THE EFFICACY OF SOME NATURAL AND CHEMICAL FORMULATIONS AGAINST THE HIBISCUS MEALYBUG, *MACONELLICOCCUS HIRSUTUS* (GREEN) AND ITS NATURAL ENEMIES IN THE LABORATORY AND FIELD IN EGYPT

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Abstract

The hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) is an important pest on grapevine, guava, soybean, peanut and other plants in various locations in Egypt. In addition to debilitating the host plant due to the loss of sap, the resulting honeydew becomes covered in a thick mat of sooty mould, severely reducing respiration and photosynthesis. This paper presents the results of laboratory and field tests on the effect of natural compounds (Biofly and NeemAzal) and the formulated compounds (Super Mesrona oil and Sumithion) on *M. hirsutus* and its parasitoids and predators. The laboratory tests indicated that the effect of Sumithion on the mealybug and its natural enemies ranged from 58-98%, Biofly from 15-80%, Super Mesrona oil from 24-98% and NeemAzal from 17-73%, respectively. For the field tests the results indicated that Biofly gave moderate results against nymphs of *M. hirsutus*, with mean mortality for the two years of 41 & 36% after 3 days, 55 & 51% after 7 days and 58 & 53% after 15 days, while the parasitoids *Anagyrus kamali* and *A. pseudococci* (Hymenoptera: Encyrtidae) and *Allotropa mecrida* (Hymenoptera: Platygastridae) had mortalities of 61 & 48%, 66 & 59%, 55 & 47% respectively for the same periods in the 2 years. The predators *Scymnus seriacus* (Coleoptera: Coccinellidae) had 50 & 37% mortality and *Chrysopa vulgaris aegyptica* (Neuroptera: Chrysopidae) had 53 & 41% mortality after 15 days respectively. On the other hand, Sumithion had high efficacy against nymphs of *M. hirsutus*, with percent reductions of 95%, 96% and 91% for 2008 and 91%, 93% and 88% for 2009. The parasitoids *A. kamali*, *A. pseudococci* and *A. mecrida* had mortalities of 95 & 93%, 90 & 87% and 93 & 90% respectively after 15 days in the two years, while the predators, *Scymnus seriacus* and *Chrysopa vulgaris aegyptica* had percent reductions of 88 & 84% and 85 & 82% after 15 days in the 2 years.

INTRODUCTION

The hibiscus mealybug *Maconellicoccus hirsutus* (Green) (Hemiptera : Pseudococcidae) is one of the most dangerous pest attacking different economic crops. It attacks 125 host plants (Mani 1989). The economic importance of this pest observed by (Williams 1996). The hibiscus mealybug, is an imporant pest on grapevine, guava, soybean and some other plants raised in newly reclaimed areas in different locations in Egypt (Abd-Rabou et al. 2007). In addition to debilitating the host plant due to the loss of sap, the resulting honeydew becomes covered in a thick mat of sooty mould, severely reducing respiration and photosynthesis. The natural enemies and their role in biological control of this pest have been attracted many workers all over the world including Egypt, Mani 1989; Abd-Rabou 2000; Abd-Rabou 2005 and Reddy et al. 2009. In addition Noyes and Hayat (1994) recorded 21 parasitoids are known to attack the hibiscus mealybug world wide. Ten of them in Egypt (Abd-Rabou et al. 2007). The effect of the insecticides on the hibiscus mealybug, *M. hirsutus* and its natural enemies has been studied by Ghose (1970), Babu and Azam (1987), Mani and Thorntakarya (1988), Srinivasan and Sundarababu (1989), Mani and Krishnamoorthy (1990), Satyanarayana et al. (1991), Persad and Khan (2000), Muthukrishnan et al. (2005) and Raguraman and Premalatha (2006).

The aim of this work is to test the efficacy of some natural compound compared with a chemical compound on the hibiscus mealybug, *M. hirsutus* and its natural enemies under both laboratory and field conditions.

MATERIALS AND METHODS

1. Laboratory experiments

1.1. Mass rearing of Maconellicoccus hirsutus and its natural enemies

M. hirsutus was reared on squash under laboratory conditions (23±2ºC and 60±5% R.H.) . Culture of the natural enemies was started that emerged from the collected specimens from the field and the colony was reared *M. hirsutus* feeding on was reared on squash. The laboratory conditions were 25-27 Cº and 65-70 R.H%.

1. 2. Tested commercial formulation

The following four compounds were tested: Biofly, an entomopathogenic fungi (3X 10^7 c. fu 1ml), containing the fungus *Beauveria bassiana,* used at a rate of 2 ml/liter of water, NeemAzal, a botanical extract containing 1% Azadirachtin a (10 g/liter) from the neem tree, *Azadirachta indica* (Meliaceae), applied at a rate of 2 ml/liter of water, Sumithion 50% EC a chemical pesticide was applied at a rate of 2 ml/ liter of water and Super Misrona 95% EC, a local mineral oil, containing 95% paraffinic oil w/w, unsulfonated residue content reached 92%, applied at a rate of 20 ml/liter of water.

1. 3. Tested methods

The laboratory experiments were carried out in the laboratory of Plant Protection Research Institute, ARC, Dokki, Giza. The method of indirect exposure was used to evaluate the effect of the four compounds on the *M. hirsutus* and its natural enemies throughout the present investigation. Five concentrations of Biofly , NeemAzal, Super Mesrona oil and Sumithion were used; one hundred individuals were sprayed in each concentration for five seconds. Mealybug individuals were divided into five replicates. One hundred individuals sprayed by clean water as untreated check (control). The individuals of mealybugs were transferred to clean wide plastic dishes, which were then covered with muslin cloth held in position by rubber bands. After 24 hours the alive of *M. hirsutus* and its natural enemies were counted.

1. 4. Statistical analysis

In laboratory tests, the mortality percentages were calculated and corrected for natural mortalities by Abbott's formula (1925). The corrected percent mortalities were statistically computed according to Finney (1971) and plotted on probit analysis paper. The tested compounds were compared for their efficiency on the predators and parasitoids and prey according to their LC_{50}, LC_{90} and slopes of the toxicity lines.

2. Field experiments

The experiments were carried out to evaluate of the four compounds (Biofly , NeemAzal, Super Mesrona oil and Sumithion) on *M. hirsutus* and its natural enemies on grape were carried out at El-Minya Governorate. When the numbers of *M. hirsutus* and its natural enemies were high during September of the two seasons, 2008 and 2009.

2.1. The experiments comprised 4 compounds: Biofly, an entomopathogenic fungi (3X 10^7 c. fu 1ml), containing the fungus *Beauveria bassiana,* used at a rate of 2 ml/liter of water, NeemAzal, a botanical extract containing 1% Azadirachtin a (10 g/liter) from the neem tree, *Azadirachta indica* (Meliaceae), applied at a rate of 2 ml/liter of water, Sumithion 50% EC a chemical pesticide was applied at a rate of 2 ml/ liter of water and Super Misrona 95% EC, a local mineral oil, containing 95% paraffinic oil w/w, unsulfonated residue content reached 92%, applied at a rate of 20 ml/liter of water.

Each treatment conducted in 1/4 Fadden. One quarter of Fadden was also used as an untreated check (control). Spraying was applied at the rate of per plant which was accomplished by the use of sprayer of 600 liter capacity. Pre-spraying counts were made just before spraying. The post spraying counts were made after 3, 7 and 15 days from application. Random samples of 30 leaves and 15 twigs were picked up from each replicate. A total number of 30 infested leaves and 15 twigs for each treatment thus examined. By means of a stereoscopic microscope insect was inspected.

2.2. Statistical analysis

The percent reduction of infestation was statistically calculated according to the equation of (Henderson and Tilton 1955).

$$\% \text{ mortality} = 100 \left[1 - \frac{Ta \times Cb}{Tb \times Ca}\right]$$

Where: Ta = Post treatment insect counts, Cb = Untreated insect count before treatment

Tb = Pretreatment counts, Ca = Untreated insect count after treatment.

RESULTS AND DISCUSSION

1. Laboratory Experiments

Data presented in Table (1) showed the potency of three natural compounds namely (Biofly, NeemAzal and Super Mesrona oil) compared with Sumithion against the nymphs and adult females using direct exposure technique. Tabulated data indicated that, the potency of the tested compounds was varied tremendously due to the nature of the tested compounds, the used concentration and the tested stage. As a general trend, data proved that at any of the tested compound the higher the concentration, the higher was the rate of mortality and vice versa. According to of the data the LC_{50} and LC_{90} (Table 1) , Sumithion proved to be the most effective compound, followed by Super Mesrona oil, Neem Azal while Biofly came in the last category. The slope of line is useful to clarify the homogeneity of nymphs and adult of *M. hirsutus*. While parasitoids and predators of *M. hirsutus*, according to the LC_{50} and LC_{90}, Sumithion proved to be the most effective compound, followed by Super Mesrona oil, Biofly while NeemAzal came in the last category. The slope of line is useful to clarify the homogeneity of the parasitoids . *kamali* and *A. pseudococci* and *A. mecrida* and predators *S. seriacus* and *C. vulgaris aegyptica* of *M. hirsutus* , which collected from the field to different compounds.

2. Field experiments

The experiments were carried out to evaluate of the four compounds Biofly , NeemAzal, Super Mesrona oil and Sumithion on *M. hirsutus* and its natural enemies on grape were carried out at El-Minya Governorate. When the numbers of *M. hirsutus* and its natural enemies were high during the two seasons, 2008-2009.

2.1. The second season (2008)

In the first season (2008), the pre-spraying counts of adults and nymphs of *M. hirsutus* were 780-860 and 2210-2293 / 30 leaves, respectively and the numbers of *A. kamali* and *A. pseudococci* and *A. mecrida* were 188-199, 155-166 and 185-215 /30 leaves , respectively and also the number of the predators *S. seriacus* and *C. vulgaris aegyptica* 67-79 and 71-83 /30 leaves . Results in Table (2) indicate that in first year (2008), the two compounds Biofly and NeemAzal gave moderate effect against adults and nymphs of *M. hirsutus* after 15 days. They also showed moderate toxic effect against the parasitoids, *A. kamali* and *A. pseudococci* and *A. mecrida* and the predators, *S. seriacus* and *C. vulgaris aegyptica* . On the other hand, Super Mesrona oil and Sumithion gave high efficacy against all targets after 15 days from application.

2.2. The second season (2009)

In the second season (2009), the pre-spraying counts of adults and nymphs of *M. hirsutus* were 872-895 and 2745-2820 / 30 leaves, respectively and the numbers of *A. kamali* and *A. pseudococci* and *A. mecrida* were 198-227, 179-201 and 197-231 /30 leaves ,respectively and also the number of the predators *S. seriacus* and *C. vulgaris aegyptica* 82-94 and 100-123 /30 leaves. Results in Table (3) indicate that in first year (2008), the two compounds Biofly and NeemAzal gave moderate effect against adults and nymphs of *M. hirsutus* after 15 days. They also showed moderate toxic effect against the parasitoids, *A. kamali* and *A. pseudococci* and *A. mecrida* and the predators, *S. seriacus* and *C. vulgaris aegyptica* . On the other hand, Super Mesrona oil and Sumithion gave high efficacy against all targets after 15 days from application.

In the present work, Sumithion gave high efficacy against all targets. nymphs and adult of *M. hirsutus* were reduced by 91 & 96 and 88 & 93 % during the first and second years, respectively. Reduction in *A. kamali* and *A. pseudococci* and *A. mecrida* were 95, 90, 93% and 93, 87, 90%, during the first and second years, respectively. While Mani and Krishnamoorthy (1990) in laboratory trials at field application rates, quinalphos (0.05%), endosulfan (0.07%), malathion (0.1%), carbaryl (0.1%) and fenthion (0.1%) were toxic to the parasitoid, *Anagyrus dactylopii* that were reared on *M. hirsutus* on grapes. Also Persad and Khan (2000) tested five commonly insecticides, lambda-cyhalothrin, pirimiphos-methyl, triazophos, fipronil and decamethrin [deltamethrin] in the laboratory and under semi-field conditions for comparative effects on the mealybug and its exotic natural enemy complex. Adult *M. hirsutus* were more tolerant to all insecticides tested while the 1st instar stage was least tolerant. Chemical control was best achieved using either pirimiphos-methyl or triazophos on the 1st instar stage. *Anagyrus kamali* was most susceptible to all insecticides tested. Fipronil was also least persistent (LT50 value of 7 days) for *A. kamali* in the field. Later Raguramananmd and Premalatha (2006) observed the results indicated that methomyl (LannateR 40 SP) at 500-800 g ai/ha was effective in containing the populations of mealy bug, *M. hirsutus*, on grapes from December to April and from April to August. Methomyl 300-600 g ai/ha registered higher population of predatory coccinellids than other treatments in both the trials, however, it was not comparable with the untreated control. On the other hand, better recolonization of coccinellids was noticed in methomyl treatments than in dimethoate. While in the present work the predators *S. seriacus* and *C. vulgaris aegyptica*, the percent reduction were 88 & 85 and 84 & 82, during the first and second years, respectively, after 15 days from application. Srinivasan and Sundarababu (1989) tested the toxicity of 12 insecticides in sprays on grapevines to *C.montrouzieri* preying on *M.hirsutus* in the laboratory. The relative toxicity, as indicated from a persistence-toxicity index, was in the descending order monocrotophos, parathion-methyl, malathion, dimethoate, quinalphos, phosalone, dichlorvos, demeton-methyl, wettable sulfur, agricultural spray oil, Bordeaux mixture and fish oil resin soap. When insecticide-contaminated prey was provided, toxicity was quite high. Mani and Thorntakarya (1988) tested sixteen pesticides for their toxicity to the encyrtid parasitoid *A. dactylopii* and the coccinellid predator *Scymnus coccivora,* in India. Dichlorvos, diazinon, phosalone and fish oil resin soap were found to be non-toxic to *A. dactylopii,* while all the insecticides tested proved harmful to *S. coccivora.* However, copper oxychloride, mancozeb, sulfur, carbendazim, Bordeaux mixture and dicofol were safe to both natural enemies. Babu and Azam (1987) stated that Dichlorvos at 0.1% was found to be the safest insecticide on the predacious coccinellid *C. montrouzieri* attacking *M.hirsutus* on grapevines ; synthetic pyrethroids were highly toxic and more persistent. In the present work the effect of Sumithion , predators *S. seriacus* and *C. vulgaris aegyptica* (78 &75 and 84&82), respectively, after 15 days from application.

Table 1. LC values of the tested compounds against different stages of *M. hirsutus* and its natural enemies under laboratory conditions.

Stages	Compound	LC_{50}	LC_{90}	Slope
Nymphs	Biofly	0.517	12.605	0.924
	NeemAzal	0.764	29.427	0.808
	Super Mesrona oil	5.254	15.37	2.749
	Sumithion	0.152	1.14	1.466
Adult females	Biofly	2.009	62.62	0.858
	NeemAzal	3.205	178.025	3.205
	Super Mesrona oil	6.903	29.002	2.056
	Sumithion	0.188	2.169	1.206
Anagyrus kamali	Biofly	3.869	94.336	0.924
	NeemAzal	5.893	229.857	0.805
	Super Mesrona oil	7.67	36.829	1.881
	Sumithion	0.298	3.735	1.168
A. pseudococci	Biofly	9.686	479.284	0.756
	NeemAzal	3.138	195.492	0.714
	Super Mesrona oil	8.447	38.187	1.956
	Sumithion	0.282	4.245	1.089
Allotropa mecrida	Biofly	7.609	282.316	0.817
	NeemAzal	4.265	247.265	0.726
	Super Mesrona oil	9.285	40.475	2.004
	Sumithion	0.211	6.344	0.868
Scymnus seriacus	Biofly	6.702	161.418	0.928
	NeemAzal	10.106	547.329	0.739
	Super Mesrona oil	12.043	82.378	1.535
	Sumithion	0.304	5.228	1.037
Chrysopa vulgaris aegyptica	Biofly	6.702	161.418	0.928
	NeemAzal	10.106	547.329	0.739
	Super Mesrona oil	13.455	82.556	1.627
	Sumithion	0.344	4.755	1.124

Table 2.

Table 2. Percent reduction of *Maconellicoccus hirsutus* and its natural enemies /leaf on grape were carried out at El-Minya when treated with four different compounds during 2008 season.

Treatment	Rate /L.W.	Post spraying count																				
		3 days							7 days							15 days						
		M.		P.			Pr.		M.		P.			Pr.		M.		P.			Pr.	
		N.	A.	P1	P2	P3	Pr.1	Pr.2	N.	A.	P1	P2	P3	Pr.1	Pr.2	N.	A.	P1	P2	P3	Pr.1	Pr.2
NeemAzal	2 ml	33	26	29	36	24	22	27	49	45	46	53	39	42	45	58	55	61	66	55	50	53
Biofly	2 ml	40	34	35	44	32	27	37	58	55	53	59	49	48	53	68	65	69	74	63	57	60
Sumithion	2 ml	56	46	54	51	43	45	39	77	79	76	69	72	74	69	91	96	95	90	93	88	85
Super Mesrona oil	20 ml	45	35	45	40	33	34	32	66	69	65	58	63	68	64	85	87	85	80	83	82	79

M. *Maconellicoccus hirsutus,* P. Parasitoids, Pr. Predators, N. Nymphs of *Maconellicoccus hirsutus,* A. Adult of *Maconellicoccus hirsutus,* P1. Anagyrus kamali, P2 *Anagyrus pseudococci,* P3. *Allotropa mecrida,* Pr1. *Scymnus seriacus*, Pr2. *Chrysopa vulgaris aegyptica*

Table 3. Percent reduction of Maconellicoccus hirsutus and its natural enemies /leaf on grape were carried out at El-Minya when treated with four different compounds during 2009 season.

Treatment	Rate /L.W.	Post spraying count																				
		3 days							7 days							15 days						
		M.		P.			Pr.		M.		P.			Pr.		M.		P.			Pr.	
		N.	A.	P1	P2	P3	Pr.1	Pr.2	N.	A.	P1	P2	P3	Pr.1	Pr.2	N.	A.	P1	P2	P3	Pr.1	Pr.2
NeemAzal	2 ml	30	21	19	30	20	16	21	42	38	33	47	34	26	31	53	51	48	59	47	37	41
Biofly	2 ml	36	31	31	41	27	22	25	52	49	50	54	43	34	39	65	61	65	72	59	52	56
Sumithion	2 ml	50	53	32	33	31	39	33	76	78	74	69	60	64	58	88	93	93	87	90	84	82
Super Mesrona oil	20 ml	44	51	40	36	30	32	28	66	70	62	54	60	58	53	80	83	83	76	80	78	75

M. *Maconellicoccus hirsutus,* P. Parasitoids, Pr. Predators, N. Nymphs of *Maconellicoccus hirsutus,* A. Adult of *Maconellicoccus hirsutus,* P1. Anagyrus kamali, P2 *Anagyrus pseudococci,* P3. *Allotropa mecrida,* Pr1. *Scymnus seriacus*, Pr2. *Chrysopa vulgaris aegyptica*

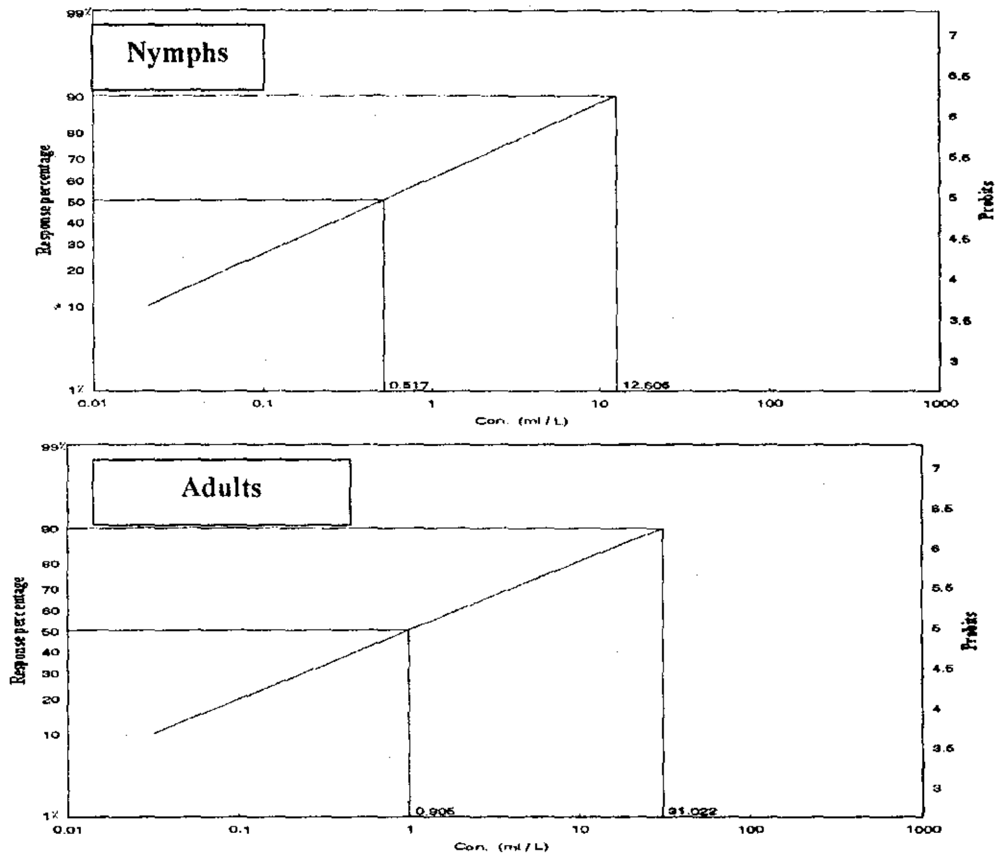


Fig. (1): Toxicity lines of the Biofly against nymphs and adults on *M. hirsutus* under laboratory conditions.

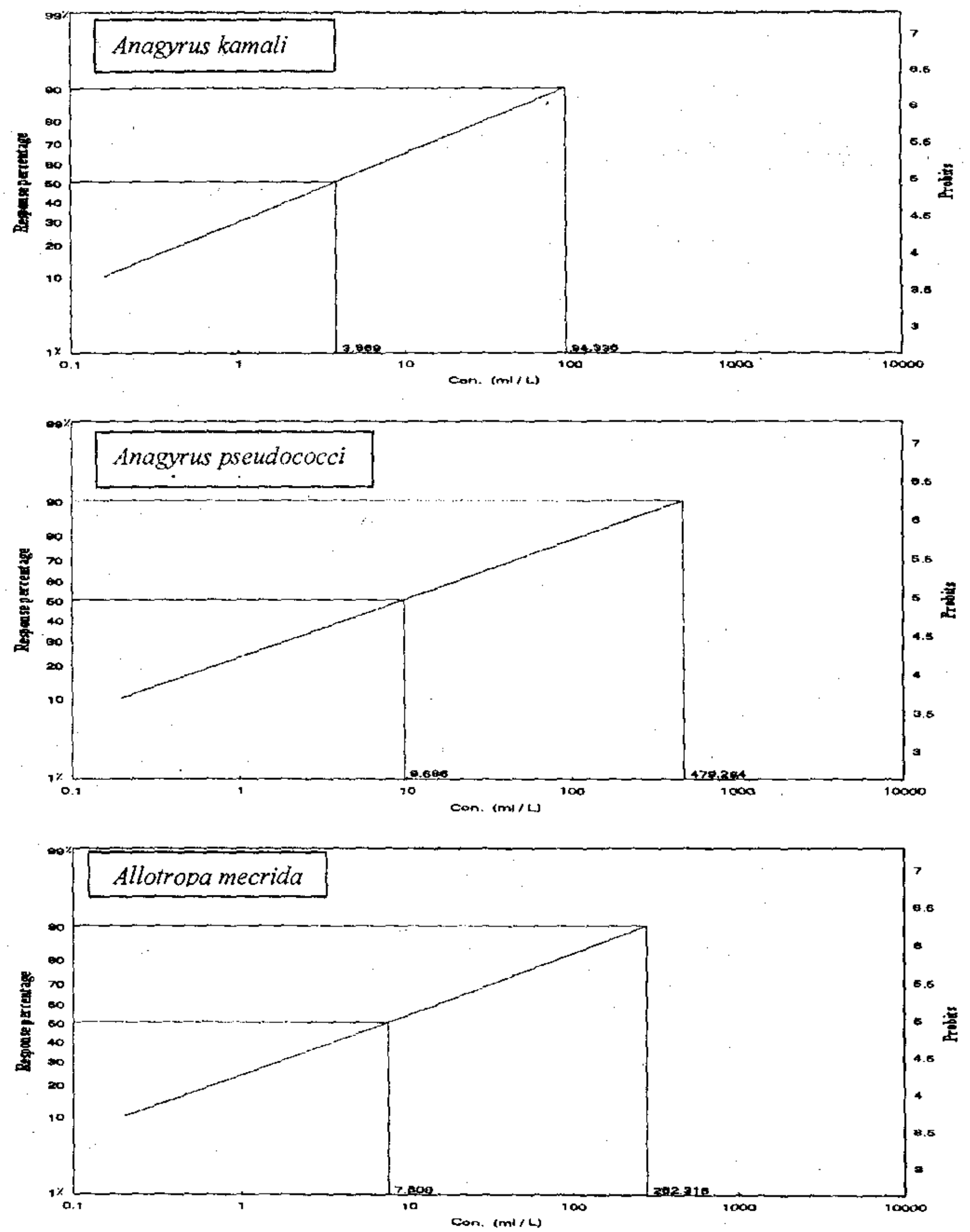
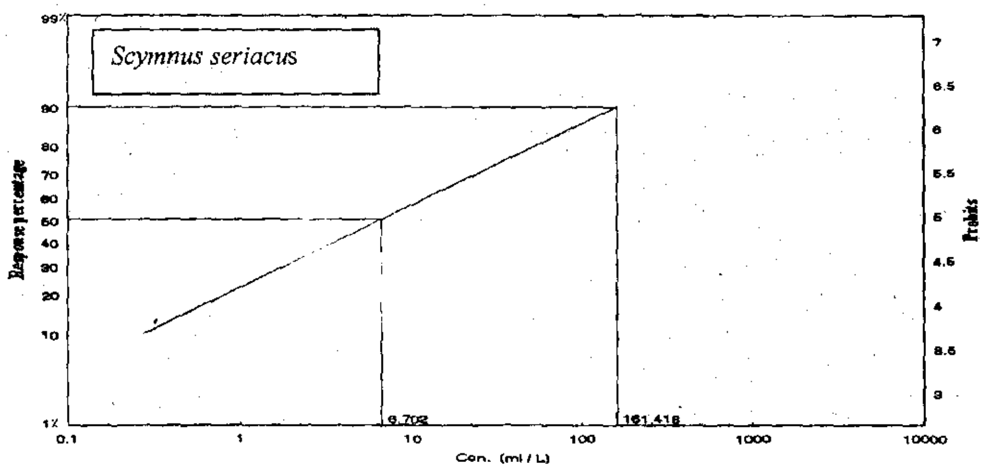


Fig. (2): Toxicity lines of Biofly against different parasitoids associated with *M. hirsutus* under laboratory conditions.



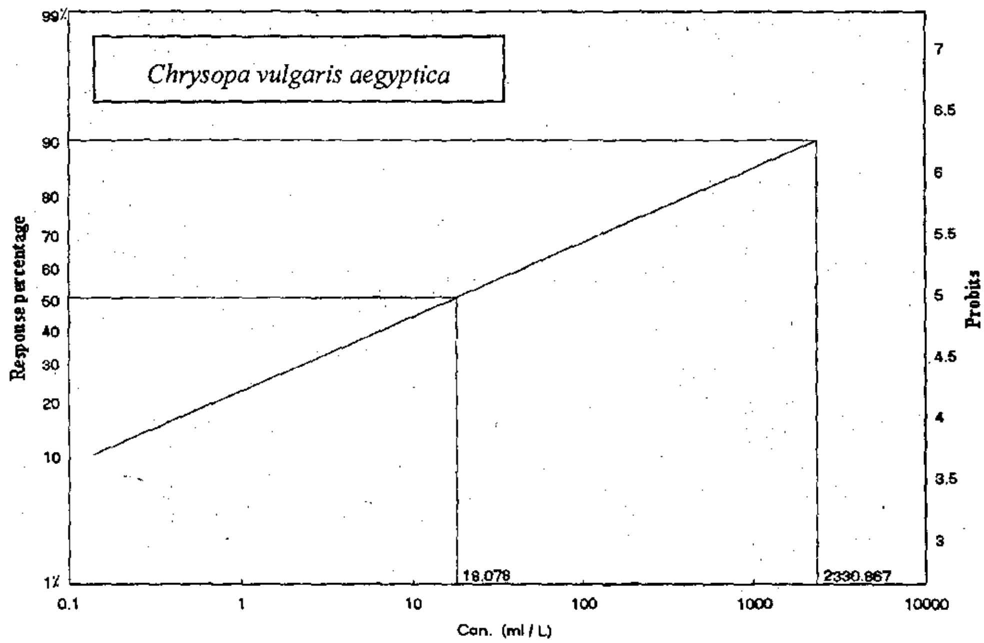


Fig. (3): **Toxicity lines of Biofly against the predators associated with *M. hirsutus* under laboratory conditions.**

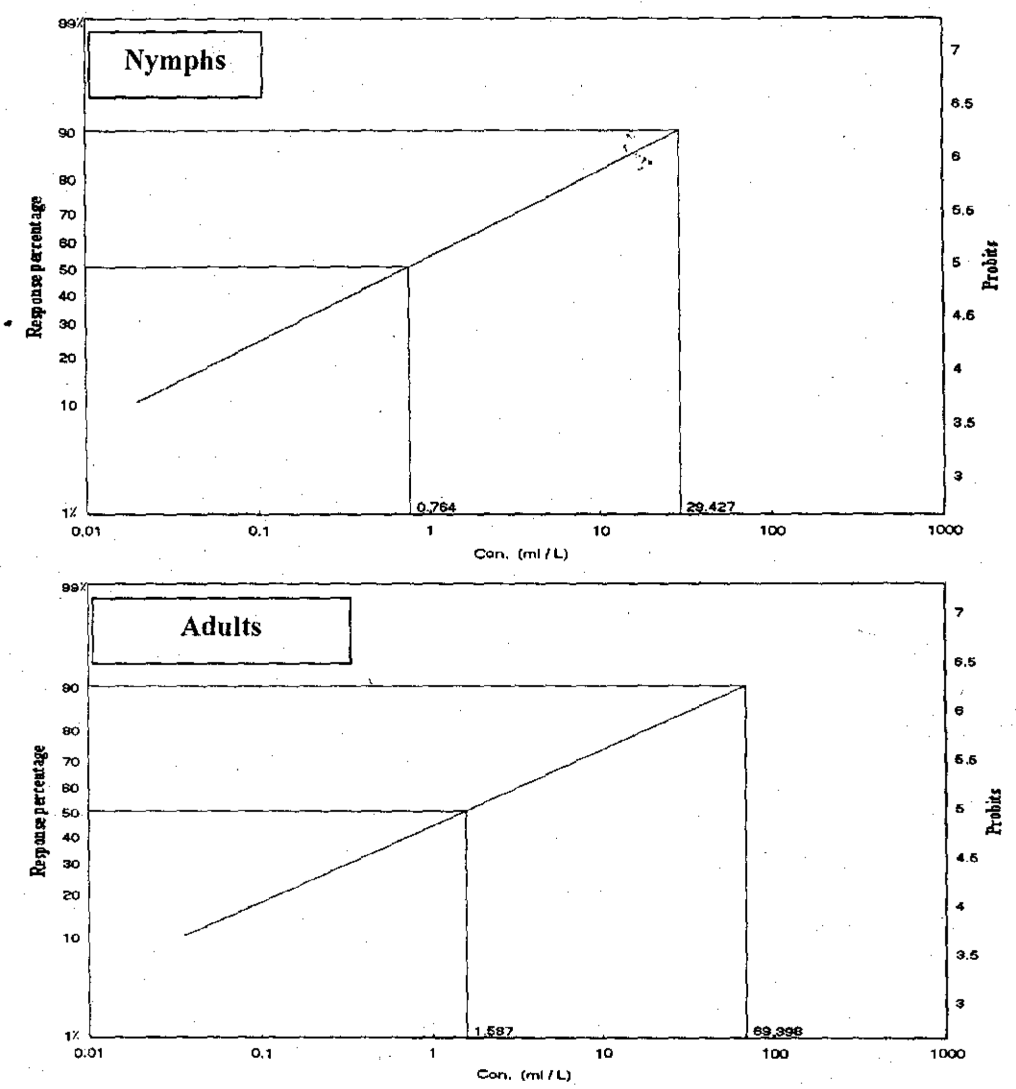


Fig. (4): Toxicity lines of NeemAzal against nymphs and adults on ***M. hirsutus*** under laboratory conditions.

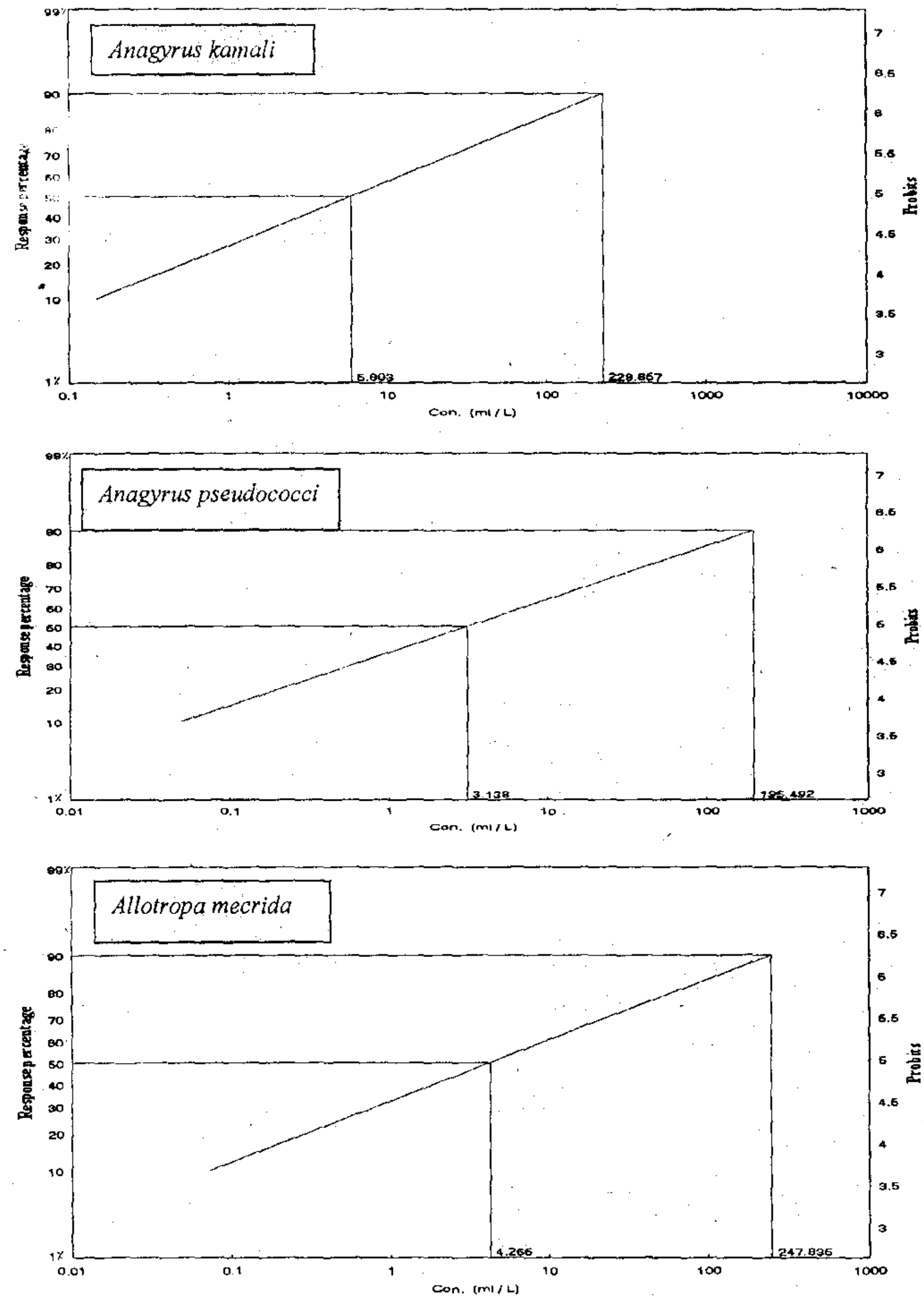


Fig. (5): **Toxicity lines of Neem Azal against different parasitoids associated with *M. hirsutus* under laboratory conditions.**

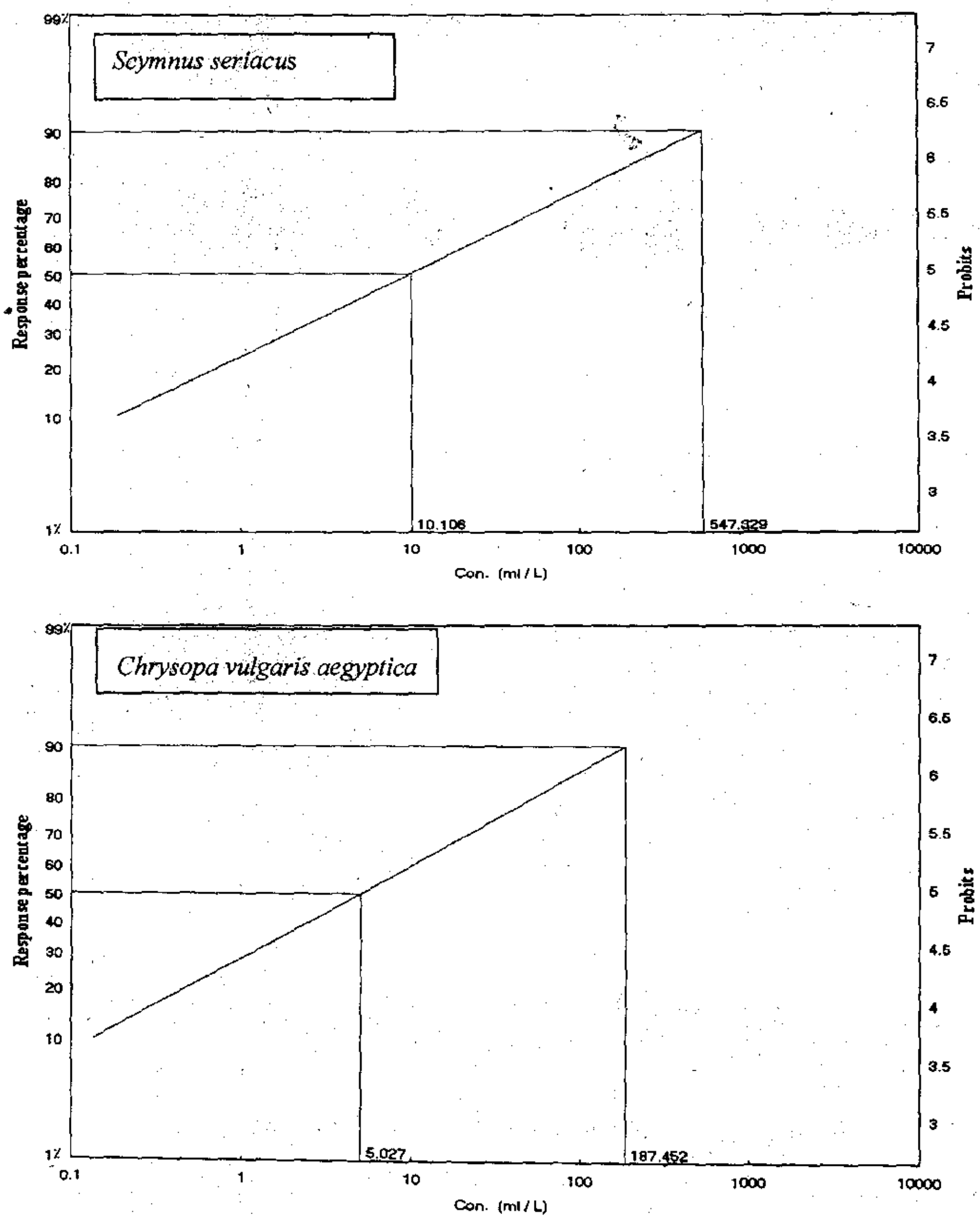


Fig. (6): Toxicity lines of Neem Azal against the predators associated with *M. hirsutus* under laboratory conditions.

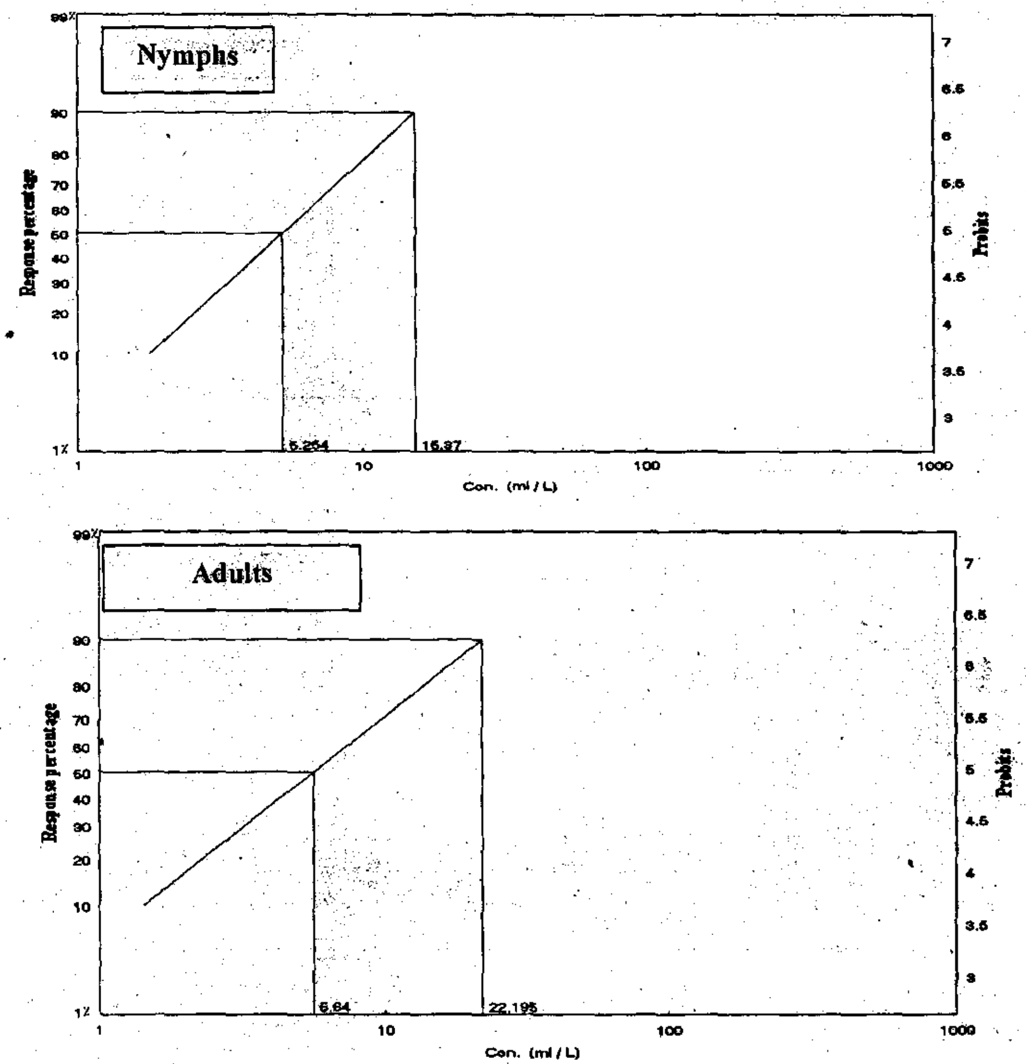


Fig. (7): Toxicity lines of the Super Misona oil against nymphs and adults on *M. hirsutus* under laboratory conditions.

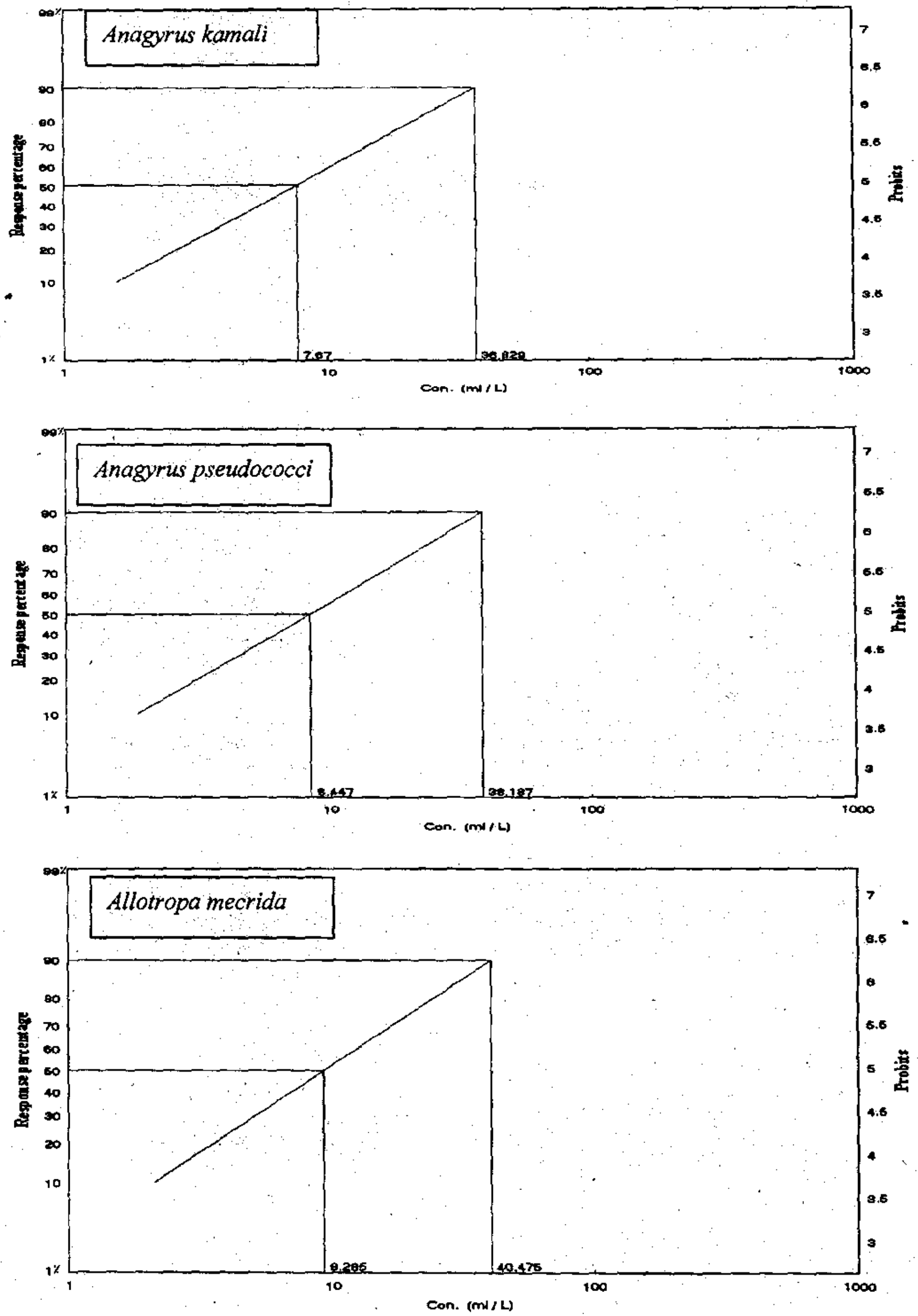


Fig. (8): **Toxicity lines of Super Misona oil against different parasitoids associated with *M. hirsutus* under laboratory conditions.**

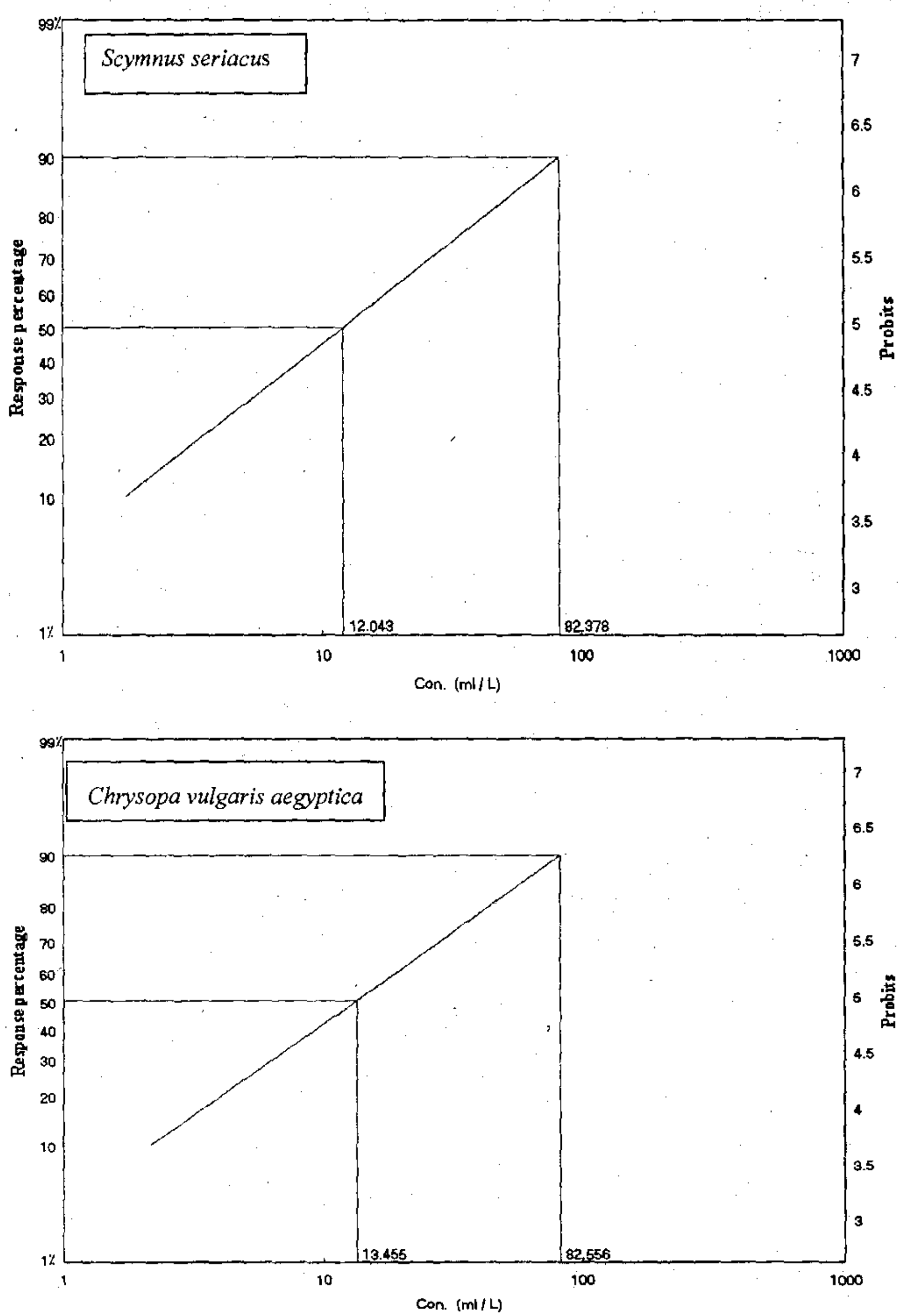


Fig. (9): Toxicity lines of Super Misona oil against the predators associated with *M. hirsutus* under laboratory conditions.

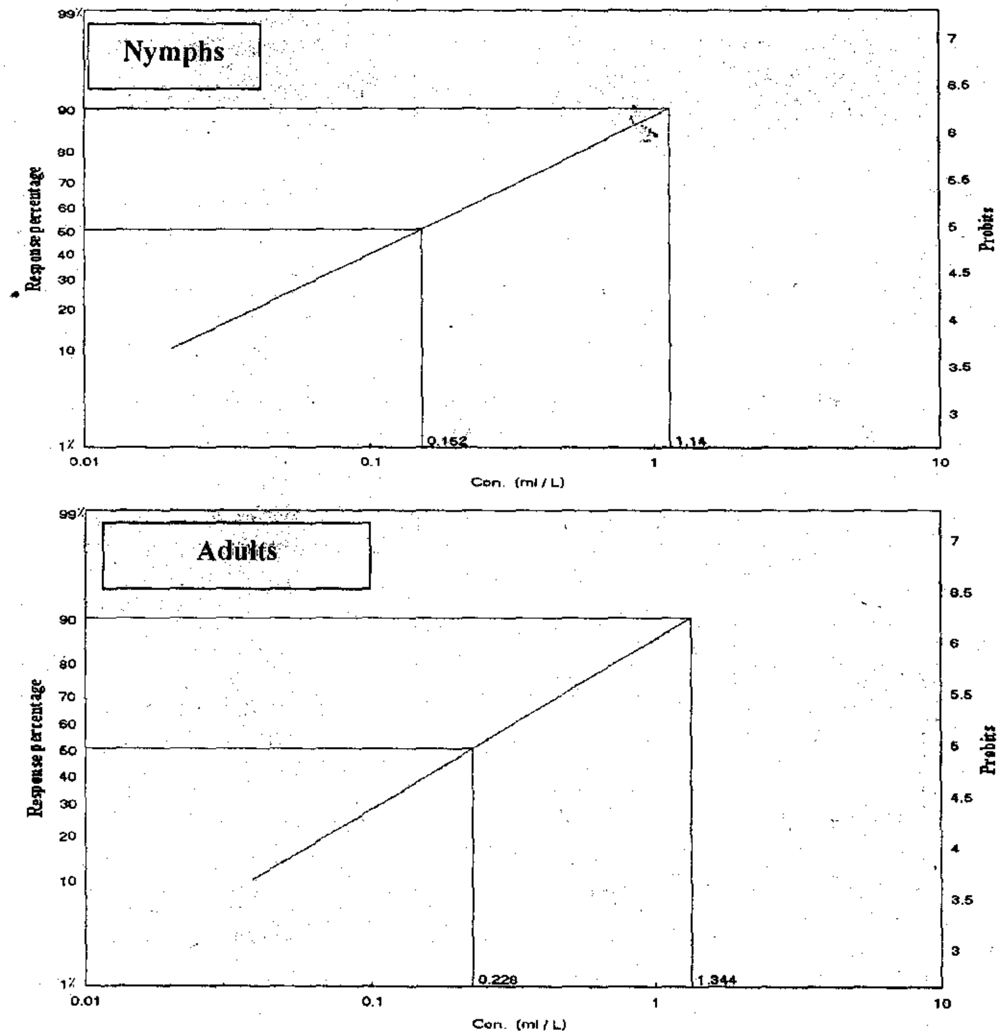


Fig. (10): **Toxicity lines of the Sumithion against nymphs and adults on *M. hirsutus* under laboratory conditions.**

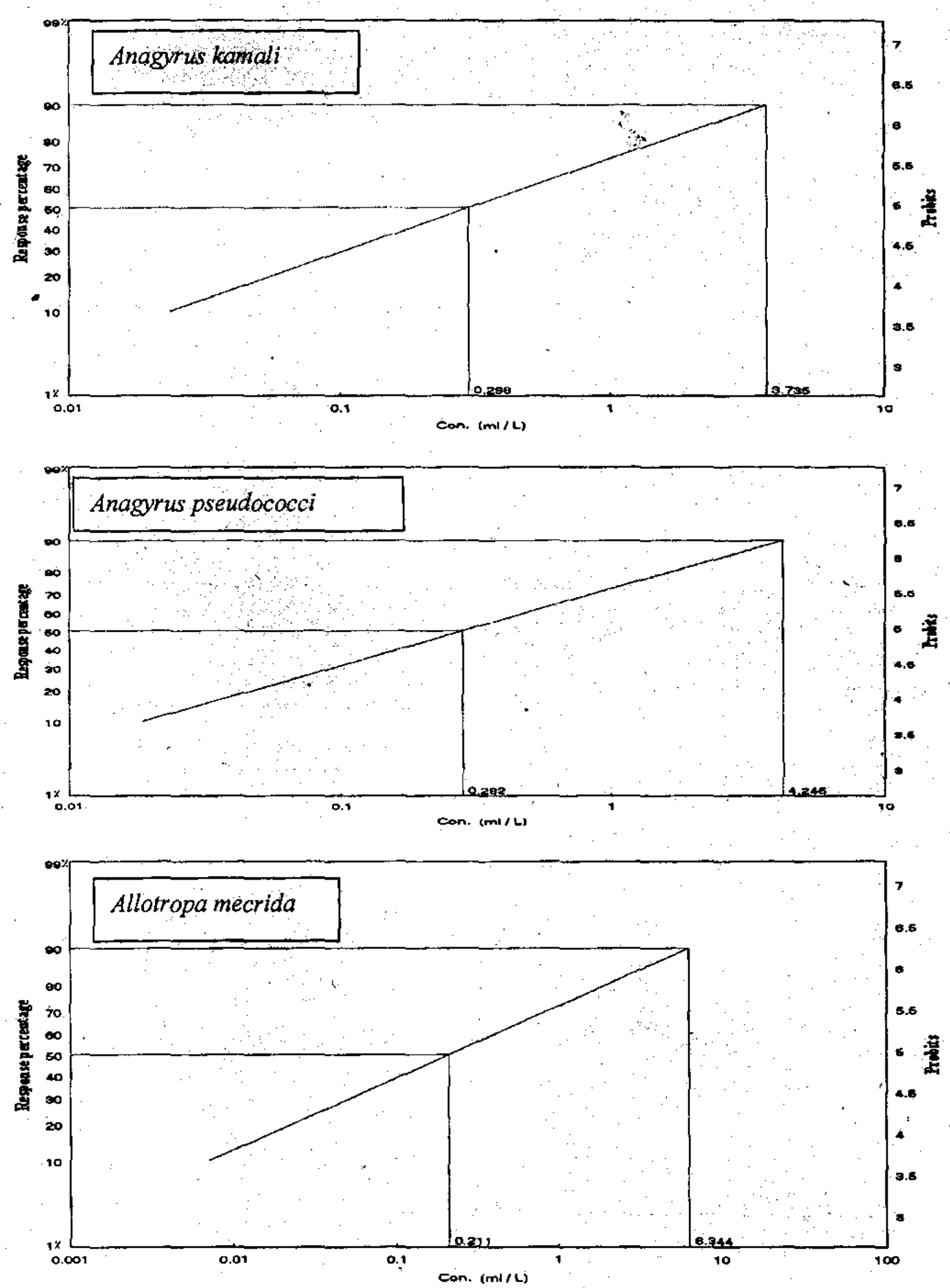


Fig. (11): Toxicity lines of Sumithion against different parasitoids associated with *M. hirsutus* under laboratory conditions.

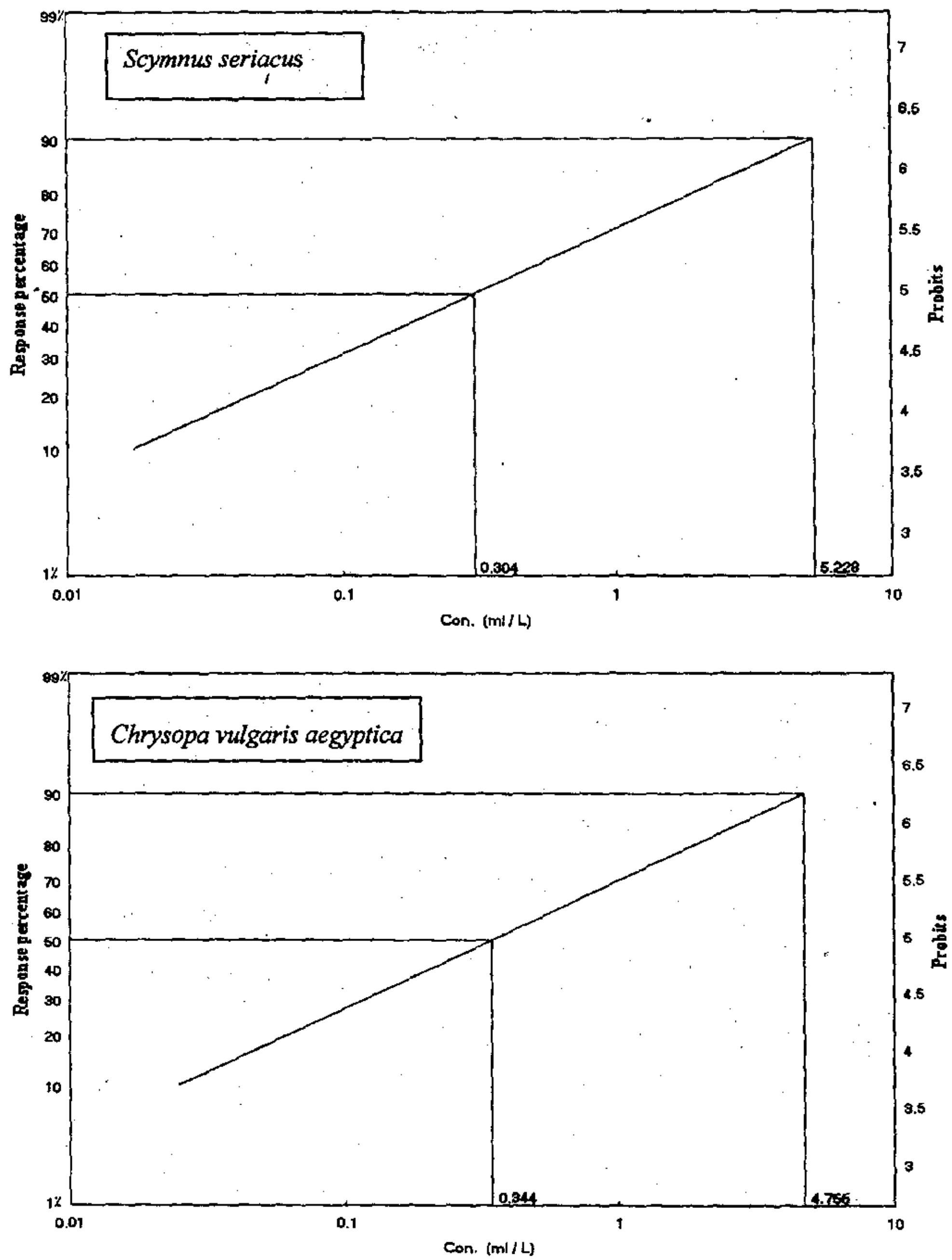


Fig. (12): Toxicity lines of Sumithion against the predators associated with *M. hirsutus* under laboratory conditions.

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تاثير بعض المركبات الكيميائية و الطبيعية على بق الهبسكس الدقيقى *MACONELLICOCCUS HIRSUTUS* و أعدائه الحيوية فى المعمل و الحقل

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يعتبر بق الهبسكس الدقيقى من أهم الآفات التى تصيب العنب و الجوافة و فول الصويا و النباتات الأخرى فى اماكن عديدة فى مصر كما أن الندوة العسلية التى تفرزها هذه الحشرات تعيق عملية التمثيل الضوئى و التنفس فى النبات و عليه فان هذا العمل يتضمن دراسات معملية و حقلية على تاثير بعض المركبات الطبيعية (البيوفلاى و النيمازال و زيت سوبر مصرونا) و المركبات الكيميائية (السومثيون) على بق الهبسكس الدقيقى و طفيلياته و مفترساته وقد أتضح من النتائج المعملية ان نسب الموت بالسومثيون على بق الهبسكس الدقيقى و طفيلياته و مفترساته تراوحت بين ٧٣-٩٨%. فى حين تراوحت هذه النسب مع باقى المركبات بين ٥٨-٩٨%. أما بالنسبة للدراسات الحقلية و التى أجريت عامى ٢٠٠٨-٢٠٠٩ فان البيوفلاى اعطى نتائج متوسطة على يرقات بق الهبسكس الدقيقى مسجلا معدلات موت قدرها ٤١ و ٣٦ % بعد ثلاثة أيام من الرش و ٥٥ و ٥١ % بعد سبعة أيام و ٥٣ و ٥٨ بعد خمسة عشرة يوما على الترتيب.

أما بالنسبة للطفيليات :

Anagyrus kamali, Anagyrus pseudococci, Allotropa mecrida

سجلت متوسطات الموت خلال عامى الدراسة: ٦١، ٤٨ % ؛ ٦٦، ٥٩% ؛ ٥٥، ٤٧% على الترتيب. أما بالنسبة للمفتـــرس *Scymnus seriacus* و *Chrysopa vulgaris aegyptica* فـــأن معدلات الموت كانت ٥٠ ، ٣٧% ؛ ٥٣، ٤١ % خلال سنتى الدراسة على الترتيـــب. ، ٩١ % ؛ ٩٣، ٨٨% فى عامى ٢٠٠٨-٢٠٠٩ على الجانب الأخر فان مركب السومثيون سجل نسب موت قدرها ٩٦، ٩١ % ؛ ٩٣، ٨٨% فى عامى ٢٠٠٨-٢٠٠٩ على الحوريات و الحشرة الكاملة لبق الهبسكس الدقيقى فى حـــين أعطـــى معـــدلات مـــوت ٩٥، ٩٣% ، ٩٠ ، ٨٧% ؛ ٩٣ ، ٩١ %. *Anagyrus kamali, Anagyrus pseudococci, Allotropa mecrida* بعـــد ١٥ يومـــا مـــن معاملـــة طفيليات خلال عامى الدراسة على الترتيب. و أعطى معدلات مـــوت ضـــد مفترســـى *Scymnus seriacus* و *Chrysopa aegyptica vulgaris* وقدرها ٨٨ ، ٨٤ % ؛ ٨٥، ٨٢% بعـــد نفـــس الفترة من المعاملة.