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RESEARCH ARTICLE

SUSCEPTIBILITY OF *MICRONECTA SCUTELLARIS* (STÅL) TO THE SYNTHETIC PYRETHROID, FENVALERATE

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ABSTRACT

Pesticides are one of the most important components of high-input farming. Fenvalerate is one among the type II synthetic pyrethroids that has replaced other groups of earlier insecticides due to its improved insecticidal potency. Susceptibility of the Oriental corixid, *Micronecta scutellaris* (Stål) to the synthetic Pyrethroid, Fenvalerate was investigated. Acute toxicity was observed as a function of duration of exposure and concentration of the toxicant. Nymphal stages were more susceptible than adults. Adult females were more tolerant than adult males. 96h LC_{50} values were 14.36, 14.2, 6.83 and 5.71 mg/l for adult female, adult male, V stage nymph and IV stage nymph respectively.

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INTRODUCTION

Aquatic environment, being stressed continuously by continued anthropogenic input of pesticides, dictates a continued assessment of their species specific effects on representatives of ecosystem.Pollution of rivers, lakes and ponds has become one of the most critical environmental problems of the century. Waste water management strategies adopted in India have failed to keep pace with industrial growth and urbanization. This has resulted in accumulation of contaminants with a consequent loss in biodiversity (Raja *et al.,* 2010). Increase in global agricultural production over the last few decades has come about through adoption of high-input forming systems. Pesticides are one of the most important components of high-input farming. Chemical crop protection is profit-induced poisoning of the environment. Median lethal concentrations of the synthetic nereis toxin pesticide, Padan 50 SP (Cartap hydrochloride) for *Diplonychus indicus* and *Ranatra filiformis* were reported to be 50,36,29, and 20 µg/l and 57,47,42 and 36.5 µg/l respectively for 24,48,72 and 92h (Ambrose *et al*., 1995). Tolerance of *Gambusia affinis* to the toxic influence of Padan 50 SP as a function of time was elucidated using static bioassay method (Ambrose, 1999). Synthetic pyrethroids are the recent major class of broad-spectrum organic insecticides used worldwide in agriculture, domestic and veterinary applications. Fenvalerate (FEN) is one among the type II synthetic pyrethroids that has replaced other groups of earlier insecticides due to its improved insecticidal potency (WHO, 1990).Toxicological properties of FEN has been extensively studied (Ohkowa *et al*., 1978; Khan *et al*., 2003; Lee *et al*., 1985; NRC,1987; Coats *et al*., 1989; WHO, 1990; Tripathi, 1992; Tripathi and Verma, 2004; Prasanthi*et al*., 2005a,b; Velmurugan *et al*., 2005; 2007; Raja *et al*., 2010). About 90 per cent of FEN is eliminated from biological systems within 24 hours (Lee *et al*., 1985).Soderlund and Knipple (2003) have reported knockdown resistance of DDT and pyrethriod insecticide in the housefly, *Musca domestica.* Liu *et al.* (2000) have reported high levels of pyrethriod resistance in *Blattella germanica.* Pyrethroids are more hydrophobic than other classes of insecticides and therefore their general site of action is biological membranes. Aquatic species are much more sensitive to FEN than terrestrial species. Aquatic insect species differ greatly in their susceptibility to pesticides, just as they do to other toxicants. However, no pattern has been established that relates susceptibility to specific physiological processes, body configuration and mode of life. Lower resistance of younger or smaller specimens than of older or larger ones has been observed (Fredeen, 1972; Eidt, 1975) and a correlation with higher metabolic rate has been suggested (Jensen and Gaufin, 1964a; 1964b). There are 3 major compartments in aquatic environment that retain chemical contaminants: biota, water and sediment or suspended particulate matter. Air is an important compartment for the transport of toxicants into and out of water (Mackay, 1977). Corixids being bottom dweller and detritivores and omnivores, have more chances of being

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affected by insecticides. Hence tolerance of the non-target aquatic insect *Micronecta scutellaris* to the synthetic pyrethroid, FEN was investigated.

MATERIALS AND METHODS

Susceptibility of *Micronecta scutellaris* (Stål) to the toxic stress of the synthetic pyrethroid FEN was investigated following APHA (1989). Laboratory reared adults and nymphs were used as experimental animals. Mortality in test populations was less than 10 per cent during the period of stocking and maintenance in laboratory conditions. Feeding of experimental animals was stopped 24h prior to the commencement of the experiment to avoid the probable additive effects of the animal excreta in the test chamber. Commercial grade FEN (20% EC) was procured from Rallis India Pvt. Ltd, Mumbai, India. Stock solution and experimental concentrations were prepared using de-ionized water. Non-chlorinated and filtered ground water was used as holding water. Abrupt changes in quality of the holding water (Dissolved oxygen 6.55±0.45 ml/l; Chlorides as Cl375±20µg/l; Salinity 1.09±0.11ppt; p^H 7.1±0.05;Total hardness as $CaCo_3$ 527±10 mg/l; Electrical conductivity 2475±210 µmhos/cm^3 20^{o}C; Temperature 28±1^{o}C) were avoided. After addition of the required concentration of FEN in to a glass test chamber with 5 litres of holding water, 20 individuals of *Micronectascutellaris* were introduced and mortality was recorded after 24, 48, 72 and 96h. Dead individuals were removed as soon as they are observed. Test concentrations obtained from range finding test was equally spaced on geometrical scale to select test concentrations for definitive test. All experimental and control animals were maintained at 28 ± 0.3˚C with 12:12h photoperiod. Mortality was recorded at 24, 48, 72 and 96h following the method of Sprague (1973). Per cent mortality was calculated and the values were transformed into probit scale (Finney, 1971). Slope function and confidence limits of the regression with Chi-square values were calculated (UNEP/FAO/IAEA, 1987).

RESULTS

Susceptibility of the aquatic bug *Micronecta scutellaris* (Stål) to the toxic impact of the synthetic pyrethroid, fenvalerate was observed as a function of time (duration of exposure) and concentration as per cent mortality. Mortality was observed to increase with an increase in concentration of the toxicant. Mortality in the controls was virtually absent. Results indicated that nymphal stages were more susceptible than adults to the acute stress of FEN. Among sexes, adult males were more susceptible than females as indicated by their 96h median lethal concentrations *viz.*14.20 µg/l (Table 1) and 14.36 µg/l (Table 2) respectively. 96h LC_{50} of FEN to nymphal *Micronecta scutellaris* was 5.71µg/l for IV stage (Table 3) and 6.83 µg/l for V stage (Table 4). V stage was more tolerant than the other stage of development. Evaluation of the degree of scatter of the observed LC_{50} values, the lower and higher lethal confidence limits for FEN irrespective of sexes and development stages of *M. scutellaris* indicates a narrow range within which toxicant concentration response fell for all exposure periods. For the adult males 24, 48, 72 and 96h LC_{50} were 14.58, 14.46, 14.38, 14.20 mg/l and their respective confidence limits ranged between 14.25 – 14.94, 14.20-14.69, 14.18-14.56 and 14.12-14.51 mg/l (Table 1). The 24, 48, 72 and 96h LC_{50} values for the adult females were 14.64, 14.54, 14.47 and 14.36 mg/l and their respective confidence limits ranged between 14.17-14.98, 14.10-14.86, 13.95-14.81 and 13.91-14.61 mg/l (Table 2). The 24, 48, 72 and 96h LC_{50} values for the IV stage nymph were 135, 11.48, 6.48 and 5.71 mg/l and their respective confidence limits ranged between 13.09-13.61, 11.19-11.77, 6.22-6.75 and 5.45-5.99 mg/l (Table 3). The 24, 48, 72 and 96h LC_{50} values for the V stage nymphs were 8.35, 7.66, 7.41 and 6.83 mg/l and their respective confidence limits ranged between 8.10-8.60, 7.44-7.89, 7.19-7.64 and 6.61-7.06 mg/l (Table 4). On the fitted regression equation b values were directly related to the exposure period. Inclination of the regression lines towards horizontal position (slanting slopes) indicated that an increase in FEN concentration enhanced mortality of *M. scutellaris*. Chi-squares test showed that calculated values were less than table values and the regression is significant at $p < 0.05$ level. Decline in slope function from 24h to 96h exposures in all the acute toxicity tests (Table 1- 4), indicate that an increase in concentration of toxicant fenvalerate there is increase in mortality of *M. scutellaris.*

Table 1. Susceptibility of adult male *Micronecta scutellaris* to the toxicity of Fenvalerate

Exposure period (h)	LC_{50} (mg/l)	Confidence limits (mg/l)		Chi square
		Lower	Upper	
24	14.58	14.25	14.94	0.96570*
48	14.46	14.20	14.69	0.98206*
72	14.38	14.18	14.56	0.99151*
96	14.2	14.12	14.51	0.99513*

*χ^2 Values are significant at $p < 0.05$

Table 2. Susceptibility of adult female *Micronecta scutellaris* to the toxicity of Fenvalerate

Exposure period (h)	LC_{50} (mg/l)	Confidence limits (mg/l)		Chi square
		Lower	Upper	
24	14.64	14.17	14.98	0.81501*
48	14.54	14.10	14.86	0.81592*
72	14.47	13.95	14.81	0.82527*
96	14.36	13.91	14.61	0.96573*

*χ^2 Values are significant at $p < 0.05$

Table 3. Susceptibility of IV stage nymph *Micronecta scutellaris* to the toxicity of Fenvalerate

Exposure period (h)	LC_{50} (mg/l)	Confidence limits (mg/l)		Chi square
		Lower	Upper	
24	13.35	13.09	13.61	15.13*
48	11.48	11.19	11.77	16.77*
72	6.48	6.22	6.75	21.33*
96	5.71	5.45	5.99	13.50*

*χ^2 Values are significant at $p < 0.05$

Table 4. Susceptibility of V stage nymph *Micronecta scutellaris* to the toxicity of Fenvalerate

Exposure period (h)	LC_{50} (mg/l)	Confidence limits (mg/l)		Chi square
		Lower	Upper	
24	8.35	8.10	8.60	20.49*
48	7.66	7.44	7.89	10.14*
72	7.41	7.19	7.64	11.46*
96	6.83	6.61	7.06	8.40*

*χ^2 Values are significant at $p < 0.05$

DISCUSSION

Observed susceptibility of *M. scutellaris*, a non-target species, to FEN as a function of time and concentration, is in agreement with earlier investigations (Ambrose, 1995; Ambrose *et al.,* 1995; Venkatesan, 2002; Agrahari *et al*., 2007). In the present investigation, adult female *M. scutellaris* exhibited higher tolerance compared to adult male. This differential response could be due to functional variability of organismal cells and tissues to chemical pollutants. Toxicity of pollutants depends upon their permeability into organisms and tolerance of species (Darmono *et al*., 1990). Pronounced tolerance of adult female *M. scutellaris* to FEN toxicity conforms with the observations of Rani (2009) in *D. rusticus* exposed to monochrotophos suggesting occurrence of sex dependent tolerance to pesticidal stress. Numerous biological monitoring methods are developed based on tolerance values for specific species according to their ability to inhabit aquatic bodies (Plafkin *et al*., 1989). Aquatic species are much more sensitive to FEN than terrestrial organism (Tripathi, 1992; Tripathi and Verma, 2004). Differences in response among various stages of development of *M. scutellaris* expressed as susceptibility to FEN conforms to Liao and Hsieh (1990), Charles and McKenney (2005) and Rani (2009). According to them immature and young neonatal organisms, in general appears to be more susceptible to chemical agents than adult individuals. Increased mortality in early larval stages in this study is comparable to that of Purohit *et al.* (1983) and Ambrose (1995). Lowered resistance of younger or smaller specimens than older or larger ones has been observed by Fredeen (1972) and Eidt (1975). Lower tolerance was correlated with higher metabolic rate by Jensen and Gaufin (1964 a,b). Adulticide as well as larvicides employed to control mosquito population was reported to be toxic to non-target organisms (Milton and Venketasan, 2002). Aquatic insects have been used as indicators of water quality since they are affected by a change in physical and chemical factors in water body as well as those induced by human activities (Bargos *et al*., 1990). Involvement of reactive oxygen species (ROS) has been demonstrated in the toxicity of organochlorine (Hincal *et al.*, 1995), organophosphorus insecticides (Banerjee *et al.*, 1999) and pyrethroid toxicity (Giray *et al.,* 2001). The propensity of fenvalerate to induce oxidative stress in rat erythrocytes *in vitro* has been demonstrated by Prasanthi *et al.* (2005). Elevated levels of detoxifying enzymatic reactions might account for lower LC_{50} values. Depletion of free sugar in tissues of water bug, *D. rusticus* under the stress of pesticides as elucidated by Raja *et al.* (2001) proves the demand for more respirable oxygen. Depletion in oxygen consumption due to toxic stress of pollutants might also be the reason for the kill of the test species (Haniffa and Porchelvi, 1985; Rao and Murthy, 1990). Probably their tolerance to pesticide may be reflected in the constituent metabolites and enzymatic interplay.

Conclusion

Susceptibility of *M. scutellaris* under acute toxic stress of Fenvalerate revealed higher tolerance among adult females followed by adult males, V stage nymph and IV stage nymph. These differences could be due to biological diversity and functional variability of organismal cells and tissues to chemical pollutants. To protect fresh water aquatic ecosystem *M. scutellaris* could be made use of as a bioindicator.

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