiders are important predators of insect pests in agro-ecosystems throughout the world. They are highly sensitive to insecticides (Pekar, 1999; Amalin *et al.*, 2000; Shaw *et al.*, 2006; Marshall and Storer, 2006; Rezac *et al*., 2010). In the present study impact of insecticide (Thiodan) on the mortality, behaviour and predatory performance was investigated in the laboratory. The results of residual toxicity experiment showed that mortality of spiders at the recommended field rate concentration of Thiodan was 40%. The mortality is expected to be high if insecticide would have been applied directly on the body of the spiders. The results of the study are in agreement with other researchers that chlorinated hydrocarbons are very toxic to the spiders (Wiktelius *et al.,* 1999). Similarly Pekar (2002) proved that alpha cypermethrin and fluvalinate + thiometon produced the highest mortality in spiders two days after application while bifenthrin and deltamethrin showed highest mortality after three days after the application. Lorsban and Lannate caused 100% mortality in black widow spiders after 1 day exposure (Daane *et al.,* 2004). Decis caused 80% mortality in *Philodromus cespitum* (Rezac *et al.,* 2007). Bajwa and Aliniazee (2001) also claimed that organophosphate azinphosmethyl (25g/100 liters) and carbamate carbaryl (60g/100 l) produced 25-75% mortality of spiders while pyrethroids, esfenvalerate (2.5g/100 l) and permethrin (4g/100 liters) produced 50-75% mortality. Armenta *et al.* (2003) claimed that chlorpyrifos exposure produced up to 73% reduction in abundance of natural enemies in the agricultural fields. Similarly Brine *et al.* (1998) reported that dimethoate exposure produced 100% mortality in Lycosid *Trochosa ruricola* at concentration below the recommended field rate. It was confirmed by De Clercq *et al.* (1991) that exposure to parathion and dimethoate caused 30% and 100% mortality, respectively, in the spiders.

Many researchers claimed that exposure to organophosphate insecticides produced no change in population of lycosid, linyphid and non insect arthropods predators (Hodge and Vink, 2000). Similarly Stark *et al.* (1995) confirmed that there is little or no adverse effect of some synthetic insecticides, fungicides and herbicides on non target organims. Rezac *et al.* (2007) reported that Dimilin, Neemazal, Mospilan and Integro caused mortality less than 10% while Spintor® produced 17% mortality in *Philodromus cespitum.* Acoording to our study Thiodan is toxic to the spiders, at least to the studied species.

It has been observed that spider avoid some chemical (herbicides or pesticides) but not others (Pekar and Hadded, 2005). The members of genus *Pardosa* avoided the surfaces exposed with residues of Decis or Nurelle (Pekar and Benes, 2008) but in our study, *P. paykulli* did not avoid the surfaces treated with Thiodan as there was no significant difference in time spent by spider in treated and control surfaces. Also there is scarcity of published data on the avoidance behaviour of spiders to Thiodan. The results of our study are not in accordance with findings of many researchers. For example, Hall and Thacker (1993) confirmed that new residues of permethrin and pyrethroids were repelled by predatory mites. Similarly the five species of spider avoided the surfaces treated with Phosalone and permethrin and some spiders also avoided the areas treated with lambda cyhalothrin (Pekar and Hadded, 2005).

Liu and Stansley (1995) also confirmed that bifenthrin produced avoidance of silver leaf whitefly *Bemisia* for 7 days. Similarly adult spiders are more active in detecting and avoiding insecticides (Petersen, 1994). Fernandes *et al.* (2010) reported that in many instances, insecticides acts as a repellent that is related to food searching behaviour and sometime avoidance occur because of contact with insecticide exposed host or prey. Many researchers reported that insecticides are cause of avoidance in spiders (Kjaer and Jepson, 1995). In present study, spiders did not avoid insecticide treated areas. It has been reported that impacts of insecticides are species specific (Kawahara *et al.,* 1971; Shaw *et al.*, 2004, Pekar and Benes, 2008).

In the present study, the non locomotory time was significantly increased after treatment with the insecticides in *P. paykulli* and also the speed and pattern of movement were changed. The increased non locomotory time may have negative impact on spiders as it may affect their colonization rates, foraging success and reproductive rates. If spiders remain in resting state for longer time in field, it may increase the chance of spending more time on the herbicide treated patches, which in turn would have negative effects on their survival. Shaw *et al.* (2003) reported that locomotion is of great importance in predatory spiders as it is responsible for dispersal, reproduction, hunting and predator avoidance.

Tietjan and Caddy (2007) reported that exposure to malathion caused *Salticus scenicus* to move more frequently and also changed their pattern of movement. Similarly the treatment with organophosphate insecticides altered the locomotory behaviour of insects and 60 to 80% of them were unable to move or had impaired moving pattern after 24 h of treatment (Rao *et al.,* 2005). It has been reported by Jones (1990) that exposure to permethrin caused spider mites to move 125% times more on treated surfaces than control. By change in locomotory behaviour with insecticide treatment produces lack of motar coordination, htremors, downfalls, abdomen tucking and rotational movement (Suchail *et al.,* 2001). Also treatment of insecticide increases the speed of spiders (William *et al.,* 2007). Shaw *et al.* (2003) confirmed that treatment with insecticide produces low number of long state of inactivity in *Pardose amentata* but it did not affected the amount of movement in them.

Toft and Jenson (1999) confirmed that there was no effect of sub lethal doses of dimethioate and cypermethrin on predation rate of wolf spiders *Pardosa armentata* but in present study, the predation rate of spider was significantly reduces after exposure to insecticide. Feeding rate was reduced to 70% in treated group which is harmful for spiders. The results of our study are in accordance with the findings of many scientists. For example, Tietjen and Cady (2007) reported that the exposure to malathion decreases predation in *Salticus scenicus*. Similarly, the exposure to Neemazal, spintor and dimilin reduced the predatory activity significantly and most adverse effect was caused by spin tor (Rezac *et al.,* 2007). Deng *et al.* (2008) also confirmed that buprofezin treatment had greatly affected the predation rate of wolf spiders *Pirata piratoides* and their rate of pattern did not recover even after 5 days of application.

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