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Original Research Paper

Toxicity of selected insecticides to different stages of brown lacewing, *Micromus timidus* Hagen (Neuroptera: Hemerobiidae)

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ABSTRACT

Investigation was carried out to study the sensitivity of four stages of *Micromus timidus* Hagen (egg, larva, pupa and adult) to five insecticides *viz*., profenophos 50EC, imidacloprid 17.8SL, lambda-cyhalothrin 5EC, chlorantraniliprole 18.5SC, buprofezin 25SC, azadirachtin 10000 ppm with water spray as control. For the egg and adult stages, imidacloprid 17.8SL at 0.5 ml/L was highly toxic causing 89.74 and 74.07 per cent mortality, respectively, followed by profenophos 50EC at 3 ml/L (52.37 and 66.67 per cent mortality). The larval and pupal stages were very sensitive to profenophos 50EC at 3 ml/L causing 100 and 96.29 per cent mortality, respectively, followed by imidacloprid 17.8SL at 0.5 ml/L (51.85 and 55.56 per cent mortality, respectively). Azardirachtin 10000 ppm was found to be safest insecticide to all stages of *M. timidus* causing less than 20 per cent mortality, which is followed by buprofezin 25EC and chlorantraniliprole 18.5SC. The current study provide insights to the safer chemicals that can be used for management of aphid species in different crop ecosystem.

Keywords: Hemerobiidae, *Micromus timidus*, potter spray tower, toxicity

INTRODUCTION

Brown lacewings are small medium sized insects belonging to the family, Hemerobiidae, known to be the third largest family in the order Neuroptera; suborder Hemerobiiformia. Hemerobiidae is represented by approximately 600 species worldwide (Oswald, 2004; Farahi et al., 2009). The brown lacewings feed on small soft bodied arthropods (aphids, scale insects, spider mites etc.) (New, 2002). Most brown lacewings are aphidophagous predators, play a role in biological control, being more effective at low aphid densities than green lacewings (Chrysopidae). The low-temperature requirement of brown lacewings also gives them a survival advantage during cold spells and frosts in temperate climates (Neuenschwander et al., 1975; Kovanci et al., 2014). *Micromus timidus* Hagen was introduced from Australia to the Hawaiian Islands in 1919 for the control of various aphid, particularly on corn and sugarcane plants (Williams, 1927). *Hemerobius nitidulus* F. and *H. stigma* Stephens were introduced from Europe to Canada as biological control agents against the balsam woolly aphid, *Adelge spiceae* (Ratzeburg), during the 1930s (Smith & Coppel, 1957). However, neither species was recovered (Garland, 1978), possibly because they did not adopt to the climate of Canada.

In India, *Micromus igorotus* Banks was used for biological control of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner in southern parts of the country during aphid outbreak, 2003 to 2006. A standardized mass production technology has been developed for the *M. igorotus* in the laboratory using *C. lanigera* as a laboratory host and the field release dosage has been standardized (1000 to 1500 cocoons per acre area) (Vidya, 2007). Similarly, another species in the same genera, *Micromus angulatus* (Stephen) has greater potential in controlling aphids as the aphid infestation are reduced by 98.8 per cent when preventive releases of adults are done and reduced infestation by 99.6 per cent compared to control when *M. angulatus* eggs were released for the infested field of sweet pepper (Pekas et al., 2023).

It is well-known that the both larval stage and adult stage of brown lacewings feed on soft-bodied arthropods like aphids (Tauber et al., 2009). In the field condition, aphids are generally controlled by employing chemical control and along with this, aphidsare also managed by components of integrated pest management *i.e.* cultural, physical, mechanical and biological methods (Khan et al., 2012). Therefore, biological control can be used as the best alternative method. In recent days no work has been carried out regarding the toxicity studies of *M. timidus*, so, to examine the sensitivity of insecticides to *M. timidus* the present study was carried out. In this study, the effect of six insecticides was evaluated for all the four stages (egg, larval, pupa and adult) of *M. timidus.*

MATERIAL AND METHODS

The present investigation was carried out at the Department of Agricultural Entomology, Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences (UAS), Bengaluru, Karnataka, India from November 2022 to September 2023. The *M. timidus* was maintained under the laboratory conditions with 28.00±2^{0}C temperature and 70 per cent relative humidity.

The adults of *M. timidus* were reared in a round plastic box (22 x 10 cm) by providing cowpea twigs infested with *Aphis craccivora* Koch. The freshness of the twigs was maintained by inserting the lower end of the twigs in a glass vial containing water and plugged with a cotton wad. The white cotton thread strings were given as an oviposition substrate as described by Vidya (2007). The mouth of the rearing container was covered with black cloth, held in position by a rubber band to avoid the escape of adults. The adults laid eggs predominantly on threads, though some eggs were also found on cloth. Cotton thread strings with eggs were placed in a plastic box (5.5 x 17 cm) for hatching. After hatching, larvae were provided with aphids-infested cowpea twigs and at the time of pupation, folded paper sheet was provided for pupation. The pupae kept for adult emergence in the round plastic container (22 x 10 cm).

The six insecticides belonging to different groups *viz*., neonicotinoids (imidacloprid 17.8SL, 0.3 to 0.5 ml/L), organophosphorus compound (profenophos 50EC, 2 to 3 ml/L), botanical compound (azadirachtin 10000 ppm), insect growth regulators like chitin synthesis inhibitor (buprofezin 25SC, 2 to 3 ml/L), newer molecules like diamides (chlorantraniliprole 18.5SC, 0.3 to 0.4 ml/L), synthetic pyrethroids (lambda-cyhalothrin 5EC, 0.5 to 0.75 ml/L) with water spray as control, were used for studies. Insecticides used in the studies have been selected based on the recommendation for aphid management in pulses. The dosage was adjusted by referencing the standard field dosage of the insecticides and also used an increased amount to check the safety. The increased dosage was chosen to simulate field conditions where farmers may use higher-than-recommended levels.

For all the toxicology studies, the Potter spray tower was used (Potter, 1952). Each insecticide of the required dosage of 1 mL quantity was taken with the help of a micropipette and manually loaded to the reservoir of the Potter spray tower. Aphids infested cowpea twigs, eggs and pupae of *M. timidus* were placed in the Petri plate on the stage of the spray tower. A completely randomized design was used for the study with seven treatments including the control (water spray) and three replications. The toxicity of insecticides was evaluated at both field dosage and increased dosage to all four stages of brown lacewing (eggs, larvae, pupae and adults). The mortality of all stages like egg, larval, pupal and adult stages were recorded after 24, 48, 72 and 96 hours of exposure to insecticides.

Toxicity of insecticides to eggs of *Micromus timidus*

One-day-old 90 eggs of *M. timidus* laid on the cotton thread were used for the study. Eggs on the cotton thread strings were sprayed with selective insecticides at different concentrations using a Potter sprayer and later placed in the round bottom plastic container (4 x 10 cm) and covered with lid having space for ventilation. The eggs were observed for hatching and the survivability of grubs.

Toxicity of insecticides to larvae of *Micromus timidus*

Ten larvae of second instar of one day old *M. timidus* were used for the study. In a plastic container (4 x 10 cm) cowpea twigs infested with aphids were placed and sprayed with different concentrations of selected insecticides using a Potter sprayer, kept for drying and then 10 larvae/replication were released and allowed to feed on it. Three replications were maintained with a total of 30 larvae per treatment. The mortality of the larva was recorded and the per cent mortality of larvae was worked out.

Toxicity of insecticides to pupae of *Micromus timidus*

Ten pupae of *M. timidus* present on the cowpea leaf/ folded paper sheet were sprayed with selected insecticides at different concentrations using a Potter sprayer and placed on the tissue paper to drain the excess solution and then placed in the plastic container (4 x 10 cm) with a lid and observed for adult emergence. Three replications were maintained with a total of 30 pupae in each treatment. The per cent mortality of pupae was calculated.

Toxicity of insecticides to adults of *Micromus timidus*

The cowpea twigs infested with aphids were sprayed with selected insecticides at different concentrations, kept for drying and then exposed to one day old 10 adults of lacewing, *M. timidus*. The adults and sprayed cowpea twigs were placed in a plastic container (16 x 12 cm) and covered with black muslin cloth and held in position by rubber bands. Three replications were maintained for each insecticide and 30 adults were used for each treatment. Mortality of adults was recorded and per cent mortality of adults was worked out.

The control treatment was maintained by spraying water. The control treatment for eggs and pupae was maintained by directly spraying with water using the Potter spray tower. For larvae and adults, aphid-infested cowpea twigs were sprayed using water and then provided to larval and adult stages of *M. timidus*. A completely randomized design was used for the study with seven treatments including the control (water spray) and three replications.

The mortality data of different stages were collected from bioassays and the per cent mortality was calculated for all the life stages of the predator.

$$\text{Per cent mortality} = \frac{\text{Number of dead insects}}{\text{Total number of insects treated}} \times 100$$

RESULTS AND DISCUSSION

The results obtained in a comparative toxicity study of six synthetics *viz*., profenophos 50 EC, imidacloprid 17.8SL, chlorantraniliprole 18.5SC, lambda-cyhalothrin 5EC, buprofezin 25SC and azadirachtin 10000 ppm on four stages of *M. timidus* (Table 1). The toxicity of insecticides was evaluated at both field dosage and increased dosage to all four stages of brown lacewing (eggs, larvae, pupae and adults).

Toxicity of insecticides to egg stage

The toxicity of insecticides on the eggs of *M. timidus* was evaluated at two dosages (Table 1 & Fig. 1). At the recommended dosage imidacloprid 17.8SL was found to be highly toxic to the egg stage resulting in 79.49 per cent mortality. Insecticides like buprofezin 25SC, profenophos 50EC, lambda-cyhalothrin 5EC and chlorantraniliprole 18.5SC caused less than 50 per cent mortality *viz*., 7.78, 13.09, 13.58 and 16.67 and per cent, respectively. Azadirachtin 10000 ppm caused the lowest mortality

Table 1 : Toxicity of insecticides to different stages of *Micromus timidus*

Insecticide	Dosage	Cumulative mortality (%)			
	(ml/L)	Eggstage	Larvalstage	PupalStage	AdultStage
Imidacloprid 17.8 SL	0.30	79.49	44.44	37.03	33.33
	0.50	89.74	51.85	55.56	74.07
	Control	13.33	10.00	10.00	10.00
Profenophos 50 EC	2.00	13.09	90.00	77.78	23.33
	3.00	52.37	100.00	96.29	66.67
	Control	6.67	0.00	10.00	0.00
Azadirachtin 10000 ppm	2.00	4.60	6.67	6.67	0.00
	3.00	20.69	6.67	16.67	0.00
	Control	3.33	0.00	0.00	0.00
Buprofezin 25 SC	2.00	7.78	10.00	14.81	0.00
	3.00	12.22	26.67	22.22	0.00
	Control	0.00	0.00	10.00	0.00
Chlorantraniliprole 18.5 SC	0.30	16.67	3.33	14.81	3.33
	0.40	30.00	10.00	29.63	13.33
	Control	0.00	0.00	10.00	0.00
Lambda-cyhalothrin 5 EC	0.50	13.58	26.67	11.11	3.33
	0.75	22.22	26.67	25.93	10.00
	Control	10.00	0.00	10.00	0.00

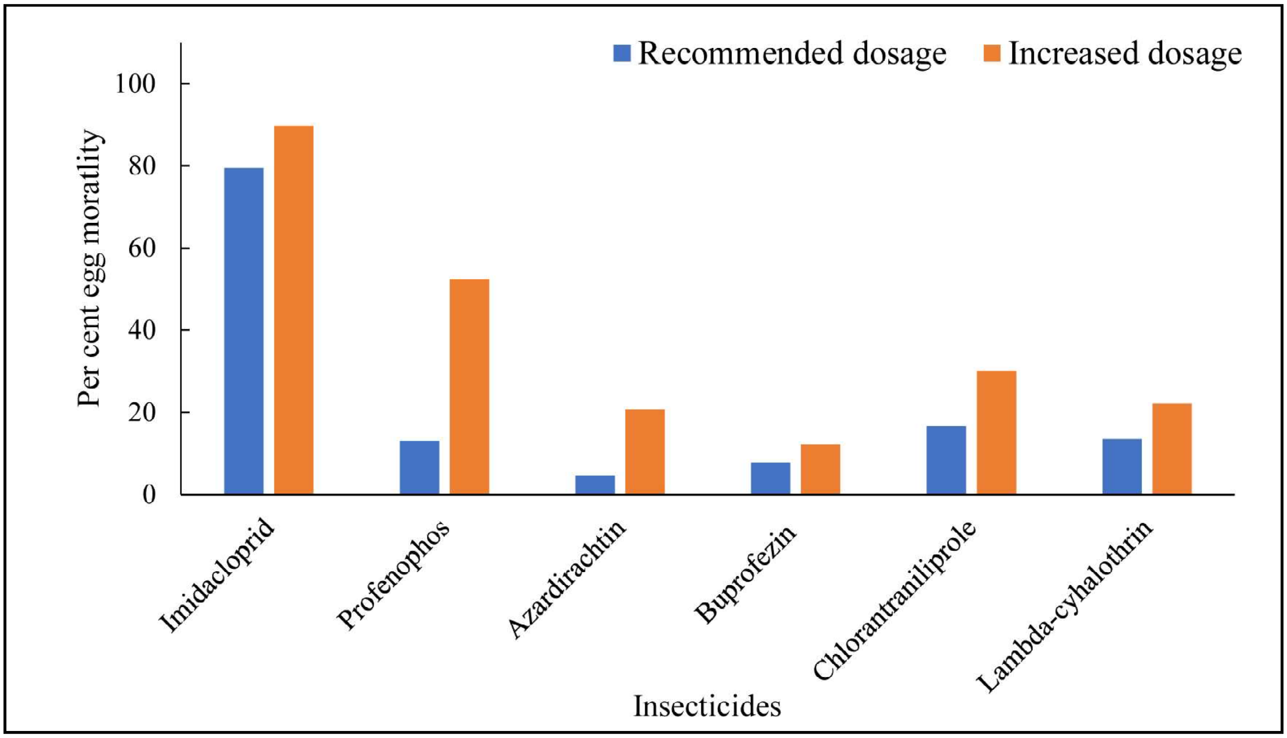

Fig. 1 : Toxicity of insecticides to eggs of *Micromus timidus*

of 4.60 per cent. On the other hand, at a higher dosage, imidacloprid 17.8SL and profenophos 50EC were highly toxic to egg stage causing 89.74 and 52.37 per cent mortality, respectively and chlorantraniliprole 18.5SC, lambda-cyhalothrin 5EC, Azadirachtin 10000 ppm and buprofezin 25SC caused less than 30 per cent mortality *viz*., 30.00, 22.22, 20.69 and 12.22 per cent, respectively at increased dosage. The control mortality varied from 0.00 to 13.33 per cent among different chemicals.

Earlier studies revealed that the *M. timidus* and *Micromus igorotus* Banks eggs were more sensitive to emamectin benzoate 5SG at a lethal concentration (LC_{50}) and the safer chemical was thiodicarb 75WP (Navi, 2009). On *M. igorotus* eggs*,* the ovicidal effect was slightly exerted by quinalphos 25EC, chlorpyrifos and profenophos 50EC accounting for 100 per cent mortality (Vidyaet al., 2008). Gandhi et al. (2005) identified that the lowest hatchability per cent of *Chrysoperla carnea* Stephens eggs was seen in imidacloprid 35EC (43%). But as contrast to this Ham et al. (2019) recorded less than 30 per cent mortality of *Chrysoperla nipponensis* (Okamoto) eggs when they were treated with imidacloprid 10WP at 0.05 g/100 mL.

Toxicity of insecticides to larval stage

The toxicity of insecticide and botanicals on the larval stage of *M. timidus* are presented in Table 1. Among the five insecticides, profenophos 50EC at 2 ml/L and 3 ml/L was found to be highly toxic to the larval stage causing 90 and 100 per cent mortality, respectively, followed by Imidacloprid 17.8SL with 44.44 and 51.85 per cent mortality, respectively. Less than 30 per cent mortality was recorded in Azadirachtin 10000 ppm (6.67 and 6.67%), buprofezin 25SC (10.00 and 26.67%), chlorantraniliprole 18.5SC (3.33 and 10.00%) and lambda-cyhalothrin 5EC (26.67 and 26.67%) at recommended and increased dosages, respectively. From the studies, it can be concluded that Azadirachtin 10000 ppm and chlorantraniliprole 18.5SC are safe to the larval stage of *M. timidus.* The per cent mortality in control was zero for five insecticides except for Imidacloprid which recorded 10 per cent mortality (Fig. 2).

Vidya et al. (2008) reported that Azadirachtin 1500 ppm was least toxic to *M. igorotus* compared to other chemicals studied and lambda-cyhalothrin 5 EC exhibited higher toxicity. The mortality of the second instar larvae of *M. timidus* was higher due to emamectin benzoate 5SG and thiodicarb 75WP that emerged as the safest chemical (Navi, 2009).

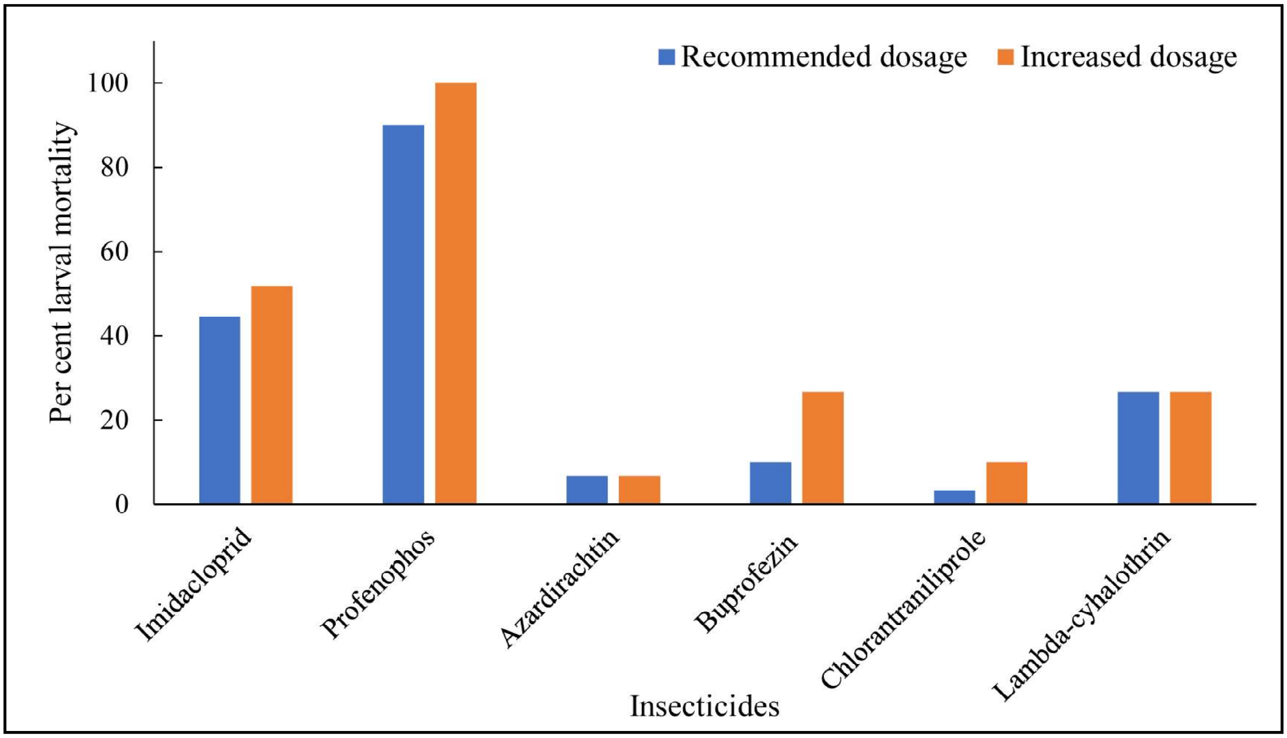

Fig. 2 : Toxicity of insecticides to larvae of *Micromus timidus*

Jeevanandham & Ganapathy (2020) reported that the higher dosage of chlorpyriphos 20EC caused 82.5 per cent larval mortality of *Chrysoperla zastrowii sillemi* Esben-Petersen.

Toxicity of insecticides to pupal stage

The sensitivity of this stage to different chemicals also differed considerably (Table 1). The hierarchy of safety of insecticides in decreasing order is Azadirachtin (6.60%), Lambda-cyhalothrin at 0.5 ml/L (11.11%), lower doses of both buprofezin and chlorantraniliprole (14.81%), buprofezin at 3 ml/L (22.22%), lambda-cyhalothrin at 0.75 ml/L (25.93%), chlorantraniliprole at 0.4 ml/L (29.63%), imidacloprid at both dosages (37.03 and 55.56%) and profenophos at both dosages (77.78 and 96.29%). Here also, profenophos at 3 ml/L was most toxic as 96.29 per cent of pupae did not emerge as an adult. The per cent mortality in control maintained by spraying water ranged from zero to ten per cent among the studied insecticides (Fig. 3).

In the previous studies, thiamethoxam 25WG at 0.8 g/L recorded 51.20-73.7 per cent pupal mortality of *C. carnea* (Mathiarajan & Regupathy, 2002). Azadirachtin 1500 ppm was found to be safer as it accounts for 70.7 per cent of adult emergence. Other insecticides such as profenophos 50EC, endosulfan 35EC, malathion 50EC and other organophosphorus insecticides and among synthetic pyrethroids fenvalerate was highly toxic to pupae of *M. igorotus* (Vidya et al., 2008).

Toxicity of insecticides to adult stage

In comparison to all stages, the adult stage was the most tolerable to all insecticides used in the study. The mortality data revealed that there is zero mortality in both Azadirachtin and buprofezin at both recommended and increased dosages. Both lamba-cyhalothrin and chlorantraniliprole accounted for less than 20 per cent of mortality. The mortality per cent of profenophos was 23.33 and 66.67 per cent at 2 and 3 ml/L, respectively. Imidacloprid is the least safe chemical for adults as it causes 33.33 and 74.07 per cent mortality at 0.3 and 0.5 ml/L, respectively. The per cent mortality in control spray was 10 per cent in imidacloprid and lambda-cyhalothrin and zero mortality for other four insecticides (Table 1 & Fig. 4).

The insecticide emamectin benzoate 5SG was reported as highly toxic to adults of *M. timidus* and a safer chemical was indoxacarb 14.5SC at a lethal concentration (LC_{50}). The same results were obtained when *M. igorotus* adults were treated with chemicals

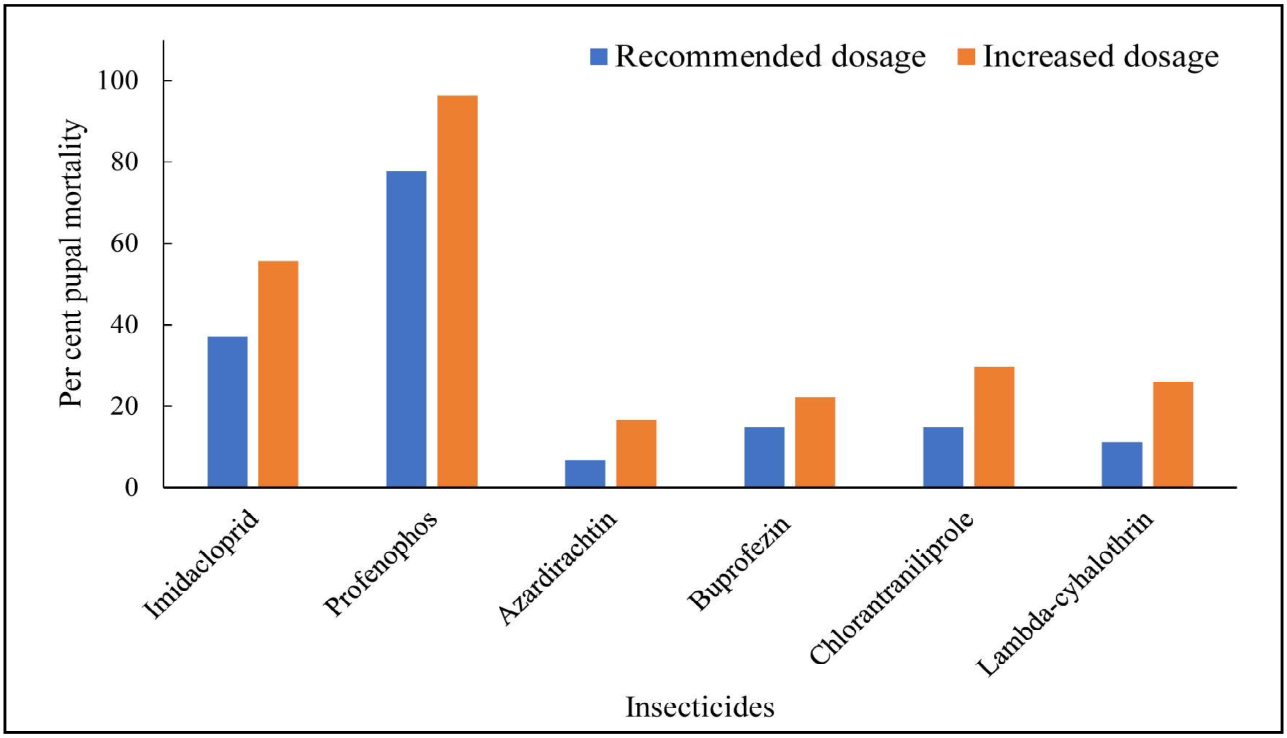

Fig. 3 : Toxicity of insecticides to pupae of *Micromus timidus*

(Navi, 2009). Whereas, spinosad at 800 mg a.i/L caused mortality of 39.8 per cent of adults of *C. carnea* (Medina et al., 2003). Golmohammadi & Hejazi (2014) reported that adult stage was very sensitive to indoxacarb, imidacloprid and endosulfan at their LC_{50} values (0.011, 0.053, and 0.343 g ai/L, respectively). Hence, these insecticides should not be applied when the density of adults is high in the field.

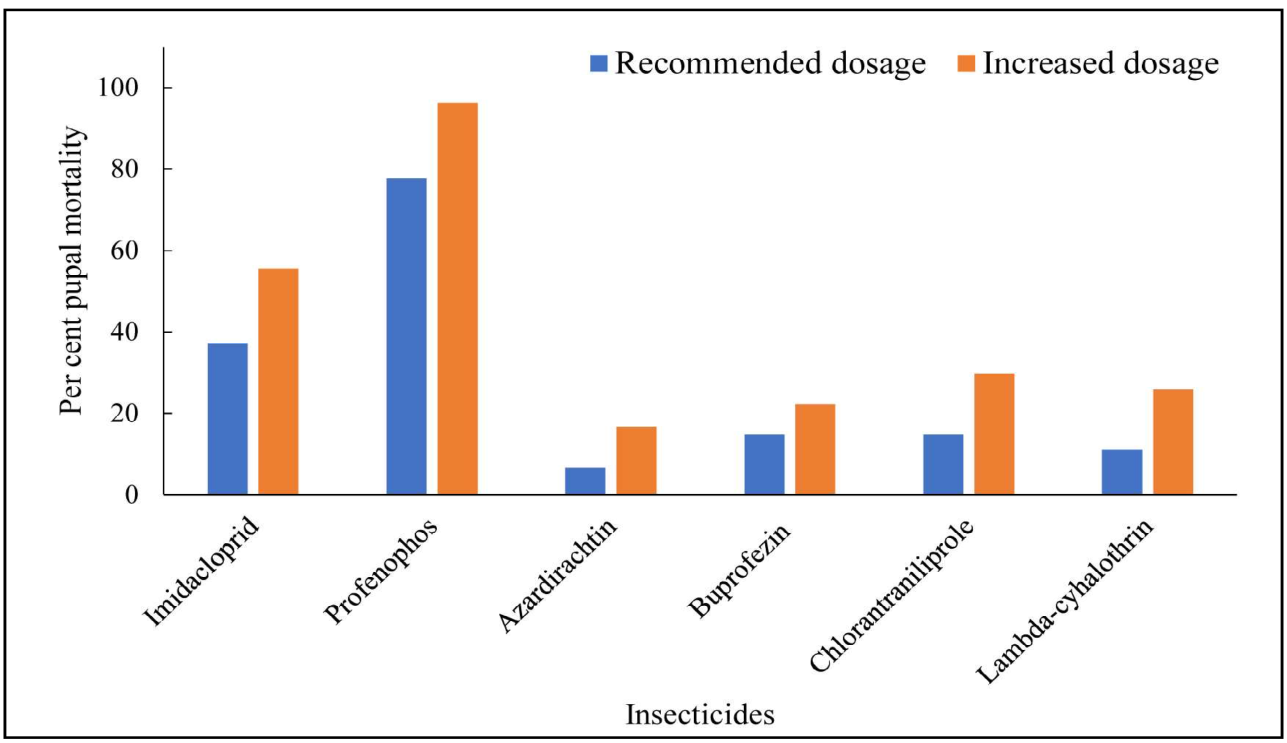

Fig. 4 : Toxicity of insecticides to adults of *Micromus timidus*

The study resulted that the recommended dosage lower mortality percentages, while, the increased dosage caused higher mortality rates across all stages. With the exception of imidacloprid 17.8SL and profenophos 50EC, all other insecticides resulted in reduced mortality in the adult stage compared to other developmental stages. Even inactive stages, such as eggs and pupae, exhibited higher mortality when imidacloprid 17.8SL and profenophos 50EC were applied directly.

CONCLUSION

Overall, the botanical insecticide *i.e.* azadirachtin 10000 ppm was found to be safest compared to the other five chemicals. Among the studied insecticides, imidacloprid 17.8SL was more toxic to egg and adult stage and profenophos 50EC for larva and pupal stage. The other three insecticides were slightly toxic to all stages and resulted in only around 30 per cent mortality. This study provides insights into selecting safer insecticides under field conditions to conserve *M. timidus* and can follow integrated pest management by using both chemical and biological control of pest. From the study, it can be concluded that both Azadirachtin 10000 ppm and buprofezin 25SC can be used to manage aphids in crop ecosystems having higher predator population.

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