Insecticidal Activity of *Some* Indole Derivatives Against *Spodoptera littoralis* (Boisd.)

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ABSTRACT

Eight indole derivatives were studied for their insecticidal activity on both larvae and eggs of *Spodoptera littoralis* (Boisd.). Insecticidal effects were a function of chemical structure, larval instar and concentration. All derivatives were more effective on the 4th larval instar after 5 days except compounds **3** and **7** with 612.8 and 437.7 µg/gm LC_{50} on 6th instar, respectively. Indole-3-butyric acid (**2**) was the most effective with 70.9 and 39.7 µg/gm LC_{50} on the 4th after 9 and 13 days, while 1-acetylindole-3-butyric acid (**3**) and 1-acetyl-2-phenylindole (**7**) were more effective with 151.4 and 80.6 µg/gm LC_{50} values against sixth instar. While compounds **1, 2, 3** and **4** activated the larval weight of both instars, effect of the other derivatives was based on larval instar and concentration. Compound **3** was the most effective inhibiting pupation to 10% and blocking adult emergence to 25% after 21 and 45 days at 10 µg/gm in comparison to control. Malformations of intermediates and pupae as well as blocking adult emergence were higher in treated 4th larval instar based on the structural differences. Egg hatching was completely suppressed at 100 µg/gm of compounds **3** and **7**. Dipping eggs in compound **2** solution inhibited hatching with IC_{50} equaled 29.1 µg/ml and killed the produced larvae with LC_{50} equaled 26.2 µg/ml. Transferring the immersed eggs to a poisoned medium enhanced the toxicity with IC_{50} equaled 13.2 µg/gm and LC_{50} equaled 15.2 µg/gm. Compound **7** multiplied the effect with IC_{50} of 15.3 µg/gm and LC_{50} of 7.5 µg/gm.

Key words: Indole ; Spodoptera littoralis ; larval mortality ; development ; egg hatching

INTRODUCTION

The Egyptian cotton leaf-worm, *Spodoptera littoralis* (Boisd.) is an important polyphagous insect attacking cotton, several cultivated crops and ornamentals worldwide. Several synthetic insecticides that may not be environmentally safe are used for its control. Searching for other new insecticides is one of important concerns. Several plant extracts showed persuasive lethal and sublethal effects against it (Abbassy *et al.*1998; Shonouda *et al.* 2000 & 2008). These activities were referred to plant originated heterocyclic alkaloids Ben Jannet *et al.*, (2000) & Tringali *et al.*,(2001).

Among heterocycles, the indole nucleus occupies a major importance as pharmaceuticals and antimicrobial agents. 5-Nitro-2-phenyl-1H-indole, 2-arylindole derivatives with ortho substitution on the phenyl ring and 5-methoxyindole-3-acetic acid exhibited potent antibacterial activity (Wang and Ng, 2002) & Samosorn *et al.*, (2005).
3-Acetyl-2,5,6-trichloro-1-(2-deoxy-beta-D ribofuranosyl)-indole and some other derivatives induced potent antiviral activity Williams *et al.*, (2004). Indole-3-butyric acid controlled 23 bacteria and 15 fungi species Gulluce *et al.*, (2003). Combination of indole acetic acid at 100 µg/ml with *Cryptococcus laurentii* suppressed *Penicillium expanum* and *Botrytis cinerea* more than did *C. laurentii* alone (Yu and Zheng, 2007). Indole acetic acid, its 5-methoxy derivative, 1H-indole-4,7-diones and other indole alkaloids reduced spore germination, mycelial dry weight and protein content of several fungi (Jingyong *et al.*, 2008, Kumar *et al.* (2007) and Ryu *et al.* (2007)). Antileishmanial activity of *Aspidosperma ramiflorum* is due to indole alkaloid content Tanaka *et al.*,(2007).

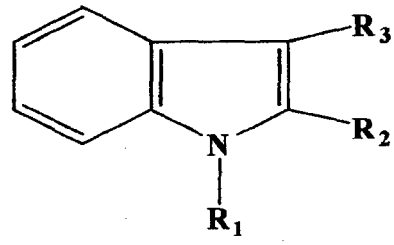
Regarding the insecticidal activity, sulfur-containing indole, camalexin plays an important role of defense in Brassicaceae, as toxic to pathogens and insects with antimicrobial and anti-fungal properties (Glazebrook, 2005). *S. littoralis* showed generally low sensitivity to feeding on different classes of alkaloids. Accumulation of indole glucosinolates reduced insect herbivory by *S. exigua* Gigolashvili *et al.*, (2007). Tryptanthrin, indole-3-acetonitrile showed insecticidal and anti-feeding activity against termites, *Reticulitermis santonensis* and larvae of the house longhorn beetle, *Hylotrupes bajulus* (Seifert and Unger, 1994).

Due to the mentioned biological activities and others of indole derivatives, this study aimed to examine eight indole derivatives for their effects against *S. littoralis*. These effects included larval lethality, reduction of larval weight, inhibition of pupation, blocking of adult emergence, developmental stages and malformations in the produced stages as well as egg hatching beside produced larval mortality.

MATERIALS AND METHODS

1. Tested Compounds:

Both indol-3-acetic acid GRG, Batch No 971381, Code No L 17070 and indol-3-butyric acid, Sisco Research Laboratories PVT. LTD,



cmpound	R_1	R_2	R_3
Indole-3-acetic acid (1)	H	H	$-CH_2-COOH$
Indol-3-butyric acid (2)	H	H	$-(CH_2)_3-COOH$
1-Acetylindole-3-butyric acid (3)	CH_3CO	H	$-(CH_2)_3-COOH$
1-Benzoylindole-3-acetic acid (4)	C_6H_5CO	H	$-CH_2-COOH$
1-Benzoylindole-3-butyric acid (5)	C_6H_5CO	H	$-(CH_2)_3-COOH$
2-Phenylindole (6)	H	C_6H_5	H
1-Acetyl-2-phenylindole (7)	CH_3CO	C_6H_5	H
1-Benzoyl-2-phenylindole (8)	C_6H_5CO	C_6H_5	H

Mumbai, India, Batch No T828452 were purchased from El-Gomhouria Drug Company, Egypt. Other derivatives were prepared and identified (Abdel-Aty, 2009). These compounds are arranged as follows

2. Insecticidal effects:

2.1. Larval treatment:

The mother colony of *S. littoralis* was maintained under average laboratory conditions of 27 ± 3 °C and 60±5.0 % RH. The insecticidal activity was tested on both the 4th and 6th larval instars. The tested larvae were reared on a semi artificial growing medium composed and modified from Shory (1963) by Hegazi *et al.* (1977). The tested compounds were dissolved in dimethylsulfoxide (DMSO) and well mixed with 2.0 gm of freshly prepared medium at concentrations of 10, 50, 100, 200, 500 and 1000 µg/gm. The control was concurrently kept under the same conditions. The dimethylsulfoxide concentration was as high as 1 %. After solidification of the used medium, fifteen larvae of the newly moulted 4th or 6th instar were placed on the treated medium in the plastic cups, covered with a cloth and secured with a rubber band as a replicate. Three replicates were used for each treatment. Each larval instar was individually treated. After feeding on the poisoned medium for 4 days, the treated larvae were transferred to an untreated medium. The alive larvae were daily counted. Mortality percents were calculated according to (Topps and Wain 1957) and its relation with exposure time was shown. Reduction in larval weight, larval developmental growth and malformations of intermediates, pupae and adults as well as percents of adult emergence were evaluated.

2.2. Egg treatment:

Some of the tested compounds that are persuasively active were studied for their effects on *S. littoralis* eggs. The compounds were prepared in 5, 10, 20, 50 and 100 µg/ml solutions. A consistent egg mass (0.030 gm) was dipped in the toxicant solutions for two minutes as a replicate. The contaminated egg masses were divided into two groups. The first group was transferred to 2.0 gm of non-poisoned medium. The other contaminated egg mass was transferred to a poisoned medium at the mentioned concentrations. Egg-hatching and the mortality of the produced larvae were evaluated and compared between the two groups as well as control. The concentration inhibited 50% of egg hatching (IC_{50}) and the lethal concentration of 50% of the newly hatched larvae (LC_{50}) were determined.

3- Statistical analysis:

Percentages of mortality and larval weight reduction were analyzed using the analysis of variance (ANOVA) and Student-Newman-Kules Test. LC_{50}, IC_{50} and EC_{50} values were determined using probit analysis method (Finney, 1971).

RESULTS AND DISCUSSION

1. Insect mortality:

Lethality results obtained as lethal concentration of 50% of the treated 4th and 6th larval instars are presented in Tables (1&2). All the tested compounds were more effective against the fourth larval instar than the sixth instar after 5 days except 1-acetylindole-3-butyric acid (3) and 1-acetyl-2-phenylindole (7). These compounds gave 612.8 and 437.7 µg/gm LC_{50} values on the sixth larval instar, respectively comparing with >1000 and >1000 µg/gm on the fourth larval instar. The effect was increased after nine days in all cases. 1-Benzoyl-2-phenylindole (8) was less effective on the sixth and

its 1-acetyl derivative (7) were more effective on the sixth larval instar. The lethal effects were increased in all tested compounds against sixth larval instar except for compounds **2** and **5**, which were more effective on the fourth instar. It was also found that substitution of compound **3** raised the toxicity on the sixth instar. The increase due to its acetylation appeared to be greater than benzoylation. Substitution of 2- phenyl moiety on the indole ring with removal of the side aliphatic carboxylic group increased the larval mortality in case of compound **6** more than in indole-3-acetic acid (**1**). Substitution with 1-acetyl on 2-phenylindole multiplied the lethality against the two tested larval instars, while substitution with 1-benzoyl in compound **8** enhanced the toxicity only against the fourth larval instar. The most effective compound was indole-3-butyric acid (**2**) with 70.9 and 39.7 µg/gm LC_{50} values on the fourth instar after 9 and 13 days, while 1-acetylindole-3-butyric acid (**3**) and 1-acetyl-2-phenylindole (**7**) were more effective with 151.4 and 80.6 µg/gm LC_{50} values against the sixth instar. So, compounds **2, 3** and **7** were chosen for egg treatment.

2. Sub-lethal effects:

2.1. Fresh body weight:

The larval weight of the 4th instar (after 7 days) was differently affected with the applied derivatives. Compound **1** and **2** raised larval weight at all concentrations in comparison to control. Benzoylation of indole-3-acetic acid in compound **4** affected the larval weight in non systematic arrangement with the tested concentrations. Acetylation of indole-3-butyric acid in compound **3** reduced the larval weight to 0.489 and 0.515 gm at 50 and 100 µg/gm, followed by an increase at higher concentrations. On the contrary, its benzoyl derivative (compound **5**) increased the larval weight when the lower concentration was used, followed by reduction at the two higher concentrations. Light reduction occurred at low concentrations, followed by gradual activation with increasing the concentration to 0.773 gm at 1000 µg/gm, which was exhibited by compound **6**. Substitution with 1-acetyl moiety in compound **7** increased the the larval weight at low concentration with 16.0 and 2.3 %, followed by inhibition percents ranging from 3.2 to 18.5% of control at 100-1000 µg/gm. Benzoylation of 2-phenylindole in compound **8** decreased the reduction effect more than compound 7.

Comparing with the untreated 6th larval weight (0.77 gm) after two days, all the tested compounds reduced the treated larval weight at all concentrations with different degrees and arrested their development to 7 days after treatment. Compounds **1** and 2 showed narrow differences among their concentrations and with less reducing effect, followed by compounds **8, 6, 5** and **7**. Compounds **3** and **4** were the most active derivatives in weight reduction that may be due to benzoylation.. From these results, it could be realized that the hormonal effect was obviously clear through the activation of larval weight in most cases specially when applied earlier at the 4th instar more than at the 6th instar. These effects are shown in Figure (1).

2.2 Development:

The control of 4th instar larvae reached the pupal and adult stages after 6-7 and 9-10 days, respectively. Indole-3-acetic acid (**1**) at 10 µg/gm delayed the development of the treated larvae to the pupae and adults to 29 and 45 days, respectively. However, the other compounds were less effective against pupation than compound **1** causing developing of 50, 10, 75, 92, 13, 63, and 83% of the treated larvae to pupae in case of compounds **2, 3, 4, 5, 6, 7** and **8**, respectively after 21 days. While, compounds **5** and **7** caused complete transformation of the treated population to adults, compounds **2, 4, 6** and **8** caused developing of 75, 75, 55 and 67 % of population to adults. Compound **3** (1-acetylindole-3-butyric acid) was the most effective structure blocking adult emergence to 25% of the treated population after 45 days.

Regarding the 6th larval instar, its control larvae completely reached the pupal and adult stages after 2-3 and 7-8 days, respectively. All compounds arrested the larval development except compounds **3** and **5**, which caused 25 and 18% pupation after 13 days. Compound **1** was the most effective inhibiting the adult emergence, followed by its 1-benzoyl derivative (**4**), 1-benzoylindole-3-butyric acid (**5**), indole-3-butyric acid (**2**), 2-phenylindole (**6**), 1-acetylindole-3-butyric acid (**3**), 1-benzoyl-2-phenylindole (**8**) and 1-acetyl-2-phenylindole (**7**). They blocked the adult emergence to 7, 14, 31, 33, 39, 46, 48 and 50% of the treated population after 35 days.

From the obtaied results, the duration of *S. littoralis* larval stage was significantly affected by the tested compounds. It required long time to reach next stadium differing from control and differently among the studied derivatives (Figures **2a & 2b**).

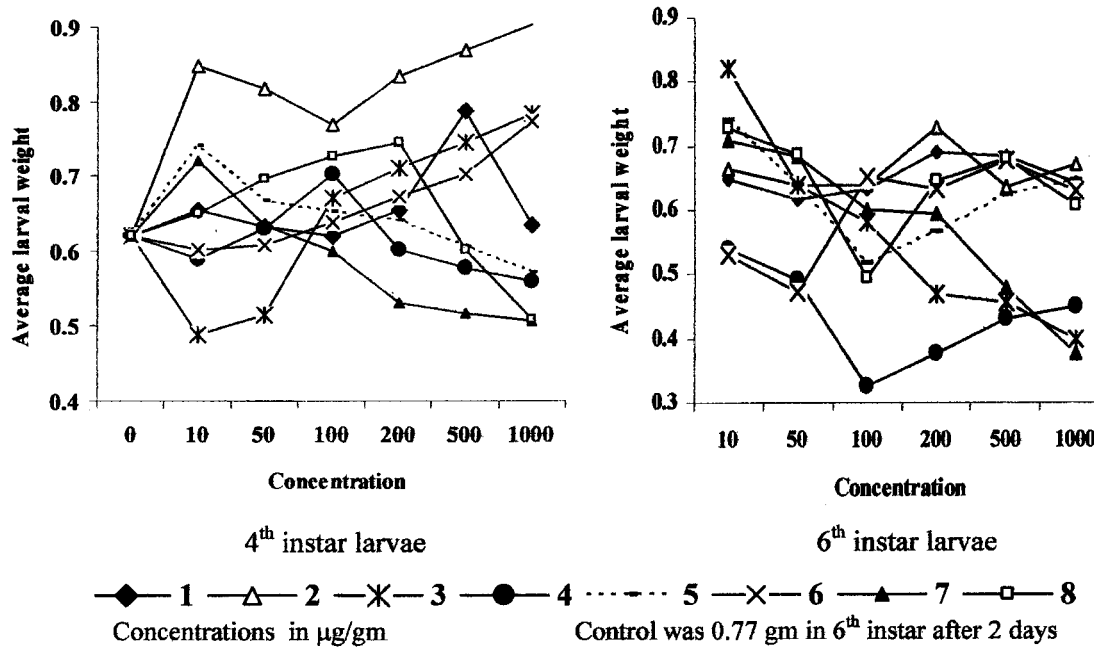
2.3 Malformations:

Several morphogenic effects in each stage at 10-200 µg/gm concentration are recorded in Table (**3**). Comparing with the untreated larvae, both compounds **1** and **2** exhibited 14.6% and 16.7% malformation in the intermediates of the treated 4th larval instar at 200 µg/ml, with no effect on that of the 6th larvae. Acetylation of indole-3-butyric acid in compound **3** affected the intermediates at lower concentrations in the 6th larval instar, while its benzoylation increased this effect against the 4th instar only. Acetylation of 2-phenylindole caused 32.6 and 61.1% malformation at 100 and 200 µg/ml in intermediates of the treated 4th instar larvae with1-benzoyl-2-phenylindole affected 4th larvae at 10 µg /ml with 7.6% malformation. However, its effect was as high as 10.1% at the higher concentrations against 6th instar intermediates

Table 1: Mortality effects of the tested compounds against the 4th instar of *S. littoralis* larvae

Compound	LC_{50} (µg/gm) after different times								
	5 Days			9 Days			13 Days		
	LC_{50} 95%CL	Slope ± SE	χ^2	LC_{50} 95%CL	Slope ± SE	χ^2	LC_{50} 95%CL	Slope ± SE	χ^2
Indole-3-acetic acid (1)	> 1000			804.7 503-1300	0.79± 9.0	1.94	543.2 373-795	0.86± 9.2	1.92
Indol-3-butyric acid (2)	117.8 69-201	0.44± 6.4	0.42	70.9 37.5-132	0.40± 6.4	1.52	39.7 21.9- 71	0.51± 6.6	1.10
1-Acetylindole-3-butyric acid (3)	> 1000			459.3 263-815	0.54± 7.1	0.75	243.2 159 - 375	0.59± 6.9	4.06
1-Benzoylindole-3-acetic acid (4)	828 535- 1293	0.87± 10.3	0.57	637.5 445-919	0.96± 10.7	0.84	376 287-494	1.07± 10.4	1.47
1-Benzoylindole-3-butyric acid (5)	424.4 297-609	0.83± 8.6	3.93	248.1 181-341	0.81± 7.9	2.17	116.7 86-159	0.79± 7.4	1.25
2-Phenylindole (6)	> 1000			779 441-1398	0.64± 8.0	5.37	352 235-532	0.69± 7.5	7.44
1-Acetyl-2-phenylindole (7)	> 1000			561.4 357-891	0.72± 8.2	6.83	223.5 157-319	0.71± 7.4	4.78
1-Benzoyl-2-phenylindole (8)	> 1000			514 316-845	0.65± 7.6	0.87	207 147-293	0.72± 7.3	1.55

Degree of freedom= 4 SE, Standard error × 10^3



1: Indole-3-acetic acid; **2:** Indol-3-butyric acid; **3:** 1-Acetylindole-3-butyric acid; **4:** 1-Benzoylindole-3-acetic acid; **5:** 1-Benzoylindole-3-butyric acid; **6:** 2-Phenylindole; **7:** 1-Acetyl-2-phenyl indole; **8:** 1-Benzoyl-2-phenyl indole

Fig. 1: Effect of the tested compounds on fresh larval weight of *S. littoralis*; shown as average weight (gm) after 7 days of treatment

Table 2: Mortality effects against the 6th instar of *S. littoralis* larvae treated with different compounds

Tested compound	LC_{50} after different times					
	5 Days			9 Days		
	LC_{50} 95%CL	Slope± SE	χ^2	LC_{50} 95%CL	Slope ± SE	χ^2
Indole-3-acetic acid (1)	> 1000			680.4 428.9 – 1090.6	0.76 ± 8.72	3.93
Indol-3-butyric acid (2)	> 1000			794.9 473.7 – 1351.7	0.71 ± 8.60	1.0
1-Acetylindole-3-butyric acid (3)	612.8 395.6 – 958.4	0.77 ± 8.7	1.3	151.4 113.5 – 201.9	0.85 ± 7.7	3.93
1-Benzoylindole-3-acetic acid (4)	> 1000			209.1 146.9 – 298.6	0.76 ± 7.3	1.0
1-Benzoylindole-3-butyric acid (5)	> 1000			397.8 295.3 – 537.6	0.98 ± 9.7	1.01
2-Phenylindole (6)	> 1000			307.6 216.5 – 439.1	0.77 ± 7.84	1.92
1-Acetyl-2-phenyl indole (7)	437.7 256.3 – 758.6	0.55 ± 7.1	4.5	80.6 59.6 – 108.6	0.86 ± 7.61	5.8
1-Benzoyl-2-phenyl indole (8)	> 1000			> 1000		

Degree of freedom= 4 SE, Standard error × 10^3

These malformation symptoms appeared as larval-pupal intermediates in which the posterior portion of the body only exhibited the pupal shape, while the anterior portion had larval head capsule and thoracic legs.

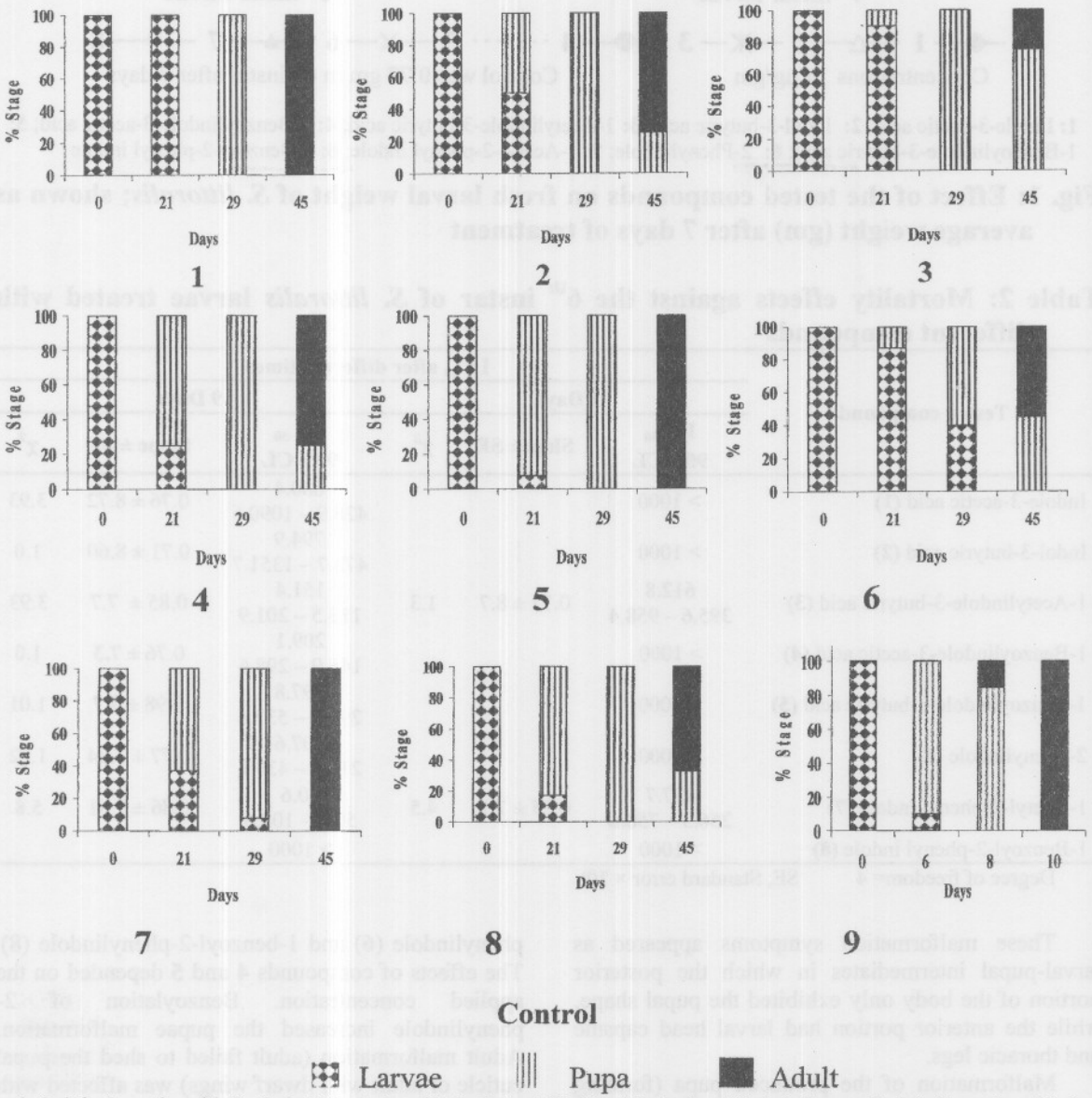
Malformation of the produced pupa (forming abnormal pupa without wings or that failed to shed of the larval cuticle) resulted from the 4th larval instar, which was more sensitive than that from 6th larval instar to treatment with compounds **1-3** , 2-phenylindole (**6**) and 1-benzoyl-2-phenylindole (**8**). The effects of compounds **4** and **5** depended on the applied concentration. Benzoylation of 2-phenylindole increased the pupae malformation. Adult malformation (adult failed to shed the pupal cuticle or adult with dwarf wings) was affected with the tested compounds, concentration and treated larval instar.

Adult emergence from the both treated larval instars was also affected. Compounds **1**, **2**, **3** and **5**

blocked the adult emergence to 10.3 - 47.4%, 16.7 - 50%, 20.2 - 50.6% and 10.6 - 55.7% in systematic arrangement, respectively from 4th larval populations comparing with 100% of control. The blocking effect was reduced with increasing the concentration. They blocked adult emergence to 25.9-43.7%, 36.8-57.0%, 31.9-40.9% and 32.5-66.9%, respectively in non systematic arrangement in case of the 6th larval population. Compound 4 caused 9.5-20.8% and 22.9-69.5% adult emergence in case of the treated 4th and 6th larval instars, respectively. Although 2-phenylindole and its 1-acetyl derivative affected the adult emergence from both treated larval instars in non systematic arrangement, its 1-benzoyl derivative blocked the adult emergence with increasing the concentration. Adult emergence was more inhibited from 4th larval instar treatment indicating that treatment of the lower larval instars gave good result of control. 1-Benzoylindole-3-acetic acid (4) was found more effective than indole-3-butyric acid (2) than indole-3-acetic acid (1) in their effect (Figure 3).

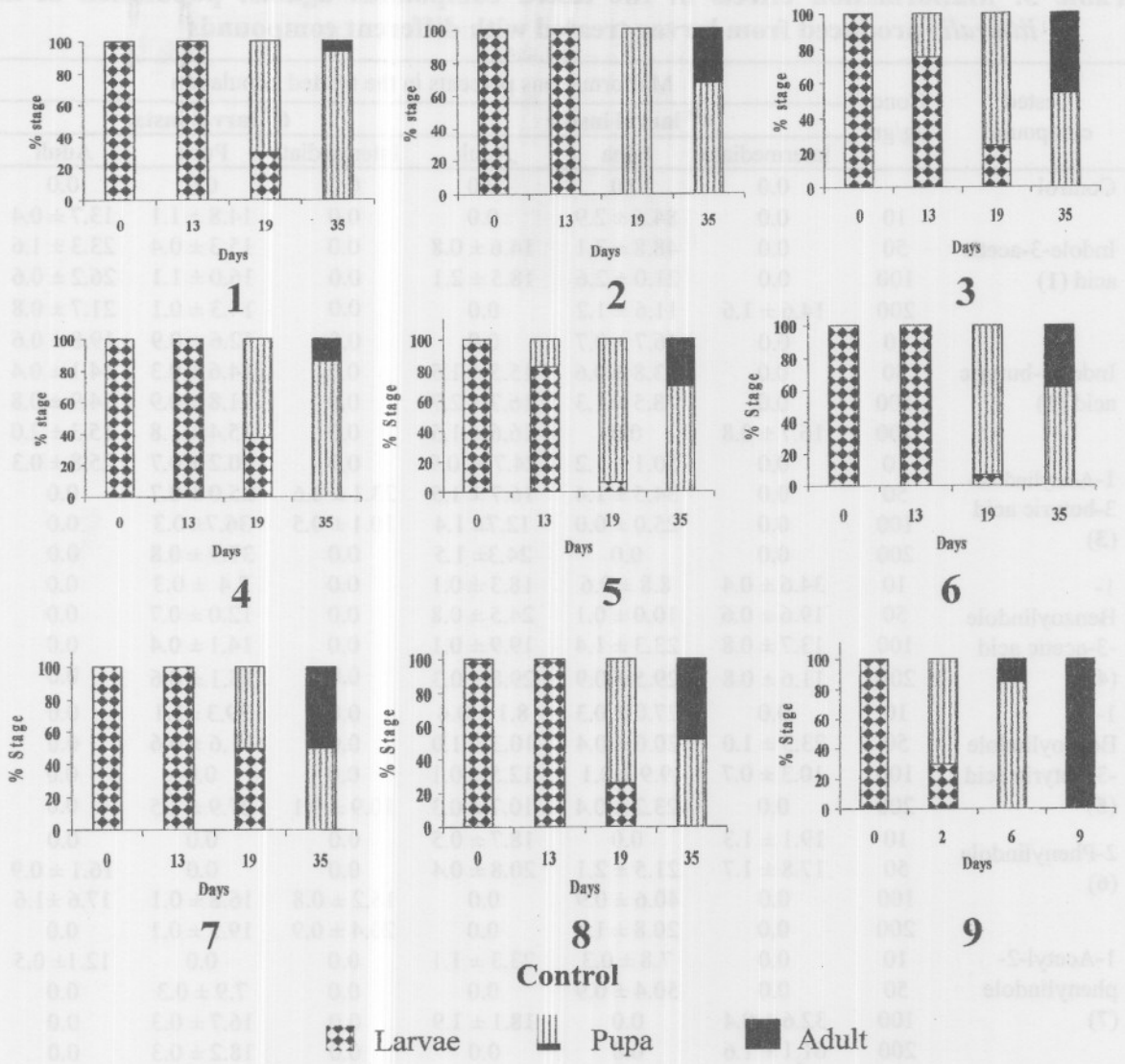
3. Effect on eggs:

Inhibition of egg hatchability was increased in systematic arrangement with the tested concentrations. Both 1-acetylindole-3-butyric acid (3) and 1-acetyl-2-phenylindole (7) completely stopped hatching when mixed at 100 µg/gm with the used medium. As the untreated egg mass hatched completely within 24 hours, treated eggs took 48-96 hours and 6-7 days at high concentrations of compound 2 and both of compounds 3 and 7, respectively.



1: Indole-3-acetic acid; **2:** Indol-3-butyric acid; **3:** 1-Acetylindole-3-butyric acid; **4:** 1-Benzoylindole-3-acetic acid; **5:** 1-Benzoylindole-3-butyric acid; **6:** 2-Phenylindole; **7:** 1-Acetyl-2-phenyl indole; **8:** 1-Benzoyl-2-phenyl indole

Fig. 2a : Effect of the tested compounds on *S. littoralis* 4th larval development at 10 µg/gm



1: Indole-3-acetic acid; **2:** Indol-3-butyric acid; **3:** 1-Acetylindole-3-butyric acid; **4:** 1-Benzoylindole-3-acetic acid; **5:** 1-Benzoylindole-3-butyric acid; **6:** 2-Phenylindole; **7:** 1-Acetyl-2-phenyl indole; **8:** 1-Benzoyl-2-phenyl indole

Fig. 2b: Effect of the tested compounds on *S. littoralis* 6th larval development at 10 µg/gm

Comparing the total number of hatched eggs and lethal effects on the produced larvae after 48 hours, only dipping the egg masses in solutions of compound **2** inhibited hatching with IC_{50} value equaled 29.1 µg/ml and killed the produced larvae with LC_{50} value equaled 26.2 µg/ml. Transferring treated eggs to the poisoned medium enhanced the toxicity on both egg-hatching with IC_{50} equaled 13.2 µg/gm and on larval mortality with LC_{50} equaled 15.2 µg/gm. Although acetylation in compound **3** decreased larval mortality in dipping technique with or without transferring the eggs to the poisoned medium, it enhanced egg-hatching inhibition when dipped only in the toxic solutions. Although compound **7** was less effective when egg masses were dipped in it, its mixing with the used medium greatly enhanced the effect with IC_{50} value equaled 15.3 µg/gm on egg-hatching and LC_{50} value equaled 7.5 µg/gm on larval mortality. The results are shown in Table (**4**).

It could be concluded that mortality of the 4th instar larvae was increased with increasing the aliphatic side chain. Substitution of N-H of 2-phenylindole raised the toxicity, vice versa in case of indole-3-butyric acid against the same instar. The tested compounds affected the larval weight, pupation and adult emergence. Several malformations in intermediates, pupae and adults were noticed with A type of juvenilization as larval-pupal intermediates were observed where the

Table 3: Malformation effects of the tested compounds against population of *S. littoralis* produced from larvae treated with different compounds

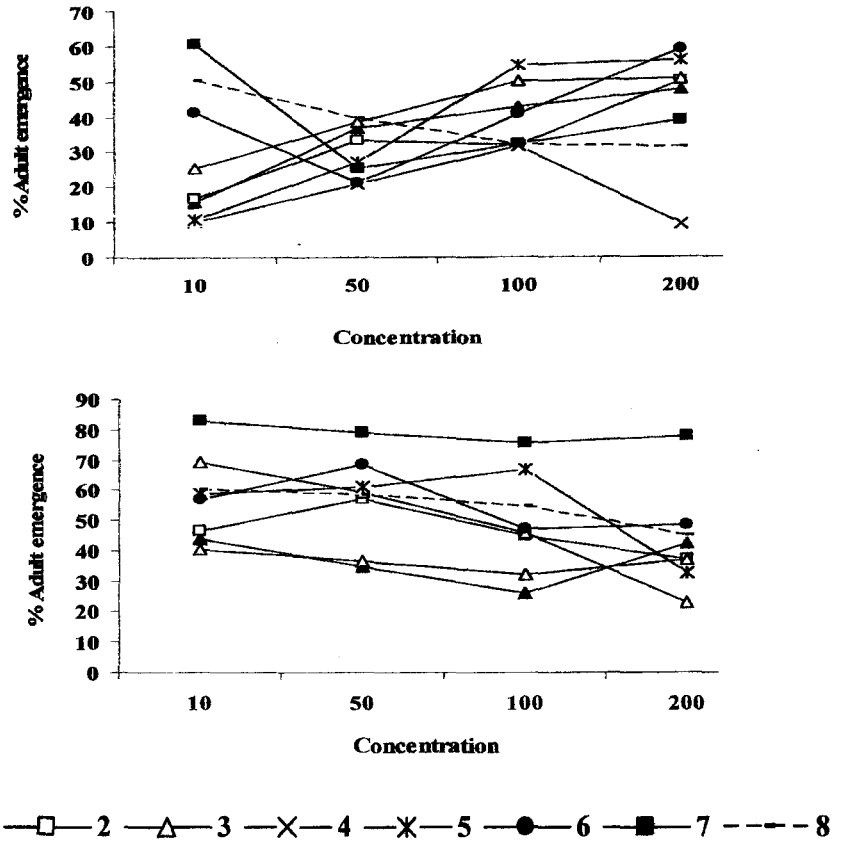
Tested compound	Conc. µg/gm	Malformations percents in the treated population					
		4th larval instar			6th larval instar		
		Intermediate	Pupa	Adult	Intermediate	Pupa	Adult
Control		0.0	0.0	0.0	0.0	0.0	0.0
Indole-3-acetic acid (1)	10	0.0	84.5 ± 2.9	0.0	0.0	14.8 ± 1.1	13.7 ± 0.4
	50	0.0	48.8 ± 3.1	14.6 ± 0.8	0.0	15.3 ± 0.4	23.3 ± 1.6
	100	0.0	21.0 ± 2.6	18.5 ± 2.1	0.0	16.0 ± 1.1	26.2 ± 0.6
	200	14.6 ± 1.6	11.6 ± 1.2	0.0	0.0	14.3 ± 0.1	21.7 ± 0.8
Indol-3-butyric acid (2)	10	0.0	46.7 ± 0.7	0.0	0.0	12.6 ± 0.9	19.8 ± 0.6
	50	0.0	33.8 ± 0.6	15.5 ± 1.5	0.0	14.6 ± 0.3	14.1 ± 0.4
	100	0.0	18.5 ± 1.3	16.7 ± 2.7	0.0	11.8 ± 0.9	14.9 ± 0.8
	200	16.7 ± 0.8	0.0	16.6 ± 1.5	0.0	15.4 ± 1.8	15.3 ± 2.0
1-Acetylindole-3-butyric acid (3)	10	0.0	50.1 ± 1.2	24.7 ± 0.9	0.0	20.2 ± 0.7	25.8 ± 0.3
	50	0.0	34.5 ± 1.4	16.7 ± 1.5	23.1 ± 0.6	25.0 ± 0.7	0.0
	100	0.0	25.0 ± 0.0	12.7± 1.4	10.1 ± 0.5	36.7± 0.3	0.0
	200	0.0	0.0	24.3± 1.5	0.0	37.9 ± 0.8	0.0
1-Benzoylindole -3-acetic acid (4)	10	34.6 ± 0.4	8.8 ± 0.6	18.3 ± 0.1	0.0	7.4 ± 0.3	0.0
	50	19.6 ± 0.6	10.0 ± 0.1	24.5 ± 0.8	0.0	12.0 ± 0.7	0.0
	100	13.7 ± 0.8	23.3 ± 1.4	19.9 ± 0.1	0.0	14.1 ± 0.4	0.0
	200	11.6 ± 0.8	29.5 ± 0.9	29.8 ± 0.3	0.0	15.1 ± 0.6	0.0
1-Benzoylindole -3-butyric acid (5)	10	0.0	27.0 ± 0.3	8.1 ± 0.4	0.0	29.3 ±1.1	0.0
	50	23.3 ± 1.0	20.0 ± 0.4	10.3 ± 1.0	0.0	11.6 ± 0.6	0.0
	100	10.3 ± 0.7	9.9 ± 0.1	12.5 ± 0.1	0.0	0.0	0.0
	200	0.0	23.2 ± 0.4	10.7 ± 0.3	10.9 ± 0.1	27.9 ± 1.5	0.0
2-Phenylindole (6)	10	19.1 ± 1.3	0.0	18.7 ± 0.5	0.0	0.0	0.0
	50	17.8 ± 1.7	21.5 ± 2.1	20.8 ± 0.4	0.0	0.0	16.1 ± 0.9
	100	0.0	40.6 ± 0.9	0.0	16.2 ± 0.8	16.8 ± 0.1	17.6 ±1.6
	200	0.0	20.8 ± 1.1	0.0	20.4 ± 0.9	19.3 ± 0.1	0.0
1-Acetyl-2-phenylindole (7)	10	0.0	7.8 ± 0.3	23.3 ± 1.1	0.0	0.0	12.1± 0.5
	50	0.0	50.4 ± 0.9	0.0	0.0	7.9 ± 0.3	0.0
	100	32.6 ± 0.4	0.0	18.1 ± 1.9	0.0	16.7 ± 0.3	0.0
	200	61.1 ± 1.6	0.0	0.0	0.0	18.2 ± 0.3	0.0
1-Benzoyl-2-phenylindole (8)	10	17.6 ± 1.3	17.3 ± 0.9	15.1 ± 0.6	5.8 ± 0.6	11.9 ± 1.1	18.2 ± 0.6
	50	0.0	21.1 ± 1.6	19.4 ± 0.8	5.7 ± 1.1	10.8 ± 0.3	10.8 ± 1.7
	100	0.0	35.6 ± 0.6	13.5 ± 1.5	6.6 ± 1.6	5.1 ± 0.9	0.0
	200	0.0	32.3 ± 0.6	19.9 ± 0.8	10.1 ± 1.5	0.0	0.0

Data are shown in percentages

Table 4: Effect of the active derivatives on *S. littoralis* eggs

Tested compound	Used technique	Inhibition of egg-hatching			Lethality on the hatched larvae*		
		IC_{50} 95% CL	Slope± SE	Chi^2	LC_{50} 95% CL	Slope± SE	Chi^2
Indol-3-butyric acid (2)	Dipping	29.1 25.0–33.9	1.96 ± 0.024	0.34	26.2 20.7–33.4	1.13 ± 0.017	4.52
	Dipping + Mixing	13.2 11.5–15.1	2.27 ± 0.032	5.81	15.2 13.5–17.2	2.7 ± 0.041	1.9
1-Acetylindole-3-butyric acid (3)	Dipping	19.3 16.8–22.1	2.2 ± 0.027	4.8	35.1 27.6–44.9	1.18 ± 0.018	1.97
	Dipping + Mixing	16.6 14.3–19.2	2.0 ± 0.025	2.47	31.6 21.5–46.9	0.7 ± 0.015	3.17
1-Acetyl-2-phenylindole (7)	Dipping	28.1 23.6–33.6	1.62 ± 0.02	3.30	> 100		
	Dipping + Mixing	15.3 13.1–17.9	1.88 ± 0.024	3.04	7.5 6.2– 9.1	2.0 ± 0.05	5.03

* Lethality on the hatched larvae were evaluated after two days



1: Indole-3-acetic acid; **2:** Indol-3-butyric acid; **3:** 1-Acetylindole-3-butyric acid; **4:** 1-Benzoylindole-3-acetic acid; **5:** 1-Benzoylindole-3-butyric acid; **6:** 2-Phenylindole; **7:** 1-Acetyl-2-phenyl indole; **8:** 1-Benzoyl-2-phenyl indole
Upper: from treated 4th instar **Lower:** from treated 6th larval instar
Concentrations are in µg/gm

Fig. 3: Emergence percents of *S. littoralis* adults produced from treated larvae

posterior of the body only showed the pupal shape while, the anterior portion had the larval head capsule and thoracic legs. This further indicates that treatment induced an effect typical to juvenile hormone excess. Juvenilized adults failed to emerge from the pupal cuticle, *i.e* produced imperfect alive adults. This effect varied according to the tested compound.

These delayed effects are expressed as developmental abnormalities in the adult stage e.g. imperfect adults, adults with eclosion problems and dead adults before emergence. These effects may be due to oxidative decarboxylation to cytotoxic species. It is thought to be due to the formation of 3-methylene-2-oxindole, which may conjugate with DNA bases and protein thiols (Folkes and Wardman, 2001). It may be also due to inhibition of cholinesterase as indole-3-butyric acid inhibited the butyrylcholinestrase (BuChE) from purified human serum and horse serum (Bodur and Cokugras, 2005). Its effect is associated with cell peroxidase activity (De Melo *et al.*, 2004). 2-phenylindole and 1-acetylindole-3-butyric acid affected fungal polyphenoloxidase (PPO), peroxidase (PO), DNA and RNA contents (Abdel-Aty, 2009). At the same time, phenoloxidase (PO) is believed to be a key mediator of immune function in insects where in larvae of the Egyptian cotton leafworm, *S. littoralis*, haemolymph PO activity varied markedly between individuals. The heritability estimate of haemolymph PO activity was high, while PO activity in the haemolymph was strongly correlated with PO activity in both the cuticle and midgut (Cotter and Wilson, 2002). This notice may clarify the effect of the tested compounds on adult emergence and pupation. N-H and N-substituted indole-2- and 3-carboxamide showed a strong inhibitory (95-100%) effect on superoxide anion (SOD). Some showed similar potency for the inhibition of lipid peroxidation (81-94%) which revealed their highly potent antioxidant properties. Substitution in the 1-position of the indole ring caused significant differences between the activity results regarding lipid peroxidation inhibition Olgen *et al.*, (2007) emphasizing the differences in effects due to the derivative structure.

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الملخص العربى

النشاط الإبادى لبعض مشتقات الاندول على دودة ورق القطن

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تم تقدير النشاط الإبادى الحشرى لثمانية من مشتقات الإندول ضد بيض و يرقات دودة ورق القطن (العمرين الرابع و السادس).

ظهر التأثير الابادى لهذه المركبات كدالة فى كل من العمر اليرقى و المركب المختبر و كذلك تركيزه المستخدم . أظهرت كل المشتقات المختبرة سمية أعلى على العمر اليرقى الرابع بعد خمسة أيام من المعاملة عدا مركبى ٣ و ٧ اللذان سببا تركيزا قاتلا لـ ٥٠% من عشيرة يرقات العمر السادس قدره ٦١٢,٨ و ٤٣٧,٧ ميكروجرام/جم بيئة مسممة.

كما ظهر مركب الـ إندول-٣- بيوتيريك أسيد ((٢) أعلى نشاطا بتركيز قاتل لـ ٥٠% من عشيرة يرقات العمرالرابع قدره ٧٠,٩ و ٣٩,٧ ميكروجرام/جم بعد ٩ و ١٣ يوم على الترتيب من بداية المعاملة بينما ظهر مركبى الـ ١-أسيتيل اندول-٣-بيوتيريك أسيد (٣) و الـ ١-أسيتيل- ٢-فينيل اندول (٧) أكثر نشاطا على عشيرة يرقات العمر السادس بتركيز قاتل لـ ٥٠% قدره ١٥١,٤ و ٨٠,٦ ميكروجرام/جم.

فى حين أزادت مركبات ١ و٢ و ٣ و ٤ وزن اليرقات بينما إختلف تأثير باقى المركبات حسب التركيز و العمر اليرقى.

ظهر مركب الـ ١-أسيتيل اندول-٣-بيوتيريك أسيد (٣) الأكثر نشاطا حيث ثبط تعذير اليرقات المعاملة إلى١٠% من العشيرة بعد ٢١ يوم كما أخمد الإنسلاخ إلى الطور البالغ إلى ٢٥% من العشيرة بعد ٤٥ يوم على تركيز ١٠ ميكروجرام/جم مقارنة بالكنترول الذى أعطى ١٠٠% تعذير و ١٠٠% تحول إلى الطور الكامل بعد٦-٧ و ٩-١٠ أيام على الترتيب. أثبتت النتائج حدوث تشوهات فى كل الأطوار الناتجة بصورة أكبر فى حالة المعاملة فى الطور اليرقى الرابع عنها حين عومل الطور اليرقى السادس.

تم إخماد فقس البيض تماما بمعاملته بتركيز ١٠٠ ميكروجرام/جم من مركبى الـ ١-أسيتيل اندول-٣-بيوتيريك أسيد (٣) و الـ ١-أسيتيل- ٢-فينيل اندول (٧).

غمس البيض فى محلول مركب الـ إندول-٣- بيوتيريك أسيد (٢) ثبط فقسه بتركيز لازم لتثبيط ٥٠% قدره٢٩,١ ميكروجرام/مل كما سبب موت اليرقات الناتجة بتركيزلازم لقتل ٥٠% قدره ٢٦,٢ ميكروجرام/مل كما أن وضع البيض على بيئة مسممة بعد الغمس أدى إلى زيادة السمية بتركيز لازم لتثبيط فقس ٥٠% قدره ميكروجرام/جم ١٣,٢ و بتركيزلازم لقتل ٥٠% قدره ١٥,٢ ميكروجرام/جم. ضاعف مركب الـ ١-أسيتيل- ٢-فينيل اندول (٧) السمية بتركيز لازم لتثبيط فقس ٥٠% قدره ميكروجرام/جم ١٥,٣ و الناتجة بتركيزلازم لقتل ٥٠% من اليرقات قدره ٧,٥ ميكروجرام/جم.