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Pyrethroids Toxicity, And Selectivity To *Microplitis rufiventris* (Kok.) And Its Prey *Spodoptera littoralis* (Laboratory And Field Strains)

By

M.A. Abbassy ; A. H. Belal, A. M. Marei* and A. K. Nassar

Pesticide Chemistry Department, Faculty of Agriculture, Alexandria University, Damanhour , Egypt.

* Pesticide Chemistry Department, Faculty of Agriculture, Alexandria University, Egypt.

ABSTRACT

The toxicity of λ-cyhalothrin, cypermethrin, deltamethrin and fenvalerate, was tested against, *Spodoptera littoralis* (Boisd.) larvae (laboratory and field strains) with and without the endoparasitoid, *Microplitis rufiventris* (KOK.). Results revealed that cypermethrin was the most toxic insecticide and fenvalerate was the least toxic one against the laboratory strain larvae . The parasitized larvae were more susceptible to the tested pyrethroids than unparasitized larvae. Also, λ-cyhalothrin was the most toxic compound followed by fenvalerate, cypermethrin and deltamethrin to the larvae of the field strain of, *S. littoralis*. The toxicity of the tested pyrethroids against field parasitized larvae was slightly greater than that of unparasitized larvae. The rank for the insecticide toxicity for the parasitoid was the same as that for its prey, except for the fact that cypermethrin was less toxic than deltamethrin and λ-cyhalothrin to the parasitoid. According to selectivity ratios at LC_{50} and LC_{95} levels, cypermethrin and fenvalerate are positively selective pyrethroids, which have a minimum effect on the cotton leafworm parasitoid, *M. rufiventris*. The susceptibility of *S. littoralis* larvae of El-Beheira field strain to the tested pyrethroids showed that the larvae of the field strain were very resistant to the tested pyrethroids. Mean of resistance ratios for parasitized and unparasitized larvae were 380.08, 731.59, 555.65 and 297.11 fold resistance to λ-cyhalothrin, cypermethrin, deltamethrin and fenvalerate, respectively. The specific activity of ATPase and CaE enzymes of microsomal and soluble fractions of *S. littoralis* larvae of laboratory and field strains and the parasitoid, *M. rufiventris* was determined. Results revealed that the activity of the ATPase was significantly higher in the larvae of the laboratory strain than in both, field strain larvae and the parasitoid, *M. rufiventris*. CaE specific activity results show that larvae of the field strain demonstrated 3 and 3.8 times the CaE specific activity as larvae of laboratory strain and the adults of *M. rufiventris*.

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INTRODUCTION

The cotton leafworm, *Spodoptera littoralis* (Boisd.) is a polyphagous pest important in many crops and a potential prey for *M. rufiventris* in Egypt. Many efforts have been made to control this pest mechanically, biologically and chemically using insecticides including pyrethroid insecticides (Abdalla, 1982; Riskallah *et al.*, 1983; Radwan *et al.*, 1984; El-Ghareeb, 1987; Yousef *et al.*, 1989 and Abo-El-Saad *et al.*,1998). Resistance to insecticides in insects may result from a lower cuticular penetration, from a modification of toxic action, or from an increase in the activity of the biotransformation enzymes (Riskallah *et al.*, 1983; El-Ghareeb and Manna, 1989; Pinchard and Vassal, 1991; Yu, 1991 and 1992; Moustafa *et al.*, 1992; Sauphanor *et al.*, 1997; and Abo-El-Saad *et al.*, 1998). There are great numbers of parasites that attack the larvae of the cotton leafworm, *Microplitis rufiventris* Kok. is a solitary endoparasitoid which oviposits and develops in the larvae of *S. littoralis* as well as many noctuidae caterpillars. A major problem that retard the development of *M. rufiventris* is the increasing usage of insecticides for the control of cotton and other crops (Elliot *et al.*, 1983; Hegazi *et al.*, 1985; Powell *et al.*, 1986; Shukla *et al.*, 1988; Bhushan and Azam, 1990; Zanuncio *et al.*, 1993; Batalha *et al.*, 1995 and 1997; and Kares *et al.*, 1998). The parasitism by various parasitoids have great effect on the susceptibility of the insect host to insecticides (Hegazi *et al.*, 1982; and Mani and Krishnamoorthy, 1984). Also, the selectivity of insecticides is of major importance in the process of conserving the biodiversity in the ecosystem (Singh *et al.*, 1983; Hower and Davis, 1988; Shukla *et al.*, 1988; Batalha *et al.*, 1995 and 1997; Suinga *et al.*, 1996; and Zanuncio *et al.*, 1998).

Therefore, the purpose of this study was to investigate the pyrethroids toxicity, selectivity and mechanism of resistance in *S. littoralis* (laboratory and field strains) and its parasitoid, *Microplitis rufiventris* to select the most appropriate pyrethroid for control of cotton leafworm without any effect on its parasitoid..

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MATERIALS AND METHODS

Tested Insecticides:

Four synthetic pyrethroids were used: Lambda-Cyhalothrin (Icon, 2.5% EC) (S) - α - cyano-3 – phenoxybenzyl (Z)- (1R, 3R)-3 - (2-chloro-3, 3, 3- trifluoropropenyl) – 2, 2- dimethyl cyclopropane carboxylate.

Cypermethrin (Sparkil, 25% EC) (RS) - α- cyano– 3- phenoxybenzyl (1RS, 3RS; 1RS, 3SR) – 3- (2, 2- dichlorovinyl) –2, 2- dimethyl cyclopropane carboxylate.

Deltamethrin (K-Othrin, 2.5% WP) (S)– α- cyano– 3- phenoxybenzyl (1R, 3R)– 3- (2, 2- dibromovinyl)– 2, 2- dimethyl cyclopropane carboxylate.

Fenvalerate (Somi-Alpha, 5% EC) (RS)– α- cyano– 3- phenoxybenzyl (RS)– 2- (4-chlorophenyl)– 3- methyl butyrate.

Tested organisms:

Susceptible and Field strains of *Spodoptera littoralis* (Boisd.):

The original stock culture of susceptible cotton leafworm strain, *Spodoptera littoralis* (Boisd.) was obtained from Entomology Department, Faculty of Agriculture, Alexandria University. Field strain of the same insect was collected from El-Beheira Governorate. The strains were reared in the laboratory on castor oil leaves under the temperature of 25°C±2 and relative humidity of 60-70% according to Eldefrawi *et al.*, (1964) rearing technique. The 4^{th} instar larvae were used for the bioassay tests.

Laboratory culture of the parasitoid *Microplitis rufiventris* (Kok.):

The first generation of *Microplitis rufiventris* (Kok.) was supplied from Entomology Department, Faculty of Agriculture, Alexandria University. The parasitoid was reared using the technique of Hegazi and El-Minshawy (1979) with some modification.

Parasitism:

Using an aspirator, fertilized adult females were sucked from rearing vials, and introduced into plastic container containing approximately 200 second instar larvae of *S. littoralis*. The larvae were exposed to the parasitoid for three hours to ensure that parasitism took place. After the parasitism, parasitoid females were removed and the parasitized larvae of *S. littoralis* were transferred to clean plastic cups (10X12cm) and provided as usual with fresh and clean castor-bean leaves. The contents of the plastic cups were examined daily to remove the unparasitized larvae whenever found. Otherwise they were likely to attack the parasitized ones, as soon as the last instar larvae of the parasitoid emerged from the host larvae they pupated inside a cocoon and they were collected into new vial.

EXPRIMENTAL METHODS:

Toxicity of tested pyrethroids to unparasitized larvae:

The 4th instar of unparasitized larvae of the Egyptian cotton leafworm *S. littoralis* was treated by topical application method using micro applicator. One µliter of pure acetone solution or dilution of each insecticide concentration was applied to the thoracic terga of the larva as described by Metcalf (1958). Three replicates, each of ten fourth-instar larvae, were used for each insecticide concentration. The control replicates were treated with acetone without any toxicant. After treatment the larvae were placed in glass cups (6X12 cm) provided with a fresh food of castor bean leaves. The cups were covered with cotton textile and kept for 24 hours at room temperature.

Toxicity of tested pyrethroids to parasitized larvae:

The larvae of the cotton leafworm at the end of their 2nd instar were subjected to *Microplitis rufiventris* parasite. After five days the parasitized larvae (5-day-parasitism-old) were used as test organisms. Three replicates, each of 10 larvae, were treated by topical application method using micro applicator. 1µl of pure acetone solution of each insecticide concentrations was topically applied to the thoracic terga of each larva as described by Metcalf (1958). The control replicates were treated with acetone without any toxicant. The larvae were placed in glass cups (6X12 cm), provided with a fresh food of castor bean leaves and cups covered with cotton textile and kept for 24hours at room temperature.

Toxicity of pyrethroid insecticides to *S. littoralis* by residual film method:

The toxicity of tested pyrethroids to the 4th instar larvae of the Egyptian cotton leafworm, *S. littoralis* laboratory strain was evaluated using residual film method. Different concentrations of each insecticide were prepared using absolute acetone as solvent and then, the dilution of each insecticide concentration was placed petri dish (Φ 10cm) as thin film and lifted under laboratory conditions until the solution or dilution was air-dried. Each petri dish received 10 larvae and replicated three times. The control was treated with acetone without any toxicant. The larvae were provided with fresh food of castor oil leaves at room temperature. The mortality percentages were recorded 24 hours after exposure.

Toxicity of tested pyrethroids to the adults of *Microplitis rufiventris* (Kok.):

The toxicity of each tested insecticide against the adults of *M. rufiventris* was evaluated. Ten 3-days old adult males were introduced to a glass vial (13X3 cm in diameter) in which the inner surface was pretreated with a thin film of each insecticide concentrations. The vials were covered with cotton textile and provided with a droplet of bee honey on the cotton textile and kept for 24 hours at room temperature. Each treatment was replicated three times.

In each bioassay test, mortality counts in each treatment were recorded after 24 hours from application. Mortality percentages were corrected by Abbott's formula (1925). Results were statistically analyzed according to the method of Finney (1971).

Assessment of adenosine triphosphatase (ATPase) specific activity:

The method was based on the spectrophotometric determination of the inorganic phosphate (Pi) liberated from the hydrolysis reaction of the ATP mediated by the enzyme according to the method of Koch (1968).

Determination of carboxylesterase (CaE) specific activity:

The activity of carboxylesterase was measured by spectrophotometer based on the determination of p-nitrophenol produced from the hydrolysis reaction of p-nitrophenyl butyrate with the enzyme. Activity measurement was carried out according to the method reported by Vershoyle *et al.*, (1982).

Determination of protein content:

Protein content was estimated using the method reported by Lowery *et al.*, (1951).

***In vivo* effect of tested pyrethroids on ATPase specific activity of microsomal and soluble fractions of *S. littoralis* head capsules:**

The 4th instar larvae of the Egyptian cotton leafworm were topically applied with doses equal to the value of the LD_{50} of each tested pyrethroid. After 24 hours, head capsules of the surviving larvae were separated and homogenized in 10 folds (w/v) of an ice cold buffer containing sucrose (0.32M), EDTA (1mM) and tris-HCL (10mM), pH 7.5. The homogenate was filtered through a double layer of cheesecloth. The filtrate was subjected to centrifugation at 10,000 rpm for 20 minutes at 4°C. The supernatant was used as a source of ATPase enzyme to determine its specific activity.

***In vivo* effect of tested pyrethroids on Carboxylesterase (CaE) specific activity of *S. littoralis*:**

The surviving larvae of the 4^{th} instar larvae of the Egyptian cotton leafworm which were treated topically with doses equal to the value of the LD_{50} value of the tested pyrethroids; were used after 24 hours of treatment. Midguts were collected by exposing the alimentary canal and sectioning it first slightly posterior to the cardiac sphincter and second slightly anterior to the pyloric sphincter. A slight pressure was followed at one end of the excised midgut contents. Midguts was rinsed and homogenized in 10 folds (w/v) of an ice-cold phosphate buffer (0.1M, pH 7.4). The homogenate was subjected to centrifugation at 10,000 rpm for 20 minutes at 4°C and the supernatant was used as a source of carboxylesterase enzyme.

In* vivo effects of tested pyrethroids on ATPase and CaE enzymes specific activity of *Microplitis rufiventris

Male adults of the solitary endoparasitoid *M.* rufiventris were placed into a glass vials in which the inner surface was pretreated with doses equal to the value of the LC_{50} of the tested pyrethroids as a thin film. After 24 hours the surviving insects were homogenized in 10 folds (w/v) of an ice-cold Tris-HCl-EDTA-Sucrose buffer pH 7.5. The homogenate was subjected to centrifugation at 10,000 rpm for 20 minutes at 4°C. The supernatant was used as a source for ATPase and CaE determinations. In each enzyme determination, protein content was measured using the method reported by Lowery *et al.*, (1951).

RESULTS AND DISCUSSION

Toxicity of pyrethroids to parasitized and non-parasitized larvae of susceptible and field strains of the Egyptian cotton leafworm:

Four pyrethroid insecticides, λ-cyhalothrin, cypermethrin, deltamethrin, and fenvalerate were topically tested against the 4^{th} instar larvae of the laboratory (susceptible) and El-Beheira field strains of, *S. littoralis* with or without the endoparasitoid, *M.*

rufiventris. Concerning laboratory strain, results in Table (1) revealed that cypermethrin was the most toxic insecticide followed by deltamethrin, fenvalerate and λ-cyhalothrin with LD_{50} values of 0.029, 0.038, 0.041 and 0.042 μg/ unparasitized larva, respectively. Concerning, parasitized larvae, results indicate that cypermethrin was the most toxic compound followed by λ-cyhalothrin, deltamethrin and fenvalerate with LD_{50} of 0.01, 0.015, 0.02, and 0.035 μg/ larva, respectively. The ranking order of toxicity was identical for both unparasitized and parasitized larvae except for λ-cyhalothrin and deltamethrin where exchanged their position. In general, these results revealed that parasitized larvae of *S. littoralis* were more susceptible to the tested pyrethroids than unparasitized larvae. In these concerns, Hegazi *et al.*, (1982) mentioned that the parasitized larvae of the cotton leafworm were highly susceptible to any residues of tamaron. Thus, the presence of parasitized larvae decreased the amounts of insecticides needed to control the pest and subsequently diminish to certain extent the contamination risks of the environment.

Among the tested pyrethroids, cypermethrin was the most toxic insecticide followed by deltamethrin, fenvalerate and λ-cyhalothrin. The four pyrethroids contain the same alcohol moiety (α-cyano -3-phenoxybenzyl), but substitution of 3- (2,2- dihalovinyl)- 2,2-dimethyl cyclopropane carboxylic in structure of cypermethrin and deltamethrin by 2- (4- substituted phenyl)- 3- methylbutyric gives fenvalerate, and by 3- (2- chloro -2- trifluoro methyl vinyl)- 2,2-dimethyl cyclopropane carboxylic gives λ-cyhalothrin, which was less toxic than cypermethrin and deltamethrin. The above mentioned substitution may affect the intrinsic toxicity to the target system and/or induced sensitivity of the structure to the metabolic systems in the cotton leafworm larvae.

Concerning, El-Beheira field strain, results in Table (2) indicate that λ-cyhalothrin was the most toxic pyrethroid followed by fenvalerate, cypermethrin and deltamethrin with LD_{50} values of 9.43, 12.19, 12.6, and 17.58 μg/unparasitized larva, respectively. Against the parasitized larvae, the toxicity of the tested pyrethroids was slightly greater than that for unparasitized larvae. The ranking order of toxicity was identical for both unparasitized and parasitized larvae except cypermethrin and fenvalerate where they exchanged their position.

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Insecticide selectivity to *Microplitis rufiventris* (Kok.) and its host *Spodoptera littoralis* (Boisd.):

The selectivity of the four pyrethroid insecticides to the cotton leafworm and its parasitoid, *M. rufiventris* was evaluated using spray-residue film technique. Based on the LC_{50} values, fenvalerate showed the lowest toxicity to the cotton leafworm followed by deltamethrin, λ-cyhalothrin, and cypermethrin as shown in Table (3). The rank for the insecticides toxicity for the parasite was the same as that for its host based on estimated LC_{50} values. These values ranged from 26.12 to 5.75 ppm and from 9.24 to 5.84 ppm for *M. rufiventris* and *S. littoralis*, respectively. Except for the fact that cypermethrin was less toxic than deltamethrin and λ-cyhalothrin to the parasitoid.

The selectivity ratio of the tested pyrethroids varied between 0.9 to 4.48 at LC_{50} level, and between 0.58 to 3.46 at LC_{95} level in favor of the parasitoid *M. rufiventris*. The selective toxicity of these pyrethroids at LC_{50} level can be arranged as follows: cypermethrin (4.48), fenvalerate (2.87), deltamethrin (1.34), and λ-cyhalothrin (0.9). It would be more practical to calculate the toxicity ratio at LC_{95} level, taking in consideration that in any pest control program, it is planned to maintain an adequate insecticide concentration on treated plants to secure 95% mortality ratio. Results in Table (4) show the selectivity ratio at LC_{95} level. According to these ratios, tested pyrethroids can be arranged as follows: fenvalerate (3.46), λ-cyhalothrin (1.45), cypermethrin (1.36), and deltamethrin (0.58). According to the toxicity ratios at LC_{50} and LC_{95} levels, cypermethrin and fenvalerate are positively selective pyrethroids, which have a minimum effect on the non-target organisms. The higher selectivity of these pyrethroids to *M. rufiventris* in relation to cotton leafworm reported here is supported by studies on other species (Wilkinson *et al.*, 1979; Yu, 1988; Guedes *et al.*, 1992; Zanuncio *et al.*, 1993; Picanco *et al.*, 1996 and Zanuncio *et al.*, 1998).

These studies provide an opportunity for a better selection of insecticides used against insect pests under partial control by parasitoids and/or predators. Therefore, to maintain a reasonable population of the parasitoid, it is recommended to decrease the amount of deltamethrin and or λ-cyhalothrin used in the control of *S. littoralis* and preferably to shift to fenvalerate and cypermethrin which are still very active against *S. littoralis* in addition to their safety to its parasitoid, *M. rufiventris*.

Detection of Resistance in El- Beheira Field Strain of Cotton Leafworm:

Pesticide resistance is one of the most serious problems in agricultural pests (National Research Council, 1998). Cotton fields in El-Beheira were heavily sprayed with insecticides to control cotton leafworm and bollworms every cotton season. These treatments include pyrethroids; therefore, the susceptibility of *S. littoralis* larvae, of El-Beheira field strain was determined to test their resistant potency to these tested pyrethroids. The resistance ratio (RR) was obtained by considering the LD_{50} values of laboratory strain as the reference values. Results in Table (5) show that larvae of the field strain were very resistant to the tested pyrethroids. At LD_{50} values, the unparasitized larvae were 224.48, 434.38, 462.55, and 290.31 times more resistant to λ-cyhalothrin, cypermethrin, deltamethrin and fenvalerate, respectively, than the unparasitized susceptible strain. On the other hand, parasitized larvae exhibited 535.68, 1028.8, 650.75 and 303.9 fold resistance for the tested pyrethroids, respectively. From these results, it was noticed that the parasitized larvae showed the greatest ratios of resistance to the tested pyrethroids, except fenvalerate. Mean of resistance ratios for parasitized and unparasitized larvae were 380.08, 731.59, 555.65 and 297.11 fold resistance to λ-cyhalothrin, cypermethrin, deltamethrin and fenvalerate, respectively. The considerable high level of resistance to cypermethrin and deltamethrin might be due to the extensive use of these two pyrethroids in the cotton leafworm and bollworms control programs. This finding is in agreement with those obtained by several investigators, e.g., Riskallah *et al.,* (1983), Martinez-Carrillo and Reynolds (1983), Umeda *et al.,* (1988), El-Ghareeb and Mannaa (1989), Saini *et al.,* (1989), Yu (1990), Pinchard and Vassal (1991), Yu (1992), Moustafa *et al.,* (1992), Cochran (1993), Moustafa *et al.,* (1995), Valles and Yu (1996), Sauphanor *et al.,* (1997) and Abo-El-Saad *et al.,* (1998). However, field strains of the Egyptian cotton leafworm, *Spodoptera littoralis* collected from different areas of El-Beheira Governorate showed resistance to cypermethrin ranged from 0.3- to 2.2- fold (Abo-El-Saad *et al.,* 1998). This was in contrast to our results, which show high resistance to the tested pyrethroids.

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Among the mechanisms responsible for resistance to insecticides, enzyme modifications play a very important role. Thus, the activities of ATP-ases and Carboxylesterases were measured in laboratory strain as well as El-Beheira field strain and cotton leafworm parasite *M. rufiventris*. Data in Table (6).

Results revealed that the specific activity of the ATPase was significantly higher in the larvae of laboratory strain (77.16 μmole of inorganic phosphate/ minute/ mg protein) than that in the larvae of the field strain (63.02 μmole of inorganic phosphate/ minute/ mg protein) and in the parasitoid, *M. rufiventris* (54.68 μmole of inorganic phosphate/ minute/ mg protein). Results in the same table show the *in vivo* effect of the sub-lethal dose of each pyrethroid (0.1 LD_{50}) on the specific activity of ATPase in the larvae of laboratory and field strains of *S. littoralis* as well as its parasitoid adults of *M. rufiventris*. The inhibitory ratios of λ-cyhalothrin, cypermethrin, deltamethrin and fenvalerate for ATPase in larvae of the field strain were: 31.8, 51.9, 59.7 and 26.5%, respectively, and the corresponding values for the laboratory strain were: 59.5, 69.8, 69.1 and 68.8%, respectively. On the other hand, the inhibitory ratios for the parasite, *M. rufiventris* were: 32.0, 44.6, 28.6 and 46.2%, respectively. Thus, ATPase of the larvae of the field strain and the parasitoid, *M. rufiventris* were significantly less sensitive to inhibition by the tested pyrethroids than that of laboratory strain.

The weak inhibitory effect of the tested pyrethroids on ATPase activity was in agreement with the results obtained by Daoud *et al.*, (1930), Bakry *et al.*, (1984), El-Gendy *et al.*, (1999), Osman *et al.*, (1994), Abdel- All *et al.*, (1990), Yang (1989), El- Ghareeb (1987) and Bartkowiak and Wilson (1995).

Carboxylesterase (CaE) is an enzyme responsible for the detoxification of chemicals that contain carboxyl ester linkages and detoxified by hydrolysis. Therefore, carboxylesterase specific activities in the larvae of laboratory and field strains of S. littoralis as well as in the parasitoid, M. rufiventris were measured in a spectrophotometric assay. Carboxylesterases activities (Figure 1) were significantly different for the two strains of *S. littoralis* and *M. rufiventris*. Larvae from field strain demonstrated 3 times and 3.8 times the carboxylesterase activity as larvae of the laboratory strain and the adults of *M. rufiventris*, respectively.

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The differences in CaE activity between susceptible and field strains suggest the role of CaE in pyrethroid resistance. Many authors have reported this relationship. Devonshire and Moores (1982), Devonshire *et al.*, (1986) and Field *et al.*, (1988) found that the level of resistance in green peach aphid, *Myzus persicae* (Sulzer), associated with increased levels of total esterase, and in particular carboxylesterase. Abbassy *et al.*, (1990) showed that field strain of *S. littoralis* possessed higher levels of esterases than the susceptible strain.

In conclusion, it appears that the lower activity and less sensitivity of ATPase to the tested pyrethroids and the elevated carboxylesterase activity contribute, at least in part, to resistance of *S. littoralis* field strain against the tested pyrethroids.

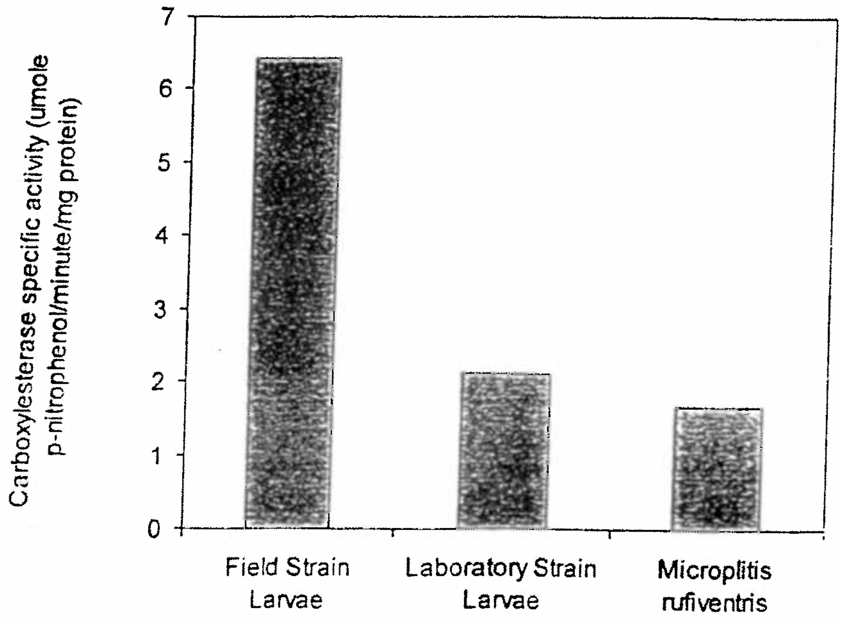

Figure (1): Specific activity of carboxylesterase specific activity of laboratory and field strains of *S. littoralis* and its parasite *M. rufiventris*.

Table (1): Toxicity of pyrethroid insecticides to the 4th instar larvae of a laboratory strain of the Egyptian cotton leafworm, *S. littoralis* by topical application method.

Pyrethroid Insecticides	Unparasitized larvae			Parasitized larvae		
	LD_{50} µg/larva	Confidence limits	Slope	LD_{50} µg/larva	Confidence limits	Slope
λ-Cyhalothrin (2.5%EC)	0.042	0.049 - 0.036	2.987	0.015	0.020 - 0.012	2.380
Cypermethrin (25%EC)	0.029	0.034 - 0.024	2.645	0.010	0.014 - 0.006	1.404
Deltamethrin (2.5%WP)	0.038	0.043 - 0.033	4.286	0.020	0.027 - 0.014	1.748
Fenvalerate (5%EC)	0.041	0.047 – 0.036	4.539	0.035	0.044 - 0.027	3.054

Table (2): Toxicity of pyrethroid insecticides to the 4th instar larvae of a field strain of the Egyptian cotton leafworm, *S. littoralis* by topical application method.

Pyrethroid Insecticides	Unparasitized larvae			Parasitized larvae		
	LD_{50} µg/larva	Confidence limits	Slope	LD_{50} µg/larva	Confidence limits	Slope
λ-Cyhalothrin (2.5%EC)	9.43	10.65 - 8.34	3.90	8.57	9.57 - 7.67	4.82
Cypermethrin (25%EC)	12.60	14.67 - 10.82	3.37	10.29	12.00 - 8.82	3.82
Deltamethrin (2.5%WP)	17.58	20.19 - 15.30	3.21	13.02	16.47 - 10.28	2.59
Fenvalerate (5%EC)	12.19	14.15 - 10.50	3.34	10.64	12.45 - 9.08	3.34

Table (3): Toxicity of the tested pyrethroids to *M. rufiventris* and its host *S. littoralis* by residual film method.

Pyrethroids	*Microplitis rufiventris*			*Spodoptera littoralis*		
	LC_{50} Ppm	Confidence limits	Slope	LC_{50} ppm	Confidence limits	Slope
λ-Cyhalothrin (2.5%EC)	5.75	8.40 - 3.91	1.13	6.37	8.92 - 3.14	1.46
Cypermethrin (25%EC)	26.17	30.21 - 22.66	3.73	5.84	7.89 - 2.86	1.57
Deltamethrin (2.5%WP)	10.99	13.30 - 9.10	2.77	8.21	12.33 - 4.07	1.61
Fenvalerate (5%EC)	26.51	31.83 - 20.10	2.91	9.24	11.86 - 7.17	3.40

Table (4): Insecticide selectivity to *M. rufiventris* and its host *S. littoralis* based on LC_{50} and LC_{95} values.

Tested Pyrethroids	LC_{50} ppm		LC_{95} ppm		Selectivity ratio*		
	M. rufiventris	*S. littoralis*	*M. rufiventris*	*S. littoralis*	Based on LC_{50} values	Based on LC_{95} values	Mean
λ-Cyhalothrin (2.5%EC)	5.75	6.37	103.4	71.16	0.9	1.45	1.18
Cypermethrin (25%EC)	26.17	5.84	72.28	53.34	4.48	1.36	2.92
Deltamethrin (2.5%WP)	10.99	8.21	43.15	74.84	1.34	0.58	0.96
Fenvalerate (5%EC)	26.51	9.24	97.26	28.12	2.87	3.46	3.17

Table (5): Resistance ratios and toxicity of the tested pyrethroid insecticides to field strain of the Egyptian cotton leafworm.

Pyrethroid Insecticides	LD_{50} (µg/larva)				Resistance ratio (RR)		
	Laboratory strain		Field strain				
	Unpara. L[1]	Parasi. L[2]	Unparasi. L.	Parasiti. L.	Unparas. Larvae	Parasi. Larvae	Mean
λ-cyhalothrin (2.5% EC)	0.042	0.016	9.428	8.571	224.48	535.68	380.08
Cypermethrin (25% EC)	0.029	0.010	12.597	10.288	434.38	1028.8	731.59
Deltamethrin (2.5% WP)	0.038	0.020	17.577	13.015	462.55	650.75	555.65
Fenvalerate (5% EC)	0.042	0.035	12.193	10.636	290.31	303.9	297.11

(1)Unpara. L. = unparasitized larvae, and (2) Parasi. L. = parasitized larvae

Resistance ratio (RR) = LD_{50} for field strain / LD_{50} for laboratory strain

Table (6): *In vivo* effect of tested pyrethroids on ATPase activity of the 4th instar larvae of the Egyptian cotton leafworm and its parasitoid, *M. rufiventris*.

Strains	Control S.A.*	λ-Cyhalothrin **		Cypermethrin**		Deltamethrin**		Fenvalerate**	
		S.A	%I***	S.A.	%I	S.A.	%I	S.A.	%I
Field strain larvae	63.02±2.58	43.95±2.77	31.8	30.3±2.34	51.9	25.37±1.97	59.7	46.29±4.2	26.54
Laboratory strain larvae	77.16±2.65	32.17±1.81	59.5	23.41±1.69	69.77	23.81±2.06	69.14	24.05±3.93	68.80
Microplitis rufiventris	54.68±2.06	37.12±0.28	32.0	30.31±1.87	44.57	39.05±3.28	28.58	29.43±1.37	46.18

*S.A. = Specific activity µmole of inorganic phosphate/ minute/ mg protein.
** *S. littoralis* larvae applied with LD_{50} from each pyrethroid.
***M. rufiventris* adults exposed to LC_{50} from each pyrethroid.
***%I = %of inhibition

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الملخص العربى

سمية واختيارية البيروثرويدات لطفيل ميكروبليتس روفيفنتريس وعائله دودة ورق القطن (السلالة المعملية والحقلية)

مصطفى عبد اللطيف عباسي – عبد السلام حلمي بلال – عبد السلام محمد المرعي * – عاطف خضر نصار

قسم كيمياء المبيدات كلية الزراعة بدمنهور – جامعة الإسكندرية

* قسم كيمياء المبيدات – كلية الزراعة بالشاطبي – جامعة الإسكندرية

تم دراسة سمية المبيدات البيرثرويدية؛ اللامدا-سيهالوثرين ، السيبرمثرين ، الدلتامثرين ،والفينفاليرات ضد حشرات يرقات ديدان ورق القطن *Spodoptera littoralis* السلالة الحقلية والسلالة المعملية المتطفل عليها وغير المتطفل عليها بالطفيل الداخلى *Microplitis rufiventris* . أوضحت النتائج أن مبيد السيبرمثرين هو الأكثر سمية ومبيد الفينفاليرات هو الاقل سمية ضمن المبيدات المختبرة ضد يرقات السلالة المعملية من ديدان ورق القطن ،ايضا وجد أن اليرقات المتطفل عليها أكثر حساسية للمبيدات المختبرة عن اليرقات غير المتطفل عليها كما وجد أن مبيد اللامداسيهالوثرين هو الأكثر سمية متبوعا بمبيد الفينفاليرات ثم السيبرمثرين والدلتامثرين ضد يرقات السلالة الحقلية من ديدان ورق القطن ، كانت سمية المبيدات البيرثرويدية المختبرة ضد اليرقات المتطفل عليها من السلالة الحقلية أعلى بدرجة بسيطة عن تلك اليرقات غير المتطفل عليها. أظهرت النتائج أن ترتيب سمية المبيدات ضد الطفيل كان هو نفسه ضد العائل فيما عدا أن مبيد السيبرمثرين كان أقل سمية عن مبيد الدلتامثرين واللامداسيهالوثرين ضد الطفيل. وتبعا لنسب الاختيارية عند مستويات الـ ج ق50 والـ ج ق95 وجد ان كل من السيبرمثرين والفينفاليرات مبيدات اختيارية ويمكن استخدامها بأمان في مكافحة دودة ورق القطن مع استخدام الطفيل لتقليل أعداد الحشرة، أوضحت يرقات السلالة الحقلية من ديدان ورق القطن نسب عالية من المقاومة للمبيدات المختبرة وكان متوسط نسب المقاومة (R.R) 380.08 ، 731.59 ، 555.65 و 297.11 ضعف للمبيدات السيهالوثرين ، السيبرمثرين ، الدلتامثرين ،و الفينفاليرات على التوالى وذلك لليرقات المتطفل عليها وغير المتطفل عليها كما و أظهرت النتائج أن نشاط انزيم الادينوزين تراى فوسفاتيز كان مرتفع فى اليرقات المعملية عن اليرقات الحقلية المستخلص منها الانزيم أوعن نشاط الانزيم المستخلص من طفيل الميكروبليتس كما وجد أن نشاط انزيم الكربوكسيل استيراز المستخلص من يرقات السلالة الحقلية أعلى عن ذلك المستخلص من السلالة المعملية وحشرات الطفيل بحوالى 3 و 3.8 ضعف.