Selectivity of insecticides to *Podisus nigrispinus* (Heteroptera: Pentatomidae) and its prey *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

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Abstract. The selectivity of malathion, carbaryl, permethrin and deltamethrin to *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae) and its lepidopterous prey *Spodoptera frugiperda* (fall armyworm) was evaluated using leaves impregnated with the insecticides. Malathion was the least toxic insecticide to the fall armyworm, followed by carbaryl, permethrin and deltamethrin, based on LC_{50} values. Malathion was also the least toxic insecticide to the predator *P. nigrispinus*; carbaryl and permethrin showed intermediate toxicities, and deltamethrin presented the highest toxicity to this species. Dosage-response regression lines for the pyrethroids permethrin and deltamethrin presented smaller slopes than the other insecticides, indicating a smaller possibility of occurrence of harmful effects due to small variations in pyrethroid dosage applied in the field. The pyrethroids were more toxic to the lepidopterous prey than to its predator, and deltamethrin was the most selective insecticide in favor of *P. nigrispinus*. Third instar nymphs as well as fifth instar nymphs and adults of *P. nigrispinus* showed high tolerance to deltamethrin, but for permethrin, fifth instar nymphs and adults of *P. nigrispinus* were more tolerant than third instar nymphs.

Key words: Pesticides, predator

Resumen. La selectividad de malatión, carbaril, permetrina y deltametrina a *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae) y a su presa *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) fueron evaluados alimentando a los insectos con hojas impregnadas de estos insecticidas. El malatión fue el menos tóxico para *S. frugiperda*, seguido por carbaril, permetrina y deltametrina basado en su LC_{50}. El malatión fue también el menos tóxico para *P. nigrispinus*; el carbaril y permetrina mostraron toxicidad intermedia, y deltametrina presentó la mayor toxicidad a esta especie. Las curvas de regresión a la dosis de los piretroides permetrina y deltametrina mostraron menor pendiente que los otros insecticidas, indicando menores posibilidades de ocurrencia de efectos dañinos, debido a pequeñas variaciones, en la dosis aplicada de los mismos, en condiciones de campo. Los piretroides fueron menos tóxicos al depredador que a la presa, siendo la deltametrina más selectiva que la permetrina, debido a las pequeñas dosis aplicadas de los mismos para el control de plagas. Las ninfas de tercer y quinto estadío y los adultos, fueron más tolerantes a la deltametrina, sin embargo las ninfas de quinto estadio y los adultos fueron más tolerantes a la permetrina que las ninfas de tercer estadio.

Palabras claves: Depredador, plaguicidas.

INTRODUCTION

True bugs of the genus *Podisus* (Heteroptera: Pentatomidae) are important predators of agricultural and forestry insect pests (McPherson, 1980; Gravena and Lara, 1982). *Podisus nigrispinus* (Dallas) (*Podisus connexivus* Bergroth) (Thomas, 1992) is reported as the main caterpillar predator in several crops in tropical areas (Gravena and Lara, 1982; Bergman *et al.*, 1984; Vitório *et al.*, 1992).

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is an important polyphagous pest of many crops. Insecticides are commonly used for its control in tropical areas, and deltamethrin is one of the most toxic compounds for this insect pest (Finney 1971; Sparks *et al.*, 1982; Yu, 1983). The toxicity of insecticides to the fall armyworm and its predator *Podisus maculiventris* (say) was studied by Yu (1988) who reported a higher selectivity of pyrethroids in favor of the predator than organophosphates and carbamates. The low impact of

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pyrethroids on *Podisus* spp. also has been reported elsewhere (Wilkinson *et al.*, 1979; Guedes *et al.*, 1992; Zanuncio *et al.*, 1993). However, there are still very few studies of insecticide selectivity for pentatomids of the subfamily Asopinae, leading to the development of the study reported here.

MATERIALS AND METHODS

Third and fifth instar nymphs and adults of *P. nigrispinus* as well as sixth instar larvae of *S. frugiperda*, both from mass rearing facilities, were used for the insecticide bioassays. The insecticides used were: malathion (Malatol® 500 EC), carbaryl (Sevin® 850 WP), permethrin (Ambush® 500 EC) and deltamethrin (Decis® 25 EC).

The predator in its different developmental stages and its prey were exposed to the dry insecticide residues on corn leaves. Each insecticide was diluted in water to obtain the desired concentrations and the leaves were immersed in the insecticide solution for 6 seconds. Afterwards they were air dried for 4 hours and placed in open 9 cm diameter Petri dishes. In the check treatment, the leaves were immersed in water. Ten insects were placed in each Petri dish, which were covered with a piece of cloth tied with a rubber band. Insect mortality was evaluated 24 hours after exposure to the insecticides in a manner similar to that of Wilkinson *et al.*, (1979). The bioassays were carried out at $25 \pm 2°C$ and $70 \pm 5\%$ R.H.

The experimental design used was completely random blocks with two replicates. Each experimental unit was formed by two Petri dishes with ten insects each. Four to five insecticide concentrations plus the check-treatment (only water was used) were used to estimate each dosage-response regression line. The deaths in the check treatment were used to correct the mortalities obtained with each insecticide dosage using Abbott's formula (Abbott, 1925). The resulting dosage-response data were analyzed using probits by the method of Finney (1971).

RESULTS

Malathion showed the lowest toxicity to this insect pest, followed by carbaryl, permethrin and deltamethrin (Table 1). The least toxic insecticide to *P. nigrispinus* was malathion, followed by permethrin, carbaryl and deltamethrin, except for third instar nymphs in which permethrin was more toxic than carbaryl based on the estimated LC_{50}s (Table 2). Pyrethroids showed higher selectivity ratios than malathion and carbaryl with deltamethrin showing the best results (Figure 1). Permethrin was more selective in favor of fifth instar nymphs and adults of *P. nigrispinus*, while deltamethrin showed higher selectivity in favor of the two nymphal stages of the predator tested.

DISCUSSION

Pyrethroids and especially deltamethrin were more toxic than the other insecticides for both species studied. Yu (1983) and Gist and Pless (1985) also obtained similar results. In addition, higher slopes in the dosage-response regression lines indicate small variation in the response of single individuals within a population to a certain compound. The slope of the deltamethrin curve for the fall armyworm was the highest, indicating a more homogeneous response of this insect to this insecticide. In this case, a small variation in dosage leads to a large variation in mortality of sixth instar larvae of *S. frugiperda*. Against *P. nigrispinus*, the pyrethroid curves presented small slopes, indicating a low probability of harmful effects of these insecticides to this species due to small variations in pyrethroid dosage applied in the field.

Working in the laboratory, Hough-Goldstein and Keil (1991) reported lower toxicity of carbamates, organophosphates and organochlorines than pyrethroids to *Perillus bioculatus*. Wilkinson *et al.*, (1979) and Guedes *et al.*, (1992) reported that pyrethroids were less toxic to *P. maculiventris* and *P. nigrispinus* using field dosages recommended for the control of their prey. These antagonistic results are explained by the fact that in the last two papers the authors used dosages recommended for the control of *Podisus* spp. prey, while Hough-Goldstein and Keil (1991) worked with dosages determined to kill the predator, reflecting the insecticide's potency but not its selectivity.

Pyrethroids are highly toxic to insect pests and because of this their dosages used to control such insects are smaller than the dosages that would cause harmful effects to at least some of their predators (e.g. *Podisus* spp.), being more selective in favor of them.

Table 1. Probit analyses of insecticides used against sixth instar larvae of *Spodoptera frugiperda*. Viçosa, Minas Gerais State, Brazil.

Insecticide	Equation[a]	X^2	Probability	LC_{50} (95% CI) mg a.i./ml	Toxicity ratio[b]
Malathion	Y = 1.2182 + 4.7737X	2.1	0.35	6.1975 (5.7627-6.8381)	1.0
Carbaryl	Y = 6.6989 + 4.8292X	1.1	0.89	0.4448 (0.4205-0.4702)	13.9
Permethrin	Y = 13.6450 + 4.7891X	1.8	0.62	0.0157 (0.0146-0.0167)	394.7
Deltamethrin	Y = 23.1462 + 6.7954X	1.9	0.60	0.0021 (0.0020-0.0023)	2951.1

[a]Y=Probit
X=log concentration (mg a.i./ml)
[b]LC_{50} of least toxic insecticide (malathion) ÷ LC_{50} of insecticide

Table 2. Probit analyses of insecticides used against *Podisus nigrispinus*. Viçosa, Minas Gerais State, Brazil.

Insecticide	Equation[a]	X^2	Probability	LC_{50} (95% CI) mg a.i./mL	Toxicity Ratio[b]
		(3rd instar nymphs)			
Malathion	Y = 4.2189 + 2.9336X	1.5	0.67	1.8461 (1.5746 - 2.0304)	1.0
Carbaryl	Y = 6.8879 + 2.3539X	3.3	0.35	0.1577 (0.1394 - 0.1767)	11.7
Permethrin	Y = 6.7149 + 2.3539X	1.6	0.81	0.1364 (0.1122 - 0.1586)	13.5
Deltamethrin	Y = 6.1129 + 1.1837X	1.7	0.65	0.1149 (0.0871 - 0.1702)	16.1
		(5th instar nymphs)			
Malathion	Y = 3.4830 + 4.2685X	3.0	0.60	2.2667 (2.1263 - 2.4151)	1.0
Carbaryl	Y = 8.9985 + 5.0654X	3.8	0.56	0.1624 (0.1537 - 0.1708)	14.0
Permethrin	Y = 5.7230 + 2.0563X	7.7	0.10	0.4450 (0.3901 - 0.5239)	5.1
Deltamethrin	Y = 6.2430 + 1.3506X	0.1	0.99	0.1201 (0.0934 - 0.1701)	18.9
		(Adults)			
Malathion	Y = 3.7848 + 6.0297X	2.3	0.31	1.5905 (1.4945 - 1.6837)	1.0
Carbaryl	Y = 8.3648 + 4.5982X	7.2	0.13	0.1855 (0.1756 - 0.1961)	2.8
Permethrin	Y = 5.4996 + 2.0172X	2.5	0.52	0.5653 (0.4840 - 0.7279)	2.8
Deltamethrin	Y = 6.2682 + 1.2266X	6.4	0.17	0.0925 (0.0723 - 0.1268)	17.2

[a] Y = Probit
X = log concentration (mg a.i./ml)
[b] LC_{50} of less toxic insecticide (malathion) ÷ LC_{50} of insecticide

The remaining conventional insecticide groups are less potent to insect pests requiring higher amounts of active ingredient to reach the same control level provided by pyrethroids. These higher dosages are usually harmful to natural enemy populations.

The higher selectivity of pyrethroids to *P. nigrispinus* in relation to *S. frugiperda* reported here is supported by the findings of Wilkinson *et al.* (1979), Yu (1988), Guedes *et al.*, (1992) and Zanuncio *et al.*, (1993). These results benefit the better selection of insecticides for use against insect pests under partial control by *P. nigrispinus*. The fact that even third instar nymphs present high tolerance to deltamethrin indicates that in augmentation programs where insecticide use is still necessary, the release of *P. nigrispinus* in this developmental stage can be carried out together with the use of deltamethrin. In the case of permethrin, the release of fifth instar nymphs or adults should be preferred in an analogous situation. Furthermore, the insecticide exposure technique used here proved valuable in selectivity studies allowing the estimation of dosage-mortality regression lines without any expensive equipment and at very low costs.

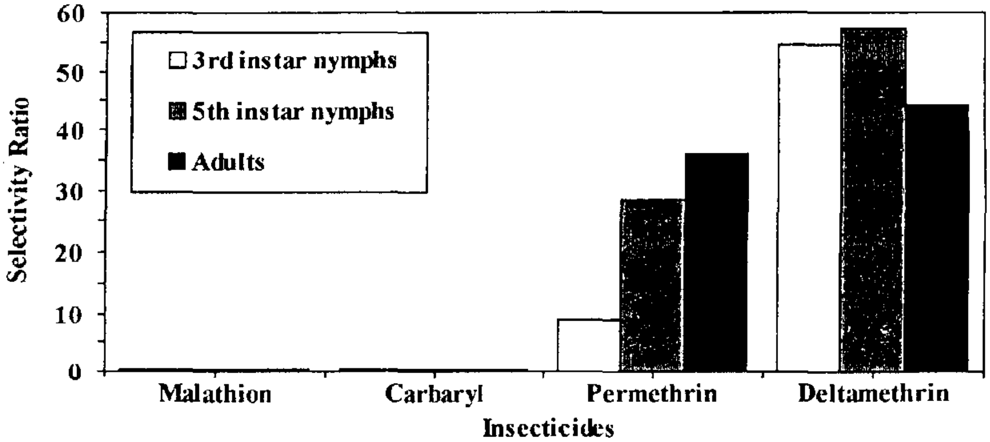

Figure 1. Selectivity ratio of insecticides to *Podisus nigrispinus* in relation to *Spodoptera frugiperda* (LC_{50} for *P. nigrispinus* ÷ LC_{50} for *S. frugiperda*) Viçosa, Minas Gerais State, Brazil.

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