RESULTS

AND

DISCUSSION

PART I

U.V. light and sex-pheromone traps for ecological estimations

RESULTS AND DISCUSSION

PART I

U.V. light and sex-pheromone traps for ecological estimations:

1- Population dynamics of *Spodoptera llittorlais* adults :

This piece of study was carried out at El - Kanater El - Khairiya district to evaluate the population of *S. littoralis* moths in weekly samples throughout two successive years (1994&1995) by using two types of traps ; *i.e.* ,U.V. light trap and pheromone trap. Mean weakly records of temperature and % R.H. were also recorded in order to find out the efficiency of these traps in attracting *S. littoralis* moths, on one hand, and relative humidity throughout the successive weeks of the year and the population of this pest, on the other hand.

A. By using U.V. light traps:

Data illustrated in Figs . (3 & 4) indicate the presence of *S.littoralis* moths in El-Kanater district all the year round. The total populaton of adults was generally higher in 1995 (976.5. adults) than 1994 (444 moths) . Low abundance of adults was detected in January, February, August and December . High abundance occurred in March, July and October, while the highest abundance

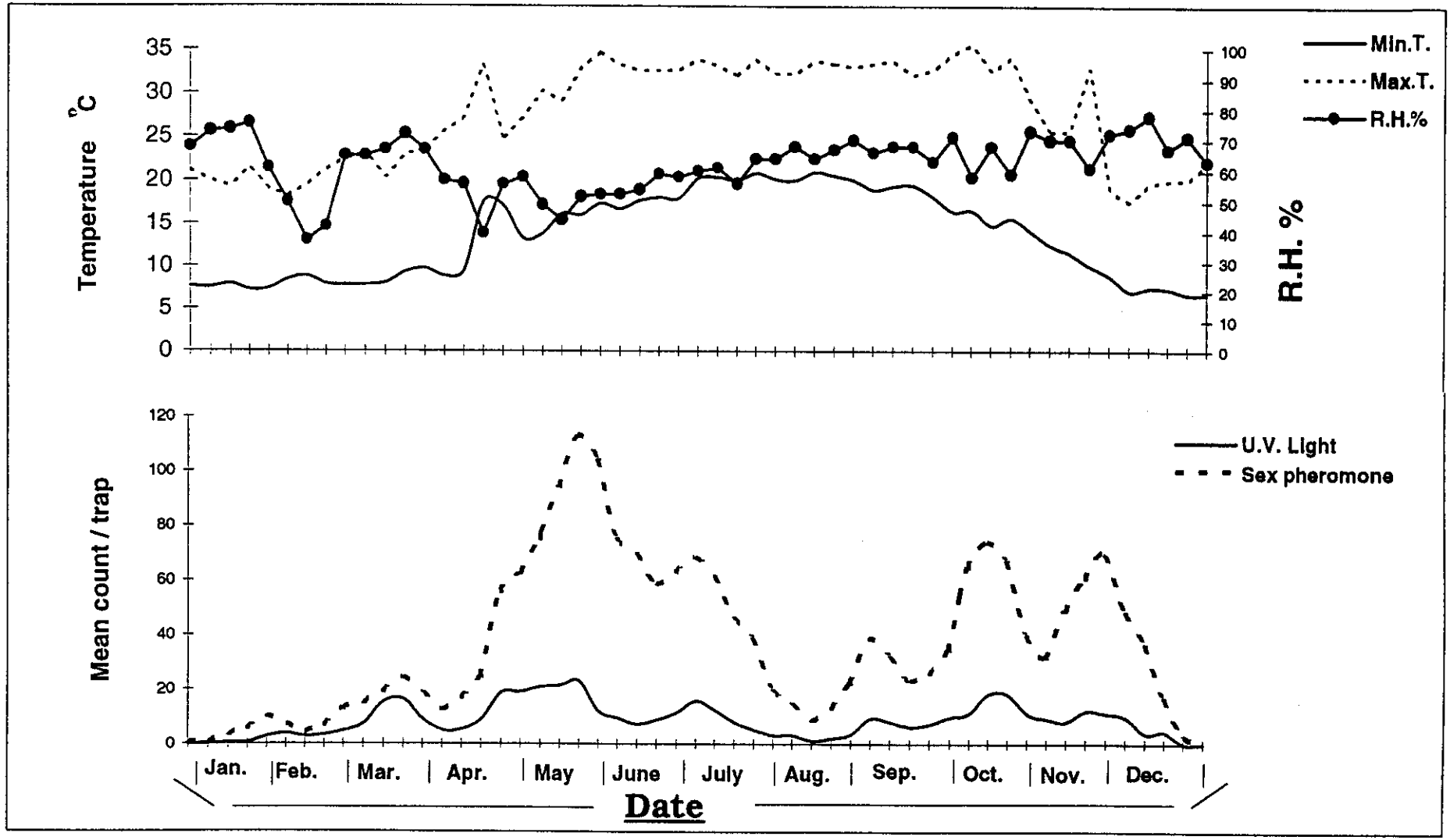


Fig. (3) : Weekly captured of *S. littoralis* male moths in the U.V light and Sex -pheromone traps in El-Kanater El-Khairiya district 1994 season.

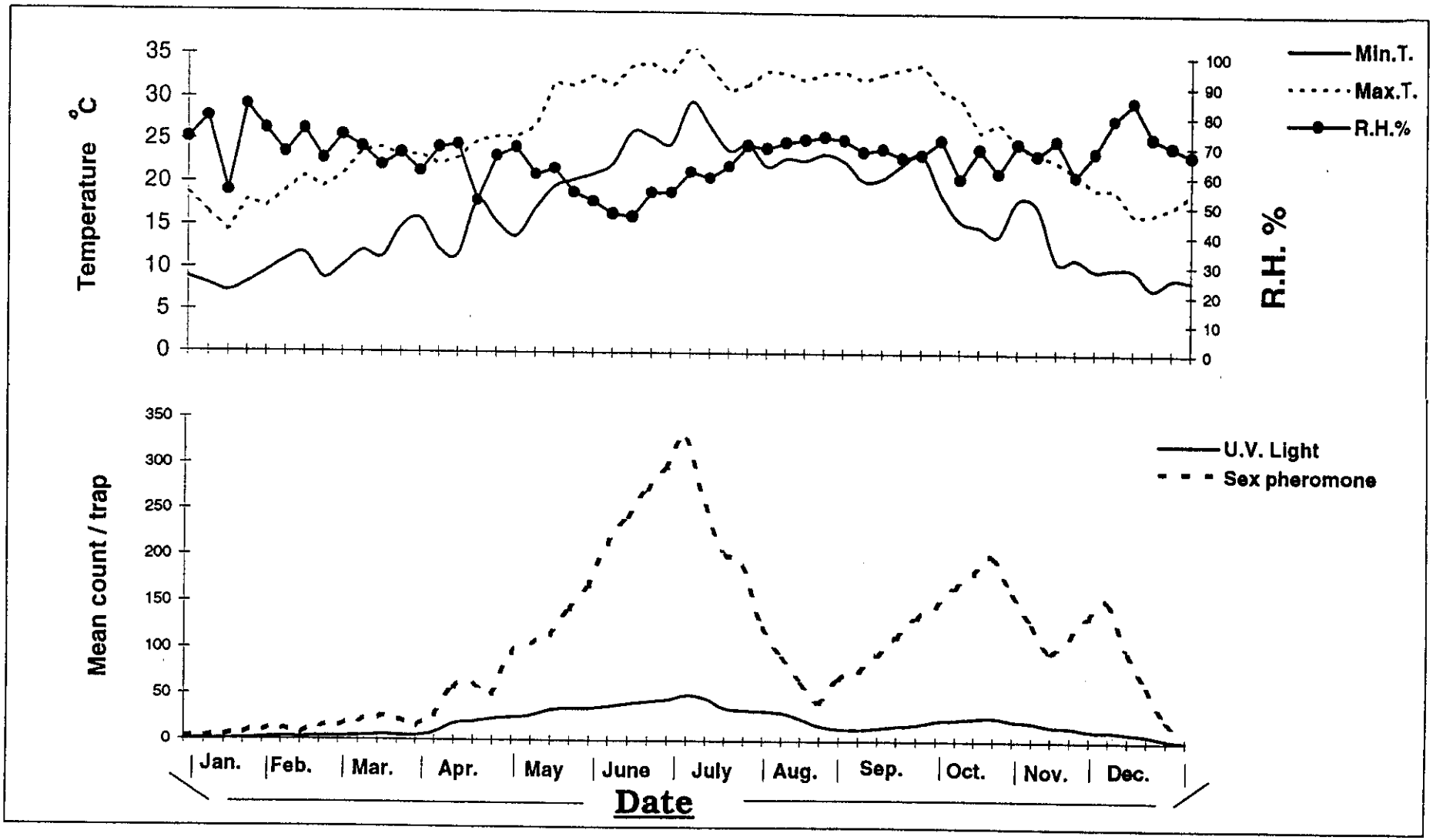


Fig. (4) : Weekly captured of *S. littoralis* male moths in the U.V light and Sex -pheromone traps in El-Kanater El-Khairiya district 1995 season.

of adults occurred throughout the last week of May in 1994 and the second week of July in 1995 (means of 23 and 49 adults / trap, respectively) .

B- By using pheromone traps :

It is quite evident from Figs (3 & 4) that the pheronmone traps were much more efficient in attracting the cotton leafworm males than the U.V. light trap (means of total moths throughout the year 444 and 976.5 adults in case of light trap opposed to 1942.5 and 5413.2 adults in case of pheromone trap in 1994 and 1995 , being about 4.4 and 5.5 times in case of pheromone traps than light traps, respectively (Table, 1) .

As shown in Figs. (3&4) and Table (1) , the population abundance of adults was also, relatively low in January, February and March, although in the latter month, a low peak of abundance may be detected (23.6 adults on March, 25th , 1994 and 23.9 adults on March, 18th 1995). It is also detectable that , by the beginning of December, the population of moths was high and continued up to the last week of this month when the population declined sharply to reach zero and only 3 adults at the end of December, 1994 and 1995, respectively.

According to Figs. (3&4) , the population of moths was relatively high during the second half of April, May , June and July.

Table (1) : Monthly mean records of *S. littoralis* moth males captured in U.V. light and Sex- pheromone traps throughout two successive years at El-Kanater El-Khairiya district in correlation to weather factors.

Date	male count / trap		Ratio	Means of		
				Temp.		R.H. %
	U.V. light	Phormone	U.V. : Pher	Max.	Min.	
1994						
Jauary	0.9	7.6	1 : 8.4	20.4	7.6	72.6
February	12.4	26.7	1 : 2.2	19.5	8.1	47.6
March	43.6	68.5	1 : 1.6	22.1	8.2	67.3
April	46.4	126.3	1 : 3	26.8	12.5	55.1
May	84.0	342.0	1 : 4.1	29.8	14.8	50.7
June	37.1	307.5	1 : 8.3	33.2	17.4	54.5
July	51.7	277.1	1 : 5.4	33.1	19.8	59.8
August	9.0	66.5	1 : 6.2	32.8	20.4	65.8
September	34.0	139.8	1 : 4.1	32.9	19.1	67.0
October	56.5	238.2	1 : 4.2	34.0	15.8	64.0
November	40.0	179.4	1 : 4.5	36.0	12.0	68.5
December	28.4	173.9	1 : 6.1	19.6	7.3	70.8
Overall in 1994	444	1942.5	1 : 4.4			
1995						
January	1.8	17.1	1 : 10.1	16.8	8.1	72.0
Febraury	11.5	38.8	1 : 3.4	19.1	10.2	70.5
March	18.3	77.7	1 : 4.2	23.0	12.1	68.0
April	73.8	228.3	1 : 3.1	23.7	14.6	63.4
May	120.0	447.4	1 : 3.7	28.8	17.7	61.3
June	154.0	885	1 : 5.7	33.0	23.4	49.5
July	208.1	1270	1 : 6.1	33.0	25.9	61.4
Augst	103.0	321	1 : 3.1	32.9	22.8	71.3
September	74.2	475.3	1 : 6.4	33.2	21.9	68.4
October	95.1	688.3	1 : 7.2	28.6	15.9	65.3
November	74.1	497	1 : 6.7	23.1	14.5	67.5
December	44.4	467.3	1 : 10.5	18.1	9.3	73.7
Orerall of 1995	976.5	5413.2	1:5.5			
Overall of 2 years	1420.5	7355.7	1:5.2			

The population decreased obviously during August and reincreased again during September, October and November. Concerning the peaks of adults' abundance, 6 peaks may be detected in 1994 . Those occurred on March, 25th ; May , 27th (highest peak) ; June, 10th ; September, 9th; October, 15th and November 18th (23.6, 112.3 , 75.4 ,37.7 ,73 and 48.1 adults / trap, respectively ; Table, 1) .
In 1995 , 4 peaks were discerned on March, 18th ; July, 8th (higest peak); October , 28th and December, 9th (23.9, 328, 198.3 and 150 adults / trap, respectively).

In similar studies on the cotton leafworm moths' population, Nada, (1990) used pheromone traps to monitor the cotton leafworm attack. The author found that the onset of appearance of moths during 1986 and 1987 took place at the last week of May and the catch in the traps increased during June representing 39.1 and 76.4 moths / fed., respectively for both seasons. The catch decreased again during the 2 weeks of July.

2- Comparison between *S. littoooralis* male catch by using the U.V. light and sex-pheromone traps :

Data presented in Table (1) and graphically illustrated in Figs. (3& 4) , clearly, show that the sex -pheromone traps were absolutely more effective in attracting the male moths of *S.*

littoralis than U.V. light traps. Throughout 1994, the pheromone trap attracted a mean total count of 1942.5 moths opposed to 444 moths caught by the light trap showing a ratio of 4.4 by pheromone trap : 1 by light trap . By the end of 1995 , these mean total counts were 5413.2 and 976.5 moths indicating a ratio of 5.5 : 1 . The mean total counts / trap throughout the two years were 7355.7 & 1420.5 moths by the pheromone and light traps, respectively, showing a mean ratio of 5.2 : 1 (Table, 1) , confirming the superiority of pheromone trap in attracting *S. littoralis* male moths than light traps .

The big difference between the catch in the two types of traps, mostly, due to the high population of moths emerged during May , June and July that, lead to high males' catches that were counted by 342,307.5 and 277.1 moths , respectively opposed to 84, 37.1 and 51.7 moths , respecttively in the light trap in 1994 . The correspondent mean counts of 1995 were 447.4, 885 and 1270 in the pheromone trap and 120 , 154 and 208.1 moths in the light trap (Table, 1).

To determine significance in the difference between numbers of males captured in the two types of traps throughout the two years of study, the "t" values were statistically calculated for each year. In the first year (1994), the "t" value was calculated by

23.5 , indicating significant difference at all probability levels , while in the subsequent year this value was 7.15 which was also highly significant (significant at 0.01 probability level).

In complete accordance with the present results, Nasr *et al.* (1978) indicated also that the catches of the cotton leafworm moths in pheromone traps were generally higher than those counted in light traps . The same authors added that the ratio between both types of traps varied from one month to another, the conclusion which can be also deduced from the present results . They concluded finally, that the pheromone traps provided a useful ecological tool for estimating the population of *S. littoralis* in the field . Also , Nasr and Wissa (1979) showed that the ratios between male moths of *S. littoralis* captured in El-Minia province for 15 months varied markedly from month to another.Catching in pheromone and light traps varied from (398: 1)during January, to (4:1) during October in favour of pheromone traps. Moreover, Radwan (1979 & 1985) indicated also that the total male catch was higher in the pheromone traps than those captured in the light traps. Metwally *et al.* (1993) studied the efficiency of light and pheromone traps as a tool for determination of *S. littoralis* population and they reported that pheromone traps are more effective and / or attractive than light traps at rate ranging from 1:2 to 1 : 19 times .

3- Effect of weather factors :

Correlation coefficient values were calculated between the size of weekly catch by pheromone traps and the weekly records of maximum temperature , minimum temperature and % R.H.

A. Maximum temperature :

Data recorded in Table (2) indicate that there was a significant positive relationship between the moths' catch and the maximum temperature; *i.e.* the population increased by the raise in highest temperature (r = + 0.794 in 1994 and +0.848 in 1995). These two values of correlation coeficient are the highest between this factor and the catch at two weeks earlier in 1994 and at 5 weeks earlier in 1995 . Thus indicating that this factor affects mainly the moths activity and also the earlier stages.

B. Minimum temperature:

The correlation coefficient (r) values shown in Table(2) indicate also significant positive correlation between moths' population abundance and the minimum temperature (r = + 0.866 in 1994 and + 0.794 in 1995).

Statistical analysis indicated that the minimum temperature was directly correlated with moths' abundance at one week earlier in 1994, but four weeks earlier in 1995. Thus indicating that this

Table (2) : Simple correlation "r" , Partial regression (P. reg.) of 3 weather factors (max. & min. temp. °C and % R.H) and Explained variance on the *S. littooral* moths captured by pheromone traps at El - Kanater El - Khairiya; Qalubiya governorate.

Year	weather factors	Earlier from	Period to	weeks	"r"	"b"	P.	Reg.	S.E.	"t"	P.	Explained variance %
1994	Max. temp.	7 Jan.	17 June	2	+0.794	+0.00187	0.01	-0.00263	+0.00174	1.076	-	84.3%
	Min. temp.	7 Jan.	17 June	1	+0.866	+0.00525	0.01	-0.00248	+0.00217	2.422	0.05	87.6%
	R.H.%	7 Jan.	17 June	5	-0.445	-0.00291	0.05	-0.00778	-0.0053	`0.548	-	74 %`
1995	Max. termp.	7 Jan.	25 Mar.	5	+0.848	+0.0031	0.01	-0.0022	+0.00162	1.91	-	93.1 %
	Min. temp.	7 Jan.	25 Mar.	4	+0.794	+0.0035	0.01	-0.00313	+0.00246	1.432	-	85.6 %
	R. H. %	8 Apr.	8 July	3	-0.797	+0.0052	0.01	-0.00134	+0.0013	4.254	-	95 %

** F_1 (Max. temp. 1994) = 16.31

** F_2 (Min. temp. 1994) = 21.92

** F_3 (R.H. 1994) = 8.05

** F_4 (Max. temp. 1995) = 17.35

* F_5 (Min. temp. 1995) = 7.32

** F_6 (R. H. 1995) = 31.18

* F : Significant (5%)

** F: highly Signifiant (1%)

factor has a direct correlation on the earlier stages and moths activity.

C. Relative humidity :

In contrast to the results obtained in case of temperature, the relationship between the population of *S. littoralis* moths and relative humidity was significantly negative in 1994 and also in 1995. The statistically calculated correlation coefficient values (r) were - 0.445 and - 0.797 for the two years of study, respectively. Thus indicating that the higher populations of the cotton leafworm moths occurred during periods of lower relative humidity percentages and vice versa. Statistical analysis of data indicated also that the correlation with relative humidity was at 5 weeks earlier in 1994 and 3 weeks earlier in 1995 (Table, 2) confirming that the effect of this factor occurred mainly on *S. littoralis* stages that preceded moths ; *i.e.* pupae and larvae of this pest.

D. The combined effect of weather factors:

The partial regression values (Reg.) and the explained variance percentages were, statistically, calculated to determine the combined effect of the studied three weather factors (maximum & minimum temperatures and % relative humidity). Data are demonstrated in Table(2).

In the first year of study, the explained variance percentages were 84.3, 87.6 and 74% for the maximum & minimum temperatures and % relative humidity , respectively. Each of these values explain the role of the desired factor in the presence of the two other factors. Thus indicating that in this year the minimum temperature was the most effective factor on the cotton leafworm population, followed by the maximum temperature, while the % relative humidity was the least effective factor. In the subsequent year, the % R.H. appeared as the most effective factor (95% explained variance; Table , 2) , followed by the maximum temperature (93.1%), whereas the least effective factor on the moths populations captured in the sex-pheromone traps was the minimum temperature which showed 85.6% as explained variance (Table, 2).

Comparing these results with those obtained by previous investigators, Larson (1943) in Denmark considered the minimum temperature as the most limiting factor for the acitvity of the noctuid moths, being in accordance with the present data of the first year. In the U.S.A., Bourne (1936) attributed the increase in number of the captured insects to the rise in temperature in most cases. Nasr and Nassif (1974) in Egypt , indicated that the effect of relative humidity on the developmental stages and moths longevity of *S. littoralis* was very slight, and they attributed the main effect to temperature. Guirgis *et al.* (1991) reported also that the

temperature was the major factor affecting of *P. gossypiella* populations, while the effect of relative humidity was very slight. While, in harmony with the present conclusion, Radwan (1979) revealed that the catch of *S. littoralis* was strongly correlated with maximum & minimum air temperature and relative humidity , and added that the combined effect of these factors alltogether was responsible for about 99% of the weekly variability in the catch . Also, Radwan (1985) in middle Egypt, indicated that relative humiditty and minimum temperature played an important role in the amount of moths population and the percentage of emergence. While, in complete disagreement with this present results, Wissa (1978) in Egypt, reported a significant negative correlation between the total number of captured moths and each of the mean temperature and the male ratio within the catch.

4- Relationship between the volume of moths' catch and the cotton leafworm egg-masses in cotton fields:

Data in Table (3) show the mean counts of *S. littotalis* male moths captured in the sex-pheromone traps at 3 day intervals and the opponent mean number of egg-masses counted / feddan throughout the period that extended from May, 21st to July 17th in 1994 and 1995, respectively. These data showed, roughly, positive correlation between the captured number of male moths and the number of egg-masses in the field *i.e.*, more egg-masses in the field

Table (3) : Relation between the average number of *S. littoralis* male moths captured by sex-pheromone traps in cotton fields and the average number of egg-masses (every three days) in El-Kanater El-Khairiya throughout two suecessive season .

Date	Average number (every 3 days) of	
	male moths / trap/ feddan	egg - masses / feddan
1994 Season		
May, 21	41	32
24	35.3	30
27	30.7	28.3
30	28	26.7
June,2	27	23.7
5	28	21.7
8	29	20
11	28.3	21
14	25.7	22
17	24.0	23
20	24	23
23	21	22.7
26	19	21.7
29	18	20
July, 2	15.3	17.3
5	12.3	16
8	9	12.7
11	7.3	9.7
14	6.7	6.3
17	10.3	5.3
1995 Season		
May,21	49	13.3
24	60.7	19.3
27	62.3	25.7
30	66.9	31.3
June,2	74.1	36.7
5	75	38.7
8	93	40.3
11	99.7	41
14	102.3	43.7
17	104	52.3
20	105.7	61
23	119.3	69.3
26	128	70.7
29	126	71.7
July, 2	129.7	74
5	141	76.3
8	141.3	78.3
11	125	79.7
14	101	82.3
17	88	83

are expected as the captured males in the sex-pheromone trap increase.

In order to determine exactly the correlation between egg-masses' counts and the number of males captured by the sex-pheromone traps, a simple regression analysis was applied and a linear regression line expressing the relationship between the two factors was drawn for each year (Figs. 5 for 1994 and 6 for 1995). Statistical analysis of data indicated that the highest sgnificant regression value (b=+0.71) was detected 3 days earlier throughout the period from May , 21st to July , 17th , 1994 (Fig.5). This meant that for every 10 male moths captured by the sex- pheromone trap , about 7 of the cotton leafworm egg-masses are expected to be detected on cotton leaves at El-Kanater ElKhairiya during May - July . In the subsequent year, and throughout the same period (May, 21st to July, 17th , 1995), statistical analysis revealed that the highest significant regression value (b= 0.608) ocurred at three days earlier ; *i.e.* every 10 male moths captured in the sex-pheromone traps indicated that there were about 6 egg- masses of the cotton leafworm on cotton leaves throughout the same mentioned period of 1994 (Fig. 5) .

These findings agree with those obtained by Radwan (1985) in two localities , Sannoris (Fayoum Governorate) and Sakha (Kafr El-Sheikh) to compare the efficiency of sex pheromone traps in

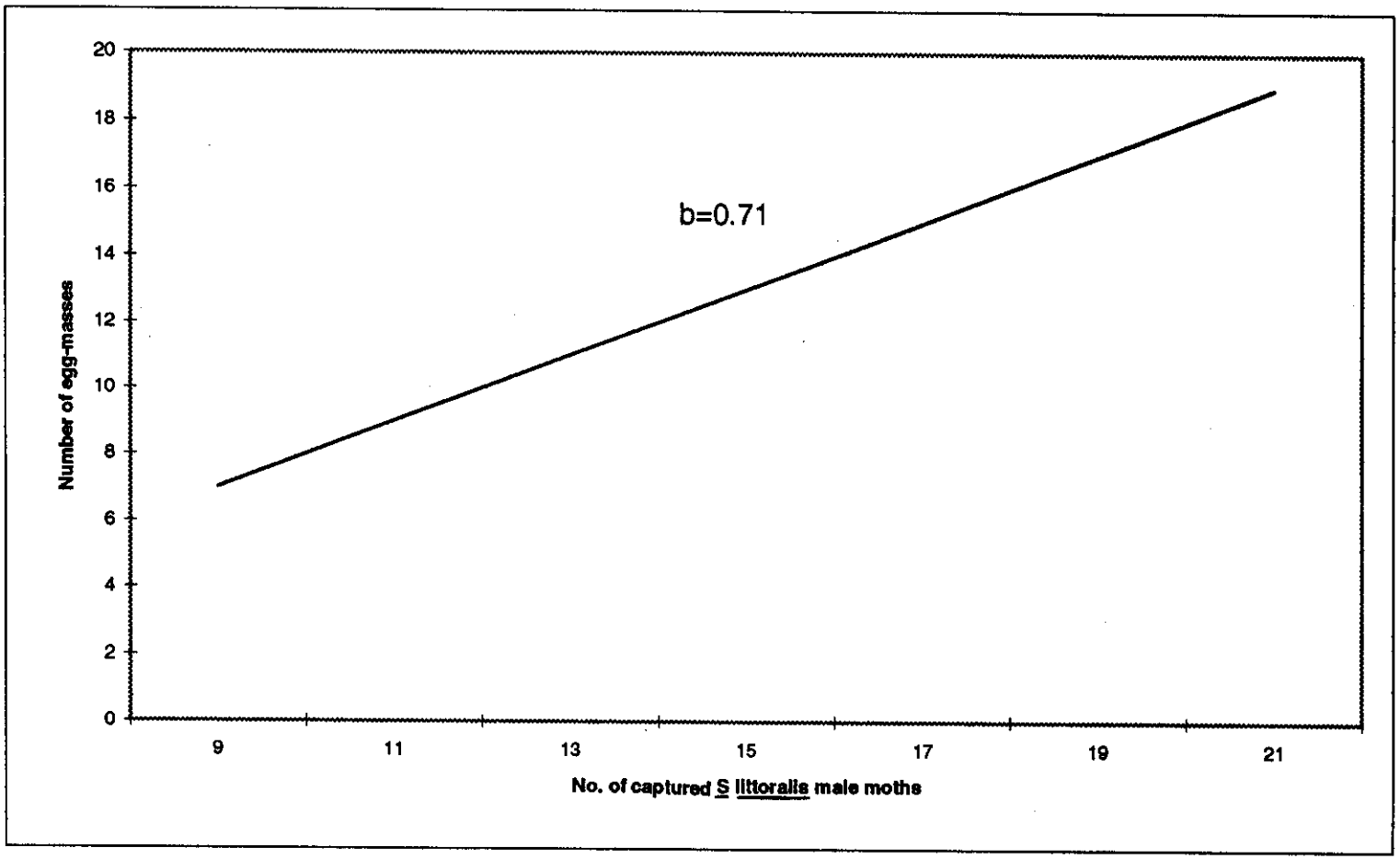


Fig (5) : Linear regression line showing the relationship between egg-mass counts in cotton fields and the numbers of *Spodoptera littoralis* male moths captured in the sex-pheromone traps during 1994 cotton season at El-Kanater El-Khairiya.

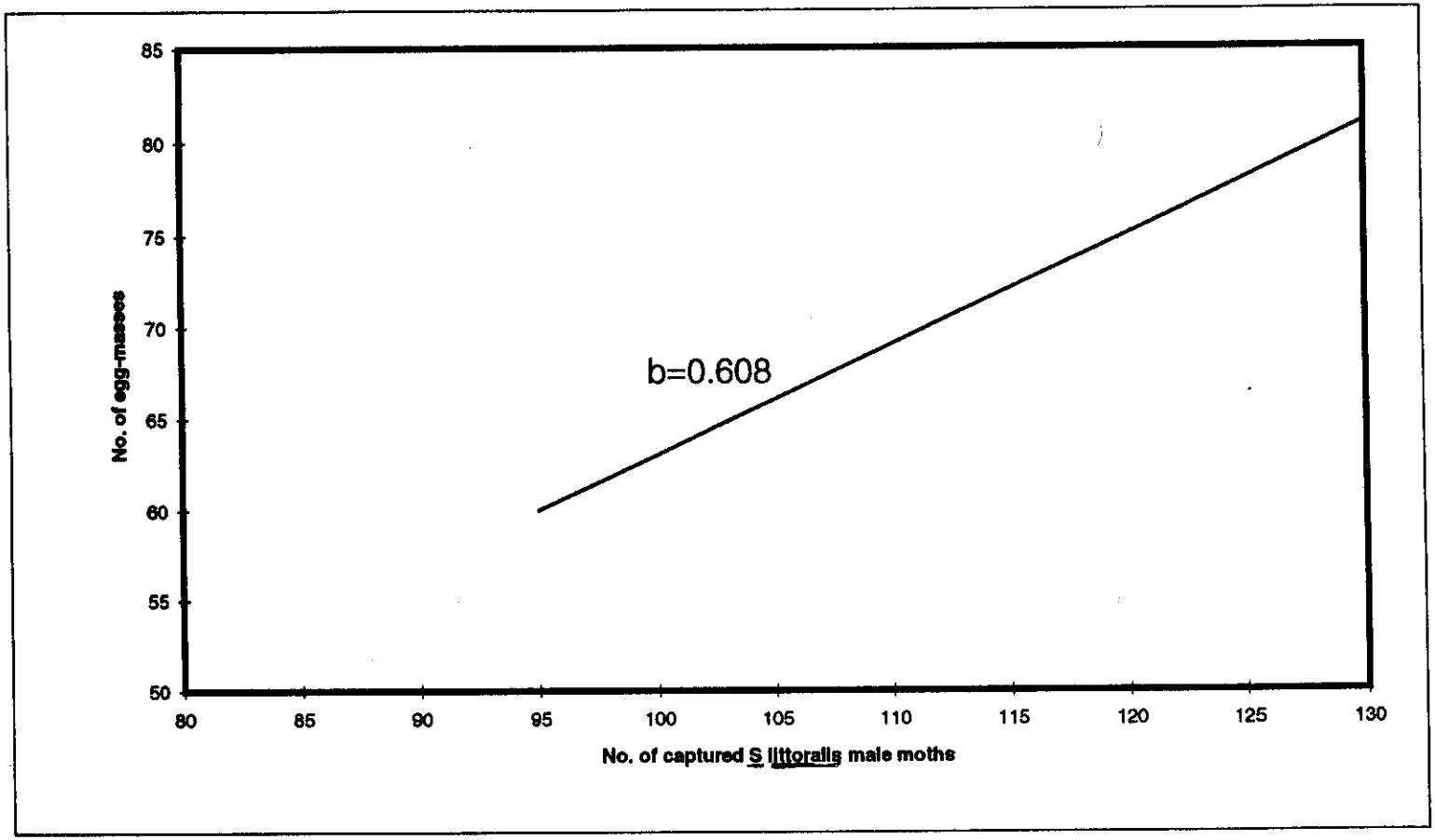


Fig (6) : Linear regression line showing the relationship between egg-mass counts in cotton fields and the numbers of *Spodoptera littoralis* male moths captuted in the sex-pheromone traps during 1995 cotton season at El-Kanater El-Khairiya.

attracting the cotton leafworm male moths as well as the pheromone effect in reducing the population density of *S. littoralis* egg-masses in cotton fields. The author found that the average number of egg -masses collected during the period from May to September, 1980 in Sannoris was 128.56 and 225.58 per feddan in areas treated with sex-pheromone traps and the untreated areas, respectively. While, in Sakha, it was 30.3 and 83.2 , respectively , per feddan in areas treated and untreated with pheromone traps, and a highly significant regression value (b=+1.322) was calculated in Sannoris indicating that for every 13 male moths captured by sex-pheromone traps, there was about 10 egg-masses on cotton plant leaves at Sannoris region, during the two tested months (May and June , 1980)

5- Comparison between infestation with pheromone traps and control areas:

This study was carried out at El-Kanater El-Khairiya district during 1994 & 1995 seasons to evaluate the efficiency of sex-pheromone traps in reducing the population density of *S. littoralis* egg-mases in cotton fields .

From data presented in Tables (4&5) it its clear that the population densities of *S. littoralis* egg-mass infestations, in cotton fields were, generally, higher in 1995 than 1994 season (average total of 1827.6 and 1088.6 eggs throught 1995 season opposed to 914 and

439 eggs in 1994 season in sex - pheromone untreated and treated areas, respectively). Regarding the averages of egg-masses that were counted /feddan at 3 day intervals, it is clear from Tables (4&5) that these counts averaged 43.5 (19.7 - 68) and 91.38 (26 - 147.3) egg - masses / feddan in the control areas and 20.9 (5.3 - 36) and 54.43 (13.3 - 83) egg - masses / feddan in areas that received pheromone traps in 1994 and 1995, respectively. By using the simple " t " test method for comparing between egg-mass counts in sex-pheromone traps treated area and the control areas, the calculated " t " values were 6.97 and 3.97 in 1994 & 1995 , respectively, indicating that using the pheromone traps, highly significantly, reduced the infestation to cotton plants with *S. littoralis* eggs in both years . Thus indicating that using the pheromone traps to capture *S. littoralis* males reduced the infestations of *S. littoralis* egg-masses by 53.53 (47.1 - 73.4) % in the former season, and by 40.44 (24.55 - 48.8) % in the latter one . These data indicate that using the sex-pheromone traps may be considered as a tool, just to reduce the egg-cluster infestations to the level that can be easily controlled by applying another method (such as hand picking or any other safe control method).

Table (4) : Numbers of *S. littoralis* egg-masses counted at 3day intervals/feddan in cotton areas in which pheromone traps were distributed and control areas (El-Kanater El-Khairiya district; 1994 cotton season).

Date	Averages of egg-mass counts in		% Reduction of egg-masses
	Area treated by pheromone traps	Control area	
May, 18th	36	68.0	47.1
21St	32	64.3	50.2
25th	30	60.3	50.2
27th	28.3	57.0	50.4
30th	26.7	53.3	49.9
June , 2nd	23.7	48.3	50.9
5th	21.7	44.0	50.7
8th	20	40.0	50.0
11th	21	40.0	47.5
14th	22	43.0	48.8
17th	23	46.0	50.0
20th	23	46.7	50.7
23rd	22.7	45.7	50.3
26th	21.7	44.0	50.7
29th	20.0	41.3	51.6
July , 2nd	17.3	36.7	52.9
5th	16.0	33.3	51.95
8th	12.7	30.7	58.6
11th	9.7	28.0	65.4
14th	6.3	23.7	73.4
17th	5.3	19.7	72.9
Total	439.1	914	53.53
Average	20.9	43.5	

$r = +0.999^{**}$

$b = +1.5934$

$t = 6.973^{**}$

** : highly significant.

Table (5): Efficacy of pheromone traps in reducing *S. littoralis* egg-mass infestations in cotton fields (El-Kanater El-Khairiya,1995) ·

Date	Averages of egg-mass counts / feddan in		% Reduction of egg-masses
	Area treated by pheromone traps	Untreated area	
May, 21st	13.3	26	48.8
24th	19.3	35	45.0
27th	25.7	46.3	44.5
30th	31.3	56.7	44.8
June , 2nd	36.7	65.3	43.8
5th	38.7	68.3	41.3
8th	40.3	70.7	43.3
11th	41.0	72.7	43.6
14th	43.7	82.7	47.2
17th	52.3	94	44.4
20th	61.0	103.7	41.2
23rd	69.3	108.3	36.0
26th	70.7	113	37.4
29th	71.7	119.3	39.9
July , 2nd	74	128.3	42.3
5th	76.3	136.0	43.9
8th	78.3	147.3	46.8
11th	79.7	126	36.7
14th	82.3	118	30.25
17th	83	110	24.55
Total	1088.6	1827.6	
Average	54.43	91.38	40.44

$r = + 0.965^{**}$

$b = + 1.4812$

$t = 3.965^{**}$

** : highly significant.

To determine the significance in the difference between rates of infestation with *S. littoralis* egg- masses in areas provided with sex - pheromone traps and those of control during the two successive seasons, the simple "t" test was applied . Values of "t" were calculated as 6.97 and 3.97 in 1994 and 1995 seasons , respectively , being significant at 0.01 probability level.

The presented results in this investigation are in complete accordance with those previously found by Radwan (1985) who estimated the *S. littoralis* egg - mass counts in cotton fields provided with pheromone and others without throughout the period from May 12th to June, 26th in Sannoris (Fayoum Governorate). The auther found that using the sex-pheromone reduced infestation with egg-masses by 48.14% .

Also, Teich (1985) in Israel recorded that trapping by sex-pheromone resulted in a reduction by 34-60% in the number of *S. littoralis* egg- clusters and by 20-30% in egg viability in the treated fields .

6- Effect of the mean temperature on the egg-laying activity of *Spodoptera littoralis* moths :

This investigation was carried out in El-Kanater El-Khairiya during 1995 season to study the effect of temperature on the egg-laying activity of *S. littoralis* moths in areas treated and untrearted with sex-pheromone traps. Data in Table (6) and Figs. (7 & 8) show the simple correlation between the mean temperature and the

Table (6): Effect of mean temperature on the egg - laying activity of *S. littoralis* moths in areas treated and untrated with sex-pheromone traps (at El-Kanater El-Khairiya cotton field, 1995).

Date	Mean temp. (°C)	% R.H.	egg-masses / feddan	
			treated	untreated
May , 21	26.8	55.0	13.3	26.0
24	25.0	55.7	19.3	35.0
27	25.8	53.0	25.7	46.3
30	27.2	51.0	31.3	56.7
June,2	26.8	52.3	36.7	65.3
5	26.0	49.0	38.7	68.3
8	28.3	44.0	40.3	70.7
11	25.7	48.7	41.0	72.7
14	28.9	46.0	43.7	82.7
17	32.6	44.7	52.3	94.0
20	29.4	51.3	61.0	103.7
23	29.9	54.0	69.3	108.3
26	28.9	59.7	70.7	113.0
29	28.7	48.0	71.7	119.3
July, 2	29.4	56.7	74.0	128.3
5	32.6	57.7	76.3	136.0
8	32.8	63.0	78.3	147.3
11	32.6	58.0	79.7	126.0
14	28.8	58.3	82.3	118.0
17	27.5	61.7	83.0	110.0
Mean			54.43	91.38

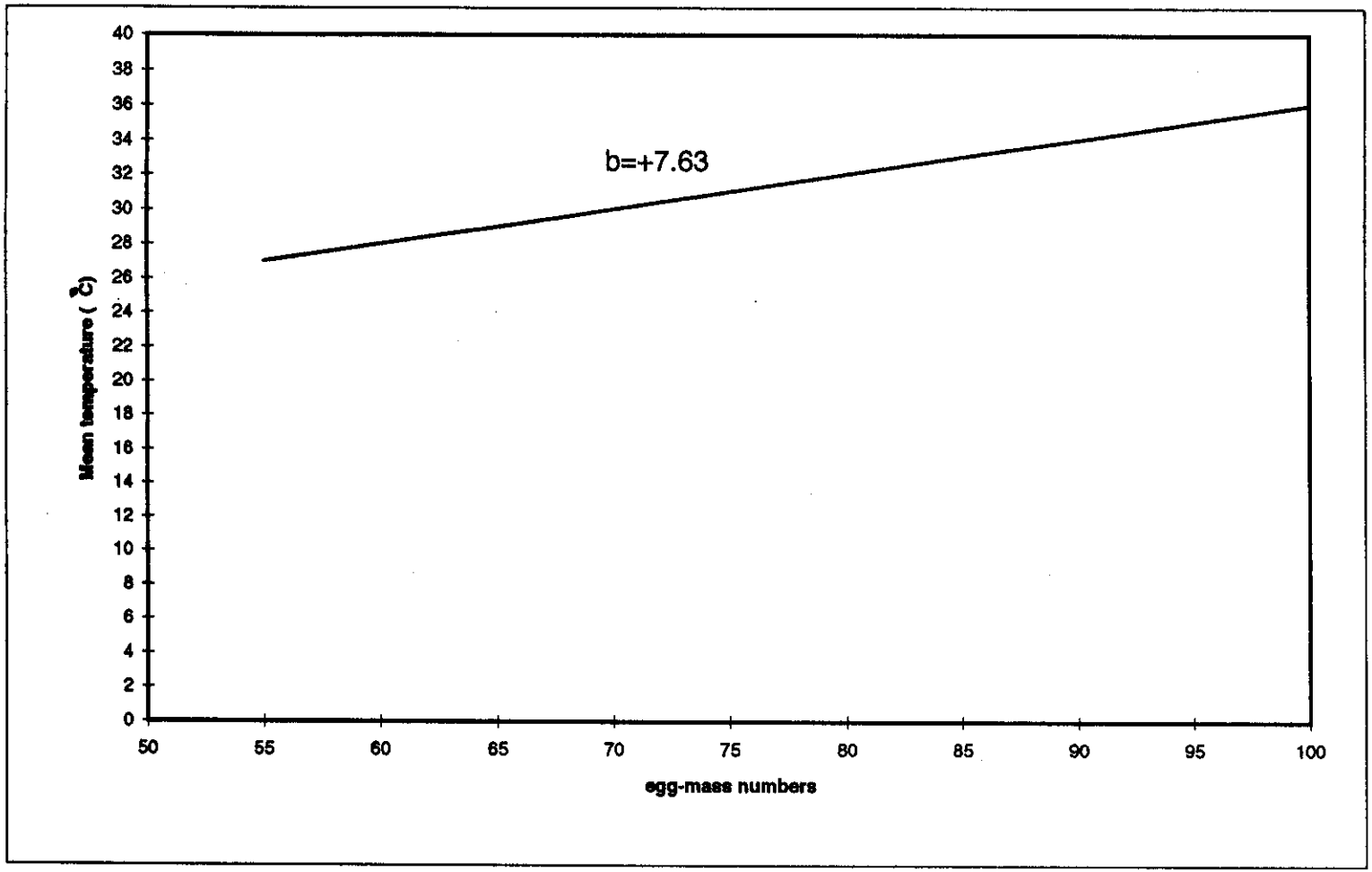


Fig (7) : Linear regression line showing the relationship between *mean* temperature and the S. *littoralis* agg-mass no. in the treated area of cotton field during 1995 cotton season at El-Kanater El-Khairiya.

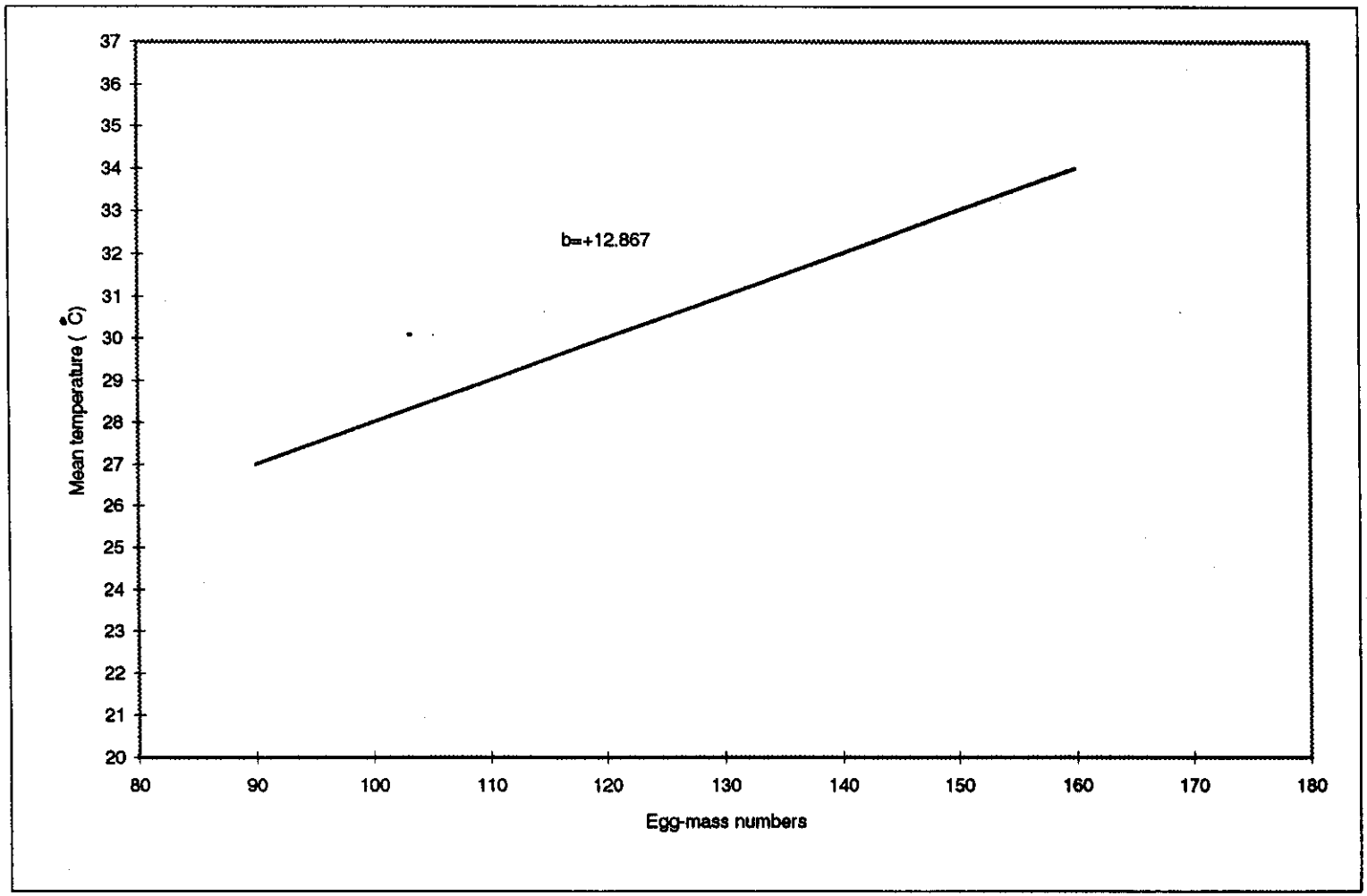


Fig (8) : Linear regression line showing the relationship between *mean* temperature and *S. littoralis* egg-mass numbers in the control area of cotton field during 1995 cotton season at El-Kanater El-Khairiya .

egg-laying activity. A significant positive correlation values were detected in both areas (r = 0.699 and 0.769 in treated and untreated areas, respectively) between temperature and the egg-laying activity. Also, highly significant regression values (b values) were calculated in both areas, being 7.63 and 12.867 in the treated and untreated areas, respectively.

This indicating that in the sex-pheromone treated area, the increase in mean temperature by 1°C increases the number of egg-masses laid by moths of *S. littoralis* by 7.63 . In the control area the rate of increase in egg-masses is about 12.86 for every 1°C increase in mean temperature . That was evident in the area of investigation throughout the period from May 2 1st to July, 17th 1995 when the mean temperature ranged from 25 to 32.8°C and the mean % R.H. was 44-63%.

These results are in a full agreement with Abdel fattah *et al.* (1988) who found that the daily maean temperature and % R.H. affected the rate of infestation by *S. littoralis* egg-masses at Sakha 1984 and 1985 cotton seasons. The authors found that an increase in the departure of the daily mean temperature by 1°C increased the number of egg-masses laid by *S. littoralis* moths by 18.61 and 29.48 on the average wihtin the two considered sseasons, respectively. The same authors studied the effect of the daily mean % R.H., and they concluded a significant negative relationship between the tested factor and *S. littoralis* egg-masses population,

and they concluded that an increase by 16.83 and 13.74 egg-masses / feddan occurred in both seasons, respectively for every 1% R.H. decrease below the general average during the considered periods of analysis . The same authors added that the combined effect of the daily mean temperature and R.H. on the egg-masses population was significant hence "F" values were 7.11 and 8.23 and the explained variance of both factor was high being 81.47 and 88.51 % for the two cotton seasons, respectively.

PART II

Non-chemical substances against *Spodoptera littoralis* (Boisd.)

PART II

Non-chemical substances against *Spodoptera littoralis* (Boisd.).

1-Toxicological and biological activity of Bio-clean on *Spodoptera littoralis:*

As previously mentioned, Bio-clean is a bioinsecticide (a mixture of *Bacillus thuringiensis* and *Beauveria bassiana*) which was assayed against the 2nd and 4th instar larvae of S. *littoralis*. Larvae were fed for 24 hours on cotton treated leaves after different periods from field application of the bioinsecticide. Mortalities were recorded 24 hrs. after treatment and continued until the prepupal stage. The surviving larvae were, afterwards, fed on fresh untreated castor-bean leaves until pupation. Emerged moths were fed on 10% sucrose solution and allowed to oviposit on oleander leaves in rearing cages.

1- Acute toxicity of Bio-clean:

Data recorded in Table(7) indicate that feeding of *S. littoralis* larvae for 24 hours on Bio-clean treated cotton leaves caused mortalities, in the larval stage, that ranged between 40 - 96% and 30-92% by treatment in the 2nd and 4th instars, respectively compared to 14% in case of the control larvae ; reduction in the weight of resultant pupae (272-337 and 284-365mg./ pupa, respectively, opposed to 416 and 414 mg. for the control pupae), and also reduction in the total eggs' reproductivity (means of 140-235 and 151-247 eggs/ female from treated larva, respectively opposed to 310 and 315 eggs / control female).

Table (7) Effect of " Bio-clean" on comulative mortality, pupal weight, egg mean number and hatching percentage after 2 nd and 4 th instars *S. littoralis* larval treatment (result from 50 larvae / treatment)

Periods (d.)	2 nd instar				4 th instar			
	% Comulative mortality	Average of Pupal weight (mg. ± SE)	Mean no. of eggs / female ± SE	% Eggs' hatching	% Comulative mortality	Average of pupal weight (mg.± SE)	Mean no. of eggs / female ± SE	% Eggs' hatching
Zero	96	(272± 0.8)	(140)	20.0	92	(284 ±0.4)	(151 ± 1.4)	23.0
1d.	92	(280±0.4)	(152)	22.0	88	(289 ± 0.6)	(157 ± 0.9)	25.0
2d.	90	(294 ± 0.6)	(167 ± 0.9)	26.0	84	(297 ± 0.5)	(169 ±0.8)	28.0
3d,	82	(306 ± 0.6)	(190± 0.7)	27.0	74	(317± 0.5)	(197 ±0.8)	32.0
5d.	72	(315 ±0.5)	(204 ± 0.4)	29.0	60	(329 ±0.5)	(219 ±0.5)	36.0
7d.	54	(325± 0.6)	(215 ±0.6)	32.0	46	(341 ± 0.4)	(234 ± 0.6)	41.0
9d.	40	(337 ± 0.5)	(235±0.0.5)	35.0	30	(365 ± 0.7)	(247 ± 0.6)	47.0
Cont.	14	(416 ± 0.7)	(310± 0.5)	90.0	14	(414 ±0.6)	(315± 0.4)	88.0
F.		732**	437**			339**	781**	
L.S.D. at 1%		6.9	10.7			9.8	8.1	
at 5%		5.0	7.8			7.1	5.9	

** Highly significant

2- The latent effect of Bio-clean :

The latent effect of the bioinsecticide extended also to affect the viability of eggs deposited by females resulted from treated larvae . Amongst these eggs, the hatchability percentage averaged 20-35 and 23-47% when eggs were deposited by females resulted from larvae fed on treated cotton leaves in their 2nd and 4th instars, respectively ,while those recorded on eggs from untreated females were 90 and 88% , respectively (Table , 7). It is clear from the same table that the severest effect of the bioinsecticide on *S. littoralis* larvae occurred when treatment took place at zero time; *i.e* , just after field application (highest larval mortality rates, least pupal weights, lowest eggs' productivity and also the least hatchability percentages). This effect decreased, gradually by lengthening the period from Bio-clean applicatioon to larval treatment. Also, the effect appeared to be higher by feeding the larvae on treated food when they were in earlier instar; *i.e.* , the 2nd instar larvae were, generally, more susceptible to treatment than those of the 4th instar.

In similar work, Bekhit (1985) studied the acute toxicity of Thuricide-HP against the 1st, 2nd and 3rd instar larvae of *S. littoralis* by using leaf dipping technique. The author found that larvae of the first instar larvae were the most susceptible. He, also , added that the maximum rate of mortality occurred predominantly within three days from larval exposure and the pupal weights from treated larvae were less than of untreated ones.Also, Sokar (1995) assayed the effect of Dipel-2X on the 4th instar larvae of *S. littoralis* and he found a direct relationship between the mortality rates and the applied concentration ; *i.e.* the mortality percentages increased as the number of *B. thuringiensis* spores applied to the larval food increased. The number of eggs averaged 142.2 & 124.6 eggs / female, when the females from treatment with LC_{25} & LC_{50} Dipel-

2X were mated with treated males, respectively. At the same time, eggs' hatchability was found to be also affected by *B. thuringiensis* treatment ; it was 18.6 & 0.0 % at the level of LC_{25} & LC_{50}, respectively.

2- Biological activity of Bio-clean:

The delayed effects of Bio-clean on the surviving larvae and the subsequent stages after treatment of the 2nd and 4 th larval instars are shown in Table (8).

A- Effect on larval period : (the remaining period after treatment) .

From data recorded in Table (8) , it is clear that the period of larval stage was affected due to larval feeding on Bio-clean treated cotton leaves, whether treatment took place on the 2nd or the 4 th instar larvae. The general trend of such effect was the lengthening of this period (23 ± 0.2-27.5 ± 0.5 days by treatment in the 2nd instar and 19.2 ± 0.3 - 24.2 ± 0.6 days by treatment in the 4th instar opposed to 20.6 ± 0.1 and 18.5± 0.3 days for the larval period of the control larvae , respectively). The effect of Bio-clean larval treatment on prolongation of the larval period, generally, increased by shortening the period from bioinsecticide application to laboratory treatment. By treatment at the zero time (just after bioinsecticide application), the longest larval period was detected as the larval duration elapsed 27.5 ± 0.5 (24-30)and 24.2 ± 0.6 (19-26) days for larvae treated in their 2nd & 4th instars, respectively (Table,8), while the shortest larval durations amongst treated larvae were, on the other hand, recorded for larvae treated in the mentioned instars after 9 days of Bio-clean field application being 23 ± 0.2 (21-25) and 19.2 ± 0.3 (17-23) days, respectively. By treatment in the 2 nd instar after 1,2,3,5 and 7days of bioinsecticide application, the larval period occupied the averages of 26.7 ± 0.4, 25.9 ± 0.5,25.2 ± 0.4 , 24.4 ± 0.3 and23.7 ± 0.3 days, respectively, while by treatment of 4th instar larvae at the same

Table (8) Effect of " Bio-clean" on *S. littoralis* larval and pupal durations (/ days ± SE) by feeding the 2 nd and 4 th instars on treated cotton leaves after different periods from application

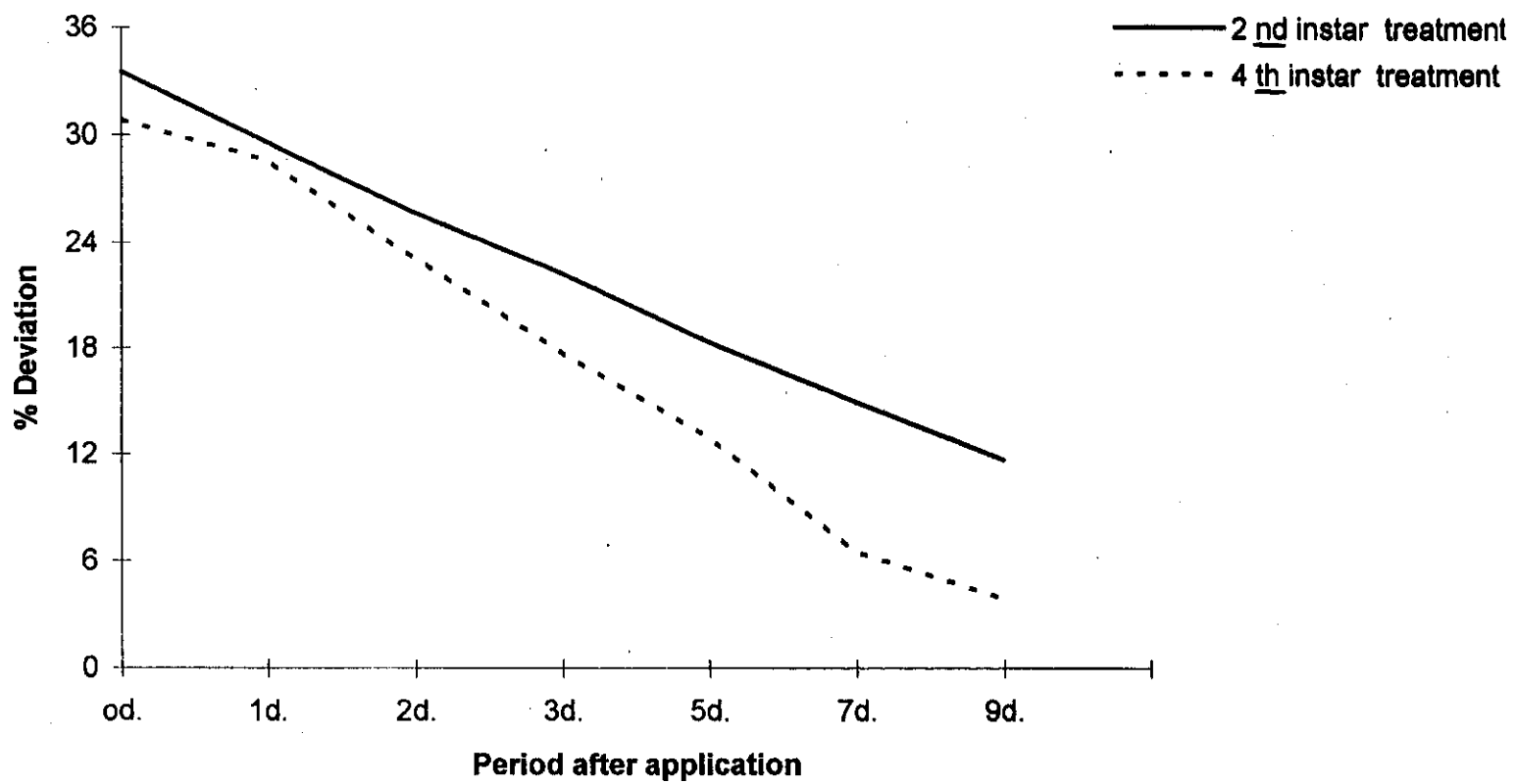
Periods (d.)	2 nd instar		4 th instar	
	Larval period *	Pupal duration	Larval period *	Pupal duration
Zero	27.5 ± 0.5 (24-30)	20.0 ± 0.7 (19-22)	24.2 ± 0.6 (19 - 26)	20.3± 0.7 (18 - 22)
1 d.	26.7 ± 0.4 (23-28)	19.5 ± 0.6 (18-21)	23.8 ± 0.6 (20-26)	19.8 ± 0.5 (19 -22)
2d.	25.9 ± 0.5 (23-28)	18.6 ± 0.5 (17-20)	22.8 ± 0.3 (21-24)	19.3 ± 0.5 (17 - 21)
3d.	25.2 ± 0.4 (22-27)	18.3±0.3 (17-20)	21.8 ± 0.3 (20 - 24)	18.8 ± 0.2 (17 - 20)
5d.	24.4 ±0.3 (21 -26)	18.0 ± 0.3 (16 - 20)	20.9 ± 0.3 (19 - 24)	18.3 ± 0.3 (16-20)
7d.	23.7 ± 0.3 (21 26)	17.4 ± 0.2 (16 - 20)	19.7 ± 0.2 (18-23)	17.5 ± 0.2 (15 - 19)
9d.	23.0 ±0.2 (21-25)	16.9 ± 0.2 (16-19)	19.2 ± 0.3 (17-23)	17.2 ± 0.2 (15-20)
Cont.	20.6 ± 0.1 (19 - 23)	16.5 ± 0.2 (13 - 19)	18.5 ± 0.3 (17 -23)	16.4 ±0.1 (13-19)

* = The larval period from treatment until pupation .

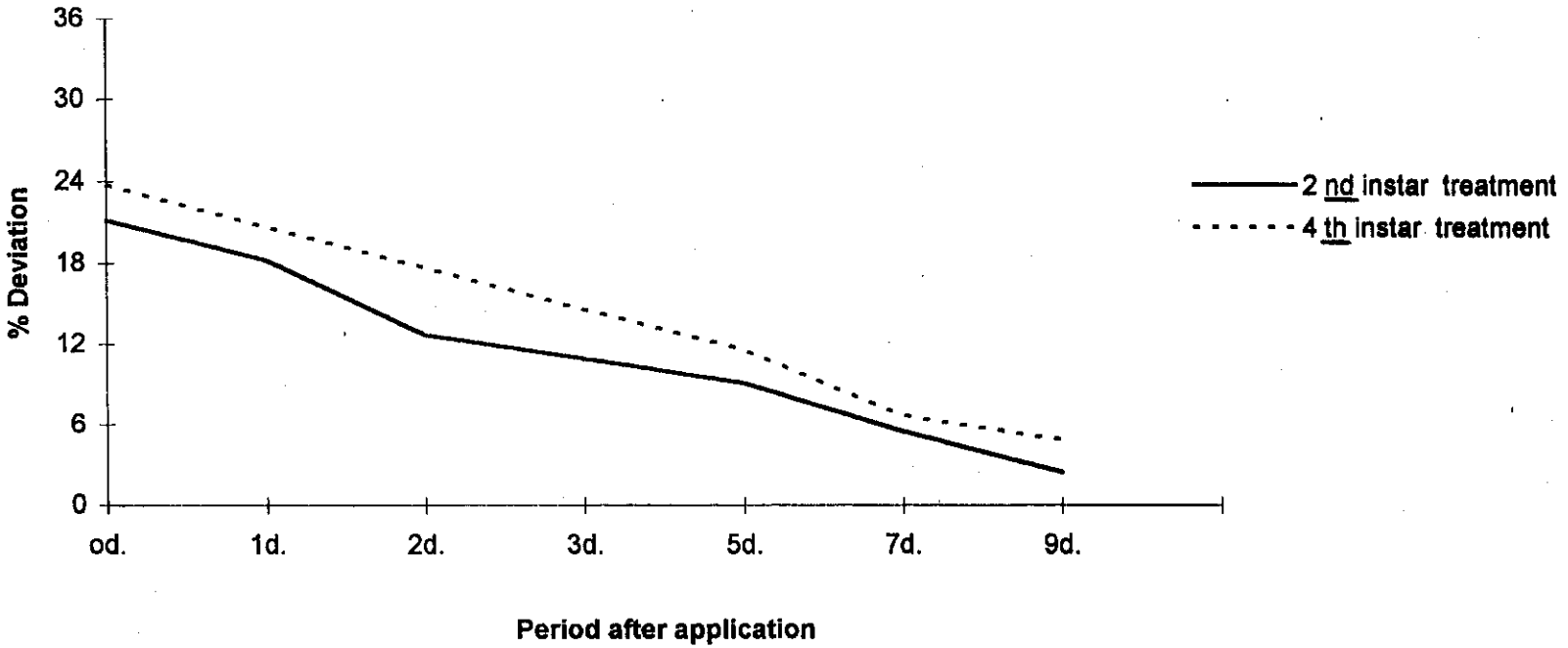
time, the correspondent larval periods were 23.8 ± 0.6, 22.8 ± 0.3, 21.8 ±0.3, 20.9 ± 0.3 and 19.7± 0.2 days , respectively (Table, 8) indicating intermediate periods compared to those treated at zero time and after 9 days of Bio-clean application. Data illustrated in Fig. (9) demonstrate the rates of deviation (increase) in the larval period due to Bio-clean treatment than control. Such data, clearly, show that highest increase in larval period occurred when larvae of the 2nd and 4th instars were fed on Bio-clean treated leaves just after application of the bioinsecticide (33.5 and 30.8% , respectively). The rate of deviation decreased, successively, as the period from field treatment and starting larval feeding on treated food became longer up to 9 days when the lowest rates of deviation than contorl were detected (11.7 and 3.9 % , respectively ; Fig. 9)

B. Effect on pupal duration :

As occurred with larvae, the larval feeding on Bio-clean treated cotton leaves caused increases in the durations of the subsequent pupae. Pupae that resulted from *S. littorallis* larvae treated in the 4th instar showed, generally, longer pupal period than those resulted from larvae treated in their 2nd instar (Table, 8). The longest pupal period (20.3 ± 0.7; 18-22 days) was estimated from pupae resulted from larvae fed in their 4th instar at zero time (just after field application of the bioinsecticide on cotton leaves) (Table ,8) and consequently these pupae showed the highest rate of deviations in pupal duration than control (23.8%; Fig, 10). While, on the contrary, the slightest deviation in pupal duration than control was detected amongst pupae resulted from larvae fed in their 2nd instar for 24 hours on Bio-clean treated cotton leaves after 9 days of the bioinsecticide (pupal duration 16.9 ± 0.2 ; 16-19 days in case of pupae resulted from larvae treated in the 2nd instar after 9 days of field treatment, opposed to 16.5 ±0.2 ;13 - 19 days in case of pupae resulted from



Fig(9): Effect of *S. littoralis* larval feeding on Bio - clean treated cotton leaves on the deviation of larval duration than control .



Fig(10): Effect of *S. littoralis* larval feeding on Bio - clean treated cotton leaves on the deviation ofpupal duration than control .

untreated larvae (Table,8) indicating only 2.2% deviation than control ; (Fig.12) . As shown in Table (8) and Fig. (10) , larval treatment after 1,2,3,5 and 7 days of the bioinsecticide field application resulted in pupae which showed intermediate pupal durations, and Subsequently intermediate deviation rates than control pupae , although the main trend of effect remained ; *i.e.,* more effect as the period from field application of Bio-clean to treatment became shorter.

The obtained results concerning the effect of the bioinsecticide field treatment on the cotton leafworm larval and pupal durations are in agreement with Raslan (1988) who indicated that treatment of *Agrotis ipsilon* 2nd and 4th instar larvae with three formulations of *B. thuringiensis* caused prolongation of the larval and pupal periods. Also, Sokar, (1995) studied the same aspects on *S. littoralis* treated as fourth instar larvae with Dipel-2X. The author found that the period of both larval and pupal durations, at the sublethaldose caused slight increase in the duration of the treated larvae, to reach 21.1 days showing an 10.3 % elongation than the duration of control larvae. Increases of the *B. thuringiensis* concentrations, brought about corresponding increases in larval duration to reach a maximum of 34% in larval period at the concentration of 0.6 %. He also, added that the pupal duration seems to be relatively longer than the check, where it was 17.8 days at 0.1% concentration while it is 16.3 days for the check.

C. Effect on pupal weight:

The freshly formed pupae that resulted from 2nd and 4th instar Bio-clean treated larvae, and those from control larvae were weighed and the obtained results are shown in Table (7) and graphically illustrated in Fig., (11).

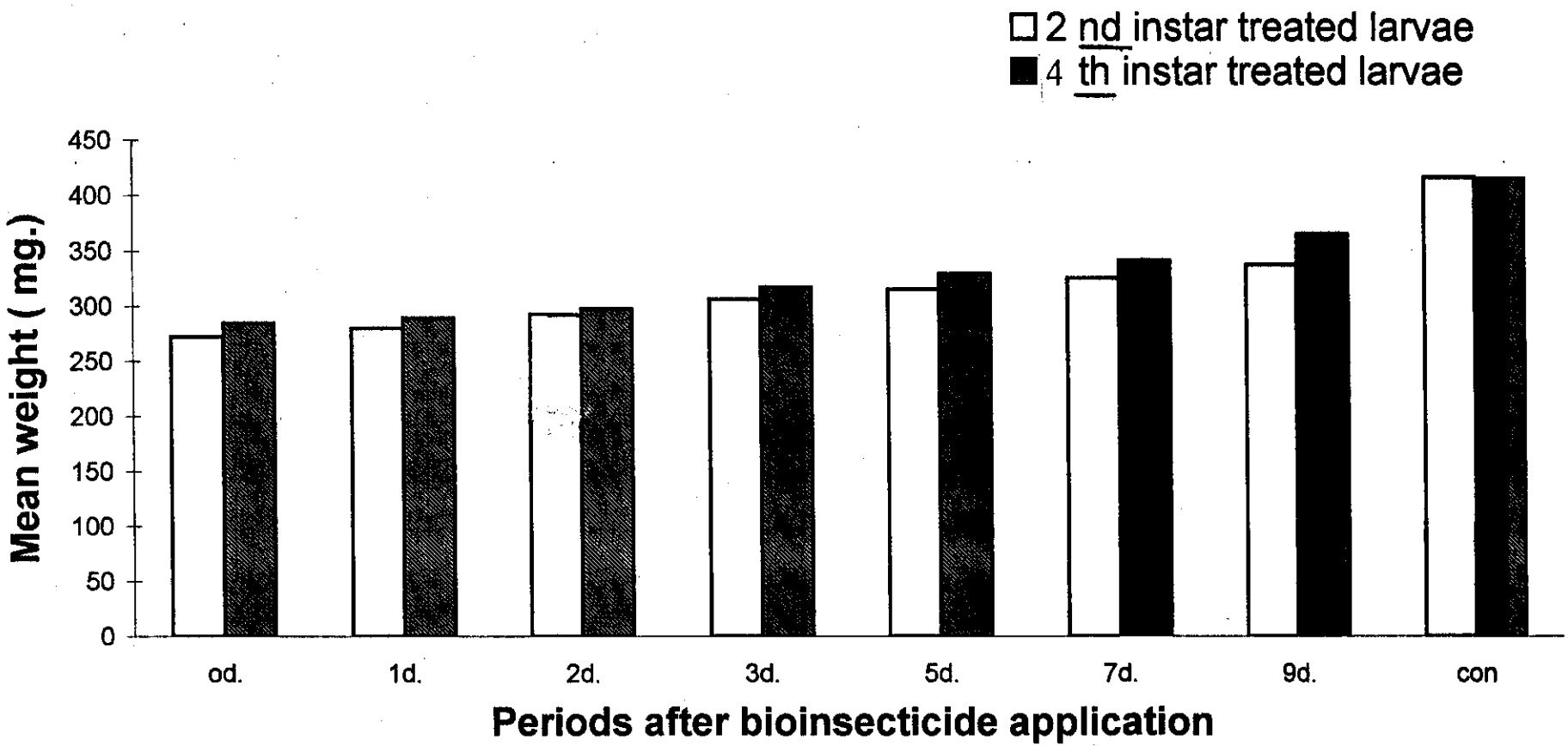


Fig (11) : Effect of *S. littoralis* larval feeding on Bio-clean treated leaves on the mean of pupal weight .

Generally, the average weight of pupae obtained from Bio-clean fed larvae were less than those resulted from the control larvae. It could be generally observed from Fig. (11) that larval treatment in the earlier instar (2^{nd} istar), lead to pupae less in weight than those resulted from larvae treated in the later one (4^{th} instar). On the other hand, the effect of larval feeding , on Bio-clean treated cotton leaves , on the weight of resultant pupae was more pronounced when treatment took place at zero time (just after bioinsecticide application) where the mean weight of pupae was 272 and 284 mg. for larval treatment in the 2^{nd} and 4^{th} instars, respectively. Mean weight of pupae became heavier, successively, as the period after the bioinsecticide application until treatment became longer until reached 337 and 365 mg. / pupae for 2^{nd} and 4^{th} instar larval treatment after 9 days of field treatment. By larval treatment at zero time and 9 days after the bioinsecticide field application, the reduction percentages in pupal weight compared to control ones ranged from 19 to 34.6% in case of the 2^{nd} instar treated larvae and from 11.8 to 31.4% for the 4^{th} instar treated larvae (Table, 7).

These results are correspondent to those previously recorded by Hegazy and Antonious (1987) on the fifth instar larvae of *S. littoralis* by using leaf dipping technique with two bactericides , Thuricide $^{(R)}$ HP and SAN 415. SAN 415 proved to be more efficient in reducing the pupal weight when compared with Thuricide $^{(R)}$ HP. The rate of pupal weight reduction as compared with the check revealed 48.8, 31.0 and 29% with Thuricide $^{(R)}$ HP at 5.0 , 2.5 and 1.0% concentrations respectively, while SAN 415 showed 53.7, 37.8 and 33.8% at the same concentrations, respectively.

D- Effect on pupation:

The mean percentages of normally formed pupae varied amongst pupae from different treatments (24-74% normal pupae from larvae treated as freshly 2nd instar at zero time and after 9 days of the bioinsecticide field application,respectively and 32-78% normally formed pupae, respectively from larvae at their 4th instar opposed to 9o and 92% pupation from the untreated larvae; (Table, 9 and Figs.12-&13) . It is clear from the same table that the severest effect occurred when treatment took place just after field application of Bio-clean. By elongation of the period from bioinsecticide application to treatment, the effect decreased and the percentage of normally formed pupae increased to 28,32,44, 52 and 66% for larvae treated in their 2nd instar and to 36,40, 48, 54 and 68% when the fourth instar larvae were treated after 1,2,3,5 and 7 days of application, respectively .

Data indicate also that the second instar larvae were more suceptible than the fourth instar ones as more normal pupae were obtained in the latter case (Table, 9).

These results are in agreement with those reported by Hegazy and Antonious (1987) who found that the toxicity of Thuricide(R) HP and SAN 415 at three levels of concentrations against the fifth instar larvae of *S. littoralis* increased successivelly from the 1st to the 3rd day after treatment and added that the supreme action could be noticed with SAN 415, while the inferior action was detected with Thuricide (R) HP at any cocentration or with any day after application. By using leaves dipping technique the mortality percentages after 72 hours from treatment exhibited 35,30 and 15% for Thuricide (R) HP and 50,45 and 35% for SAN 415 at 5, 2,5 and 1% concentrations, respectively . Also , Raslan (1988) studied the effect of SAN 415 on *Agrotis ipsilon* 1st and 2nd instar

larvae which were fed on castor bean leaves treated with different concentrations. The author found generally, that increasing the bacterial concentrations caused a decrease in pupation and adult emergence in the two tested larval instars. El - Swerki (1994) found that Dipel 2X when used at 1% caused failure in pupation while successful pupation was achieved with conc. of 0.0001% .

E- Adults' emergence:

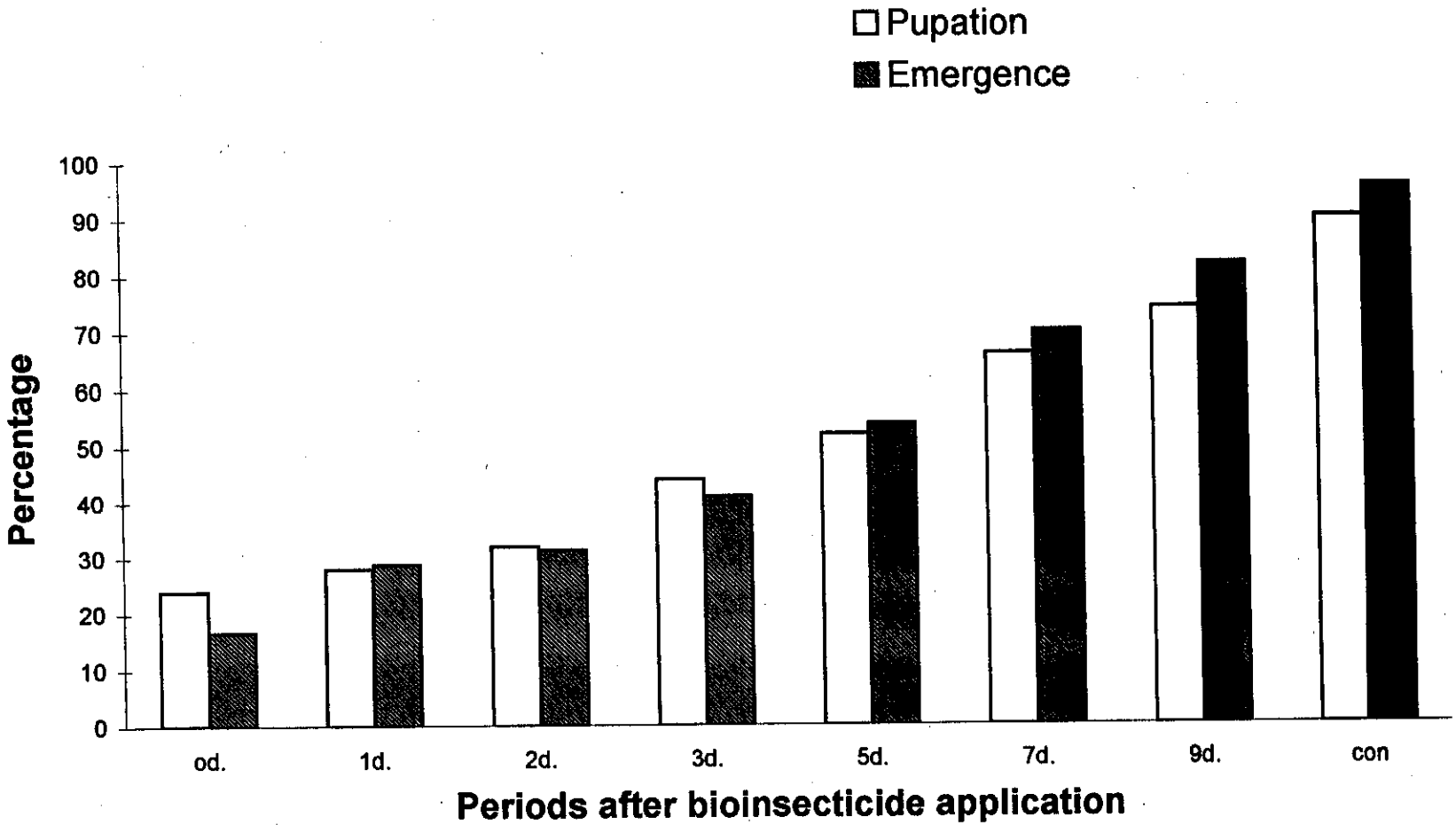
As shown in (Table, 9 and Figs. 12&13, the same tendency of bioinsecticidal effect on successful pupation after larval treatment was also detected on the percntages of adults' emergence (16.7-81.1 and 25 - 89.7% by Bio-clean treatment of the second and fourth instar larvae at zero time and after 9 days of application, respectively). Also, the effect on successful emergence of adults decreased by treatment of older instar.

In similar work, Hegazy and Antonious (1987) found that the rate of normal adult emergence was noticeably decreased due to the bactericide application. SAN 415 caused somehow higher rate of moth malformations than Thuricide. Also , Sokar (1995) indicated that the percentages of emergence decreased by the increase of concentration, those were 87.9 , 81.0 and 67.9% at 0.1 , 0.2 and 0.4 level, respectively from Dipel - 2X on 4th instar larvae of *S. littoralis* while it was 96.0% for the check. There was a negative correlation between *B. thuringiensis* concentrations and both pupation and adult emergence.

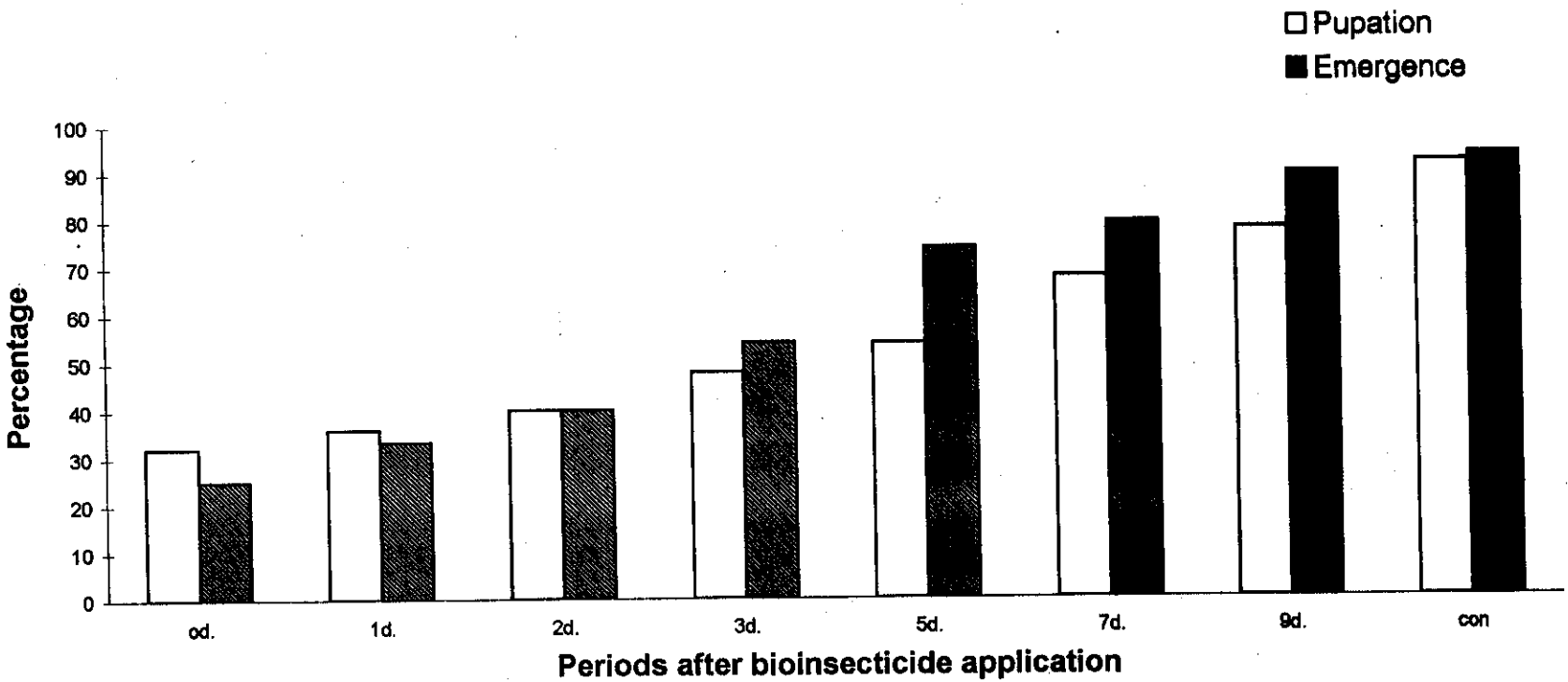
Table (9) : Effect of S. *littoralis* larval feeding on Bio-clean treated cotton leaves on pupation, emergence, adults' longevity (/ days) and malformations.

Periods (d)	2 nd instar								4 th instar							
	% Pupation	% Emergence	adult longevity		% Malformed stages				% Pupation	% Emergence	adult Longevity		% Malformed stages			
			M.	F.	L.	P.	A.	T.			M.	F.	L.	P.	A.	T.
ZERO	24	16.7	6	5	24	6	-	30	32	25	6	5.7	20	4	-	24
1d.	28	28.6	6.5	6	22	6	2	30	36	33.3	6.7	6.3	20	4	2	26
2d.	32	31.3	7.3	7	18	4	2	24	40	40	7.6	7.3	16	4	-	20
3d.	44	40.9	7.6	7.3	16	2	2	20	48	54.2	7.8	7.7	14	2	2	18
5d.	52	53.8	8.1	7.9	12	2	-	14	54	74.1	8.3	8.1	14	2	2	18
7d.	66	70.0	8.4	8.2	10	2	-	12	68	79.4	8.6	8.4	10	2	2	14
9d.	74	81.1	8.5	8.5	6	-	-	6	78	89.7	9	8.7	8	-	-	8
cont.	90	95.5	9.9	8.9	-	-	-	-	92	93.5	9.9	8.9	-	-	-	-

M : Male F.: Female L.: Larva P. : Pupa A.: Adult T. : Total



Fig(12):Effect of *S. littoralis* 2 *nd* instart larval feeding on Bio-clean treated cotton leaves on pupation and adults' emergence .



Fig(13): Effect of *S. littoralis 4 th* instart larval feeding on Bio-clean treated cotton leaves on pupation and adults' emergence

F- Deformations amongst different stages:

Data presented in Table (9), clearly, show that *S. littoralis* larval feeding on Bio-clean treated cotton leaves led to different degrees of malformations amongst the treated larvae, pupae and adults.

Larval-pupal intermediates:

Individuals having these malformations were characterized by one or more of the following:

a- The larvae could not complete their last moulting process .

b- All or some of the abdominal segments with patches of pupal form, forming the larval - pupal intermediates.

c- The mouth-parts of the larvae attached to pupal cuticle .

d- The pre-pupal stage could not get rid of its cuticle.

Pupal - adult intermediates:

Such individuals are characterized by one or more of the following:

1- Adults failed to emerge and remain attached to the pupal cuticle.

2- Adults having malformed wings such as reduction in scales or reduction in the length of one or both wings.

3- Adult with one or more wing curled.

Normally, the malformed stages were not able to survive. Amongst the obtained deformities, many larval - pupal and pupal - adult intermediates were observed (Fig., 14) . More deformation percentages

were recorded amongst the treated larvae (6-24% and 8-20%) than between the resultant pupae (o-6% and 0-4 %) and adults (0-2%) . The total percentages of malformed stages ranged from 6 to 30 % by treatment of the 2nd instar larvae and from 8-26 % by treatment of the 4th instar larvae at 9 days and zero time of the bioinsecticide application, respectively. Treatment of larvae at intermediate periods after Bio-clean application led to intermediate ratios of deformities (Table, 9) . On the contrary, no deformations could be observed amongst the developing stages of control. An opposite relationship may by easily detected between the percentage of deformed stages and the period from bioinsecticide application and starting treatment.

Diagnostic characters of the infected individuals:

Symptoms of infection by Bio-clean were observed on the treated larvae. These symptoms may be explained as follows:

1- After two days of treatment, the larvae became sluggish and by time lack mobility at all.

2- Larvae lose their appetite and some cases of diarrhea or oozing were observed .

3- The larval body beccame darkened in colour.

4- The diseased larvae became flaccid and soft with reddish colour .

5- The larval body became dry and mummified .

6- The tissues disintegrated with putrid odor.

In similar work, Rizk *et al.* (1987) studied the external symptoms of *Bombyx mori* infected with *Bacillus thuringiensis* at three concentrations by using different methods of application (dipping, oral and injection) on the 5th instar larvae. The larval cuticle hardened and became dry in the infected areas . Later on , the larval cuticle was found to be transformed into scales and shrinked, especially on the ventral side of the abdomen leading too the curvature shape or crescent shape" . At the end of the 5th instar, larvae escaped the bacterial infection, but most of the infected larvae with bacteria failed to pupate and mortality occurred among the individuals . Few numbers of full grown larvae could pupate with different degrees of malformations . The most common malformation in this case is the formation of pupae without cocoons. Sokar (1995) estimated the percentage of deformed adults for each of the six concentrations of a B. *thuringiensis* product . The percentages of deformations increased by the increase of concentration . The percent deformation ranged betwen 7.6 - 45.7% in case of the lowest and highest concentrations, respectively . As for the untreated larvae, no malformed pupae occurred while only 1.8% emerged adults were malformed .

G. Effect on the resultant adults :

As the 2nd and 4th instar larvae of *S. littoralis* were fed for 24 hours on Bio-clean treated cotton leaves, the delayed effect was also detected on the adult stage which showed shorter life-span and decreased fecundity than control .

a- Effect on adult's life-span :

Larvae fed in their 2nd instar on Bio-clean treated leaves, after different periods from the bioinsecticide field application , developed to adults that lived for 6 days (when treatment took place just after application) to 8.5 days (for treatment after 9 days of application) in case of males and for 5-8.5 days, respectively in case of females . The respective longevities of males and females resulted after 4th instar larval treatment were 6-9.0 and 5.7-8.7 days opposed to 9.9 and 8.9 days, respectively in case of the control moths (Table, 9) .

In all cases, the shortest life-span of moths from both sexes were recorded from larvae treated at zero time. By prolongation of the period after bioinsecticide application, the recorded longevities rendered longer , and the least effect was detected by starting treatment 9 days after bioinsecticide application .

These results are in accordance with the findings of Hegazy and Antonious (1987) who recorded that Thuricide (R) Hp and SAN 415 caused reduction in adult longevity when used against the 5th instar larvae of *S. littoralis* . Also, Sokar (1995) found that *S. littoralis* males obtained from larvae treated with LC_{25} and LC_{50} of Dipel 2X lived 9.0 & 8.8 days , respectively when they mated with treated females. The reduction percent of longevity period reached 16.6 % & 17.0 % for treated males and 20.9% & 26.7% for treated females at the level of LC_{25} and LC_{50} , respectively .

b- Effect on eggs' reproductivity and hatchability :

As shown in Table (7) , female moths of the cotton leafworm deposited fewer number of eggs that ranged from 140 to 235 eggs/ female by second instar larval feeding on Bio-clean treated cotton leaves at zero

time and after 9 days of the bioinsecticide field application, respectively opposed to mean of 310 eggs/control female. Thus indicating reduction in the mean total number of deposited eggs by 54.84 and 24.19%, respectively than control. By treatment of *S. littoralis* larvae while in their 4th instar , reduction in mean total number of produced eggs were 52.06 and 21.59% (151 and 247 eggs / female by treatment at zero time and after 9 days of application, respectively opposed to 315 eggs/ control female ; Table, 7).

Amongst the deposited eggs , the hatchability percentages were found to be also reduced due to larval treatment. These percentages were 20-35 and 23- 47% in cases of 2 nd & ^{4th} instars larval feeding on treated food, while the hatchability percentages of eggs from normally developed females from untreated larvae of the two experiments were 90 and 88% , respectively. Thus showing reductions in the hatchability percentages by 77.8 - 61.12 and 73.86 - 46.58 % , respectively .

It could be clearly observed from data in Table (7) that the reduction in mean total number of eggs/ female and also in the hatching percentages were, positively , proportional to the period from bioinsecticidal application until starting larval feeding on the treated food as , in all cases, the severest effect occurred when larvae were fed on treated food at zero time , while the lightest effect was detected when treatment took place after 9 days of spraying. It is also evident from the same table that treatment of larvae in earlier instar lead to higher effect than that occurred by treatment of older ones, although the differences were not so great as that occurred in case of prolongation of the period from bioinsecticide field application to treatment .

In similar investigations, Atwa *et al.*, (1984), studied the toxicity of *B. thuringiensis* isolated from diseased larvae of *Philosamia ricini* on the

susceptibility of *S. littoralis* larval instars. The authors found that the adult longevity of both sexes of the cotton leafworm was reduced and also the number of eggs laid / female was significantly lower than from normal female. The same trend of bioinsecticidal effect was also reported by Sokar (1995) as the greatest reduction in number of eggs occurred when mating took place between both sexes of *S. littoralis* from *B. thuringiensis* treated larvae where the egg numbers were 142.2 and 124.6 eggs/female for LC_{25} and LC_{50} concentrations, respectively . The increasing concentration lead to reduction of the number of eggs laid / female and the treated females were responsible for the supperession of egg numbers than the treated males . The same author, also added that the eggs' hatchability was also affected by *B. thuringiensis*. The reduction in fertility was more evident in case of females ensuing from the larvae treated with the LC_{50} of *B. thuringiensis* where the eggs' hatchability reached 13.0% when the mating of treated male and untreated female took place, while all the laid eggs were infertile with the two other mating types where the treated females were mated with untreated or treated males.

From the previously explained results, it could be concluded that Bio-clean is , generally, a potent bioinsecticide against *S. littoralis* as it has a considerable effect on the noxious stage (larvae) and the subsequent stages (pupae and adults). Its delayed effect didn't stop at the adult stage, but extended to the next generation as it caused detectable reduction in the percentage hatching amongst eggs deposited by moths that developed from bioinsecticide fed larvae. It seems necessary, in this respect, to point that in order to obtain successful control against the cotton leafworm in the field by this product, the bioinsecticide has to be applied by the recommended concentration on early larval stage *i.e.* , just when larvae are detected in field (as young larvae proved to be more susceptible to the bioinsecticidal effect) and also in the afternoon as in

this case the bioinsecticide will not be exposed to the direct effect of sunlight (U.V. rays are known as the main factor affecting the viable spores of *B. thuringiensis* and *B. bassiana)* so that the product will remain for the longest period (more than 12 hours) out of the direct sunlight effect up to the next day and also will be, undoubtedly, consumed by larvae which remain active during this period of the day, feeding on higher quantities of contaminated leaves.

Table (10)

Effect of "IKIPP $_{145}$" on comulative mortality, pupal weight, eggs' production and hatching percentage after treatment 2*nd* and 4 *th* instar' *S. littoralis* larvae (results from 50 larvae / treatment) .

Time (d)	2 *nd* instar				4 *th* instar			
	% Comulative mortality	pupal weight (mg. ± SE)	No. of Eggs / female ± SE	Hatchability %	Comulative mortality %	pupal weight (mg. ± SE)	No. of Eggs / female ± SE	Hatchability %
zero	94.0	(270 ± 0.5)	(147)	0.0	90.0	(280 ± 0.5)	(157)	0.0
1d.	92.0	(275 ± 0.4)	(155)	0.0	88.0	(285 ± 0.8)	(161)	0.0
2d.	86.0	(281 ± 0.3)	(181 ± 0.5)	0.0	80.0	(291 ± 0.5)	(181 ± 0.5)	10.0
3d.	76.0	(293 ± 0.7)	(222 ± 0.4)	4.0	74.0	(302 ± 0.7)	(200 ± 0.6)	15.0
5d.	60.0	(305 ± 0.3)	(240 ± 0.6)	12.0	60.0	(313 ± 0.5)	(224 ± 0.7)	18.0
7d.	42.0	(314 ± 0.6)	(261 ± 0.6)	14.0	44.0	(328 ± 0.5)	(270 ± 0.6)	22.0
gd	26.0	(320 ± 0.6)	(279 ± 0.8)	20.0	30.0	(341 ± 0.4)	(297 ± 0.8)	24.0
cont	12.0	(415 ± 0.6)	(305 ± 0.6)	88.7	10.0	(419 ± 0.3)	(320 ± 0.6)	90.3
F.		682**	626**			560**	819**	
L.S.D at 1%		7.3	6.0			7.6	8.5	
at 5 %		5.3	4.4			5.5	6.1	

** highly significant

Table (11)

Effect of "Consult 100 EC" on comulative mortality, pupal weight, eggs' production and hatching percentage after treatment 2*nd* and 4 *th* instar larvae of *S. littoralis* (results from 50 larvae / treatment) .

Time (d)	2 *nd* instar				4 *th* instar			
	% Comulative mortality	pupal weight (mg. ± SE)	No. of Eggs / female ± SE	Hatchability %	Comulative mortality %	pupal weight (mg. ± SE)	No. of Eggs / female ± SE	Hatchability %
zero	96.0	(278± 0.7)	(149)	0.0	96.0	(285 ± 0.8)	(158)	0.0
1d.	96.0	(281 ± 0.7)	(158)	0.0	96.0	(289± 0.4)	(169)	0.0
2d.	90.0	(286 ± 0.6)	(185 ± 1.4)	0.0	88.0	(292 ± 0.5)	(197 ± 1.3)	6.0
3d.	78.0	(297 ± 0.6)	(222 ± 0.8)	4.0	78.0	(303 ± 0.7)	(230± 0.8)	9.0
5d.	62.0	(310 ± 0.8)	(240 ± 0.7)	9.0	62.0	(319 ± 0.5)	(257± 0.9)	12.0
7d.	48.0	(319 ± 0.4)	(262± 0.6)	14.0	44.0	(334± 0.8)	(276 ± 0.8)	18.0
gd	38.0	(328± 0.7)	(279 ± 0.6)	17.0	32.0	(352 ± 0.6)	(288 ± 0.99)	22.0
cont	12.0	(416 ± 0.4)	(306± 0.2)	88.7	10.0	(419 ± 0.7)	(318± 0.96)	90.3
F.		543**	683**			882**	669**	
L.S.D :	at 1%	8.0	9.1			6.1	11.4	
	at 5 %	5.8	6.6			4.5	8.3	

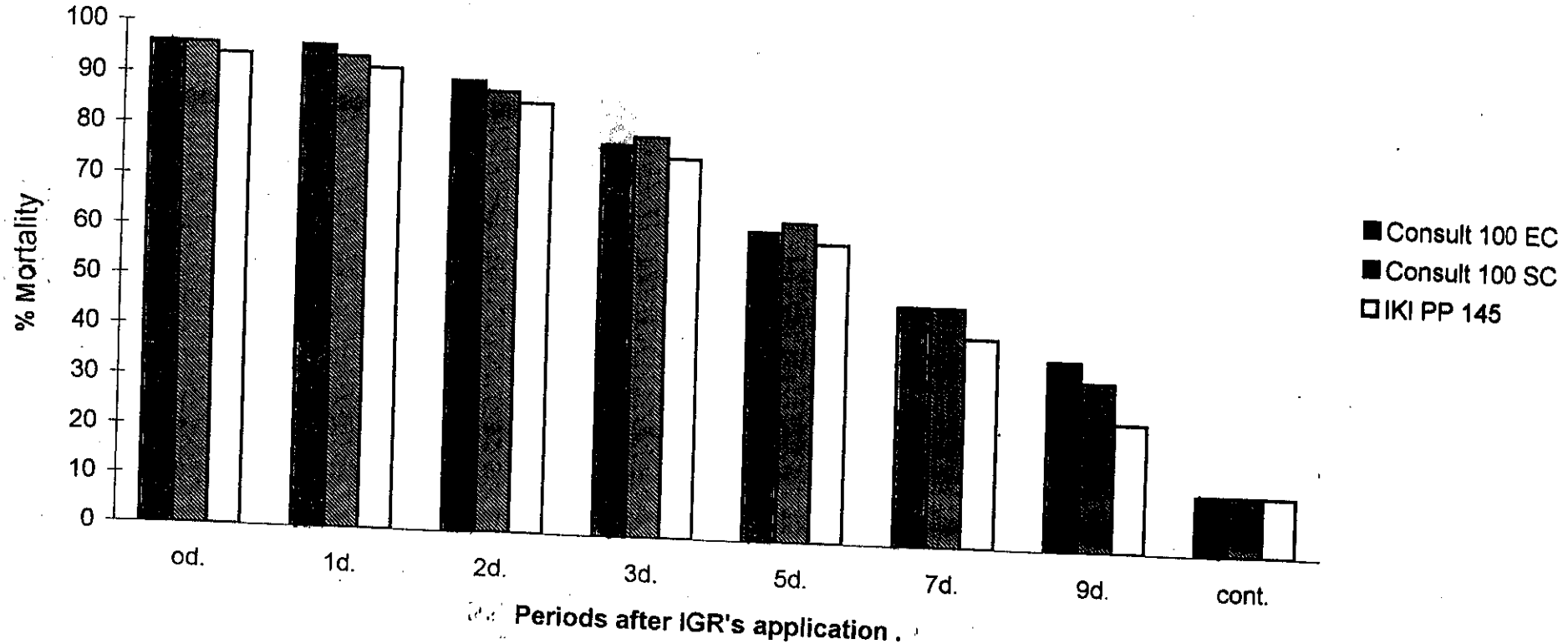
** highly significant

Table (12)

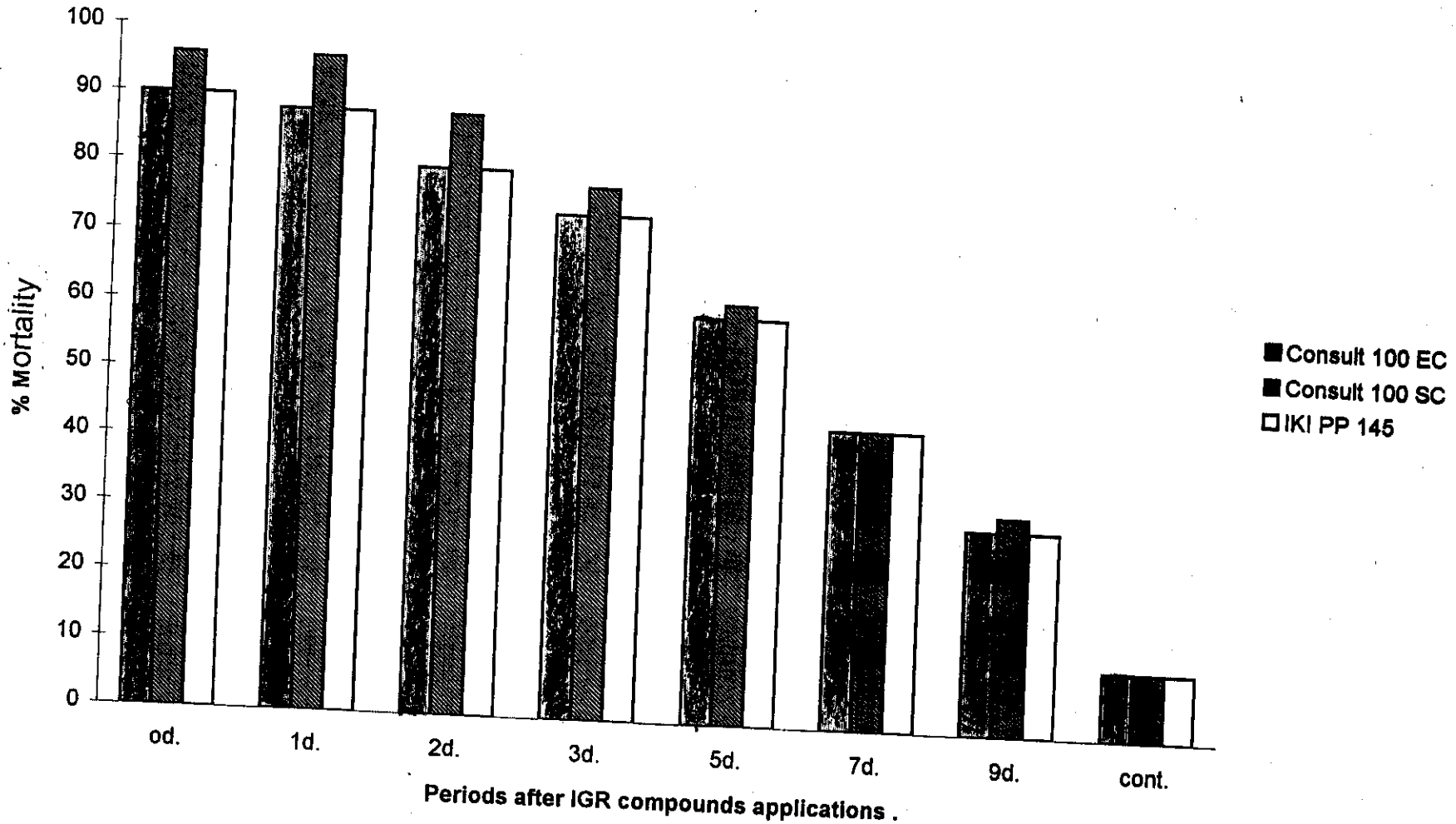
Effect of "Consult 100 SC" on comulative mortality, pupal weight, eggs' production and hatching percentage after treatment *2nd* and 4 *th* instar larvae of *S. littoralis* (results from 50 larvae / treatment) .

Time (d)	*2 nd* instar				*4 th* instar			
	% Comulative mortality	pupal weight (mg. ± SE)	No. of Eggs / female ± SE	Hatchability %	Comulative mortality %	pupal weight (mg. ± SE)	No. of Eggs / female ± SE	Hatchability %
zero	96.0	(292± 0.7)	(152)	0.0	92.0	(300±1.4)	(159)	0.0
1d.	94.0	(303 ± 0.7)	(163)	0.0	90.0	(314± 0.9)	(173± 0.9)	0.0
2d.	88.0	(317± 0.7)	(189 ± 0.9)	0.0	84.0	(324 ± 0.7)	(202 ± 0.7)	8.0
3d.	80.0	(326± 0.3)	(216 ± 0.9)	5.0	74.0	(335 ± 0.7)	(228± 0.5)	12.0
5d.	64.0	(344± 0.8)	(238± 0.9)	11.0	54.0	(353± 0.7)	(262± 0.4)	16.0
7d.	48.0	(359 ± 0.7)	(260± 0.7)	14.0	46.0	(366± 0.8)	(286 ± 0.5)	21.0
gd	34.0	(364± 0.4)	(285± 0.7)	18.0	30.0	(378 ± 0.8)	(292 ± 0.4)	24.0
cont	12.0	(415± 0.6)	(306± 0.3)	89.5	10.0	(418± 0.8)	(320± 0.4)	90.0
F.		495**	549**			366**	549**	
L.S.D at 1%		7.3	9.9			8.3	9.9	
at 5 %		5.3	7.2			6.0	7.2	

** highly significant



Fig(15): Percentages of comulative mortality resultant from 2 *nd* instar larvae of *S. littoralis* feeding on cotton leaves treated by three IGR compounds .



Fig(16): Percentages of comulative mortality resultant from 4 *th* instar larvae of *S. littoralis* feeding on cotton leaves treated by three IGR compounds .

As for *S.littoralis* pupae that resulted after 2*nd* and 4 *th* instar larval feeding on IGR treated cotton leaves , data in Tables (10 - 12) indicated reduction in their weights than control . The rate of reduction in pupal weight was found,clearly,dependent,on the period after the IGR application in the field until the time of treatment , the age of treated larvae and also on the assayed compound.In case of IKI PP145 treatments,(Table,10)the weight of resultant pupae ranged from 270 - 320 and 280 - 341 mg./pupa by treatment of the 2 *nd* and 4 *th* instar larvae, respectively. These values indicated reduction in the pupal weight by 22.89 - 34.94 % and 18.62 -33.17 %, respectively than control pupa 415 and 419 mg./pupa.The respective reductions in pupal weight due to larval treatment by Consult 100EC were 21.15 - 33.17 and 15.99 - 31.98% .In case of treatment by Consult 100 SC the pupal weight were found to be reduced by 12.29-29.64% and 9.57-28.23%, respectively than weight of control pupae;415,418 mg., respectively (Table,12).

The effects of IGR larval treatments extended also to the adult stage,as the resultant moths deposited fewer numbers of eggs than the moths from control . By feeding 2*nd* and 4 *th* instar larvae on IKI PP 145 treated cotton leaves, the subsequent moths laid 147-279 and 157-297 ggs/female, respectively opposed to 305 and 320/control female . Thus showing reductions in eggs' reproductivity by 8.52-51.8 and 7.19-50-94% than control by treatment of larval in their 2*nd* and 4*th* instars, respectively (Table,10).As shown in Table(11),larval feeding on Consult 100EC caused 8.82-51.31 and 9.43-50.31% reductions in the number of deposited eggs than control (306 and 318 eggs/female, respectively). In case of Consult 100 SC, the reduction percentages in eggs' production were 6.86-50.33 and 8.75-50.31%, respectively than those deposited by the control female (306 and 320eggs/ female respectively ,Table,12).

Not only the production of eggs was reduced due to larval feeding on IGR's, but also the percentages hatching was also diminished (Tables,10-12).It's clear from the mentioned tables that the effect was more pronounced when larvae were fed in their earlier instar on treated leaves. When the cotton leafworm second instar larvae were fed on cotton leaves treated by either of the three IGR

compounds, nill of the eggs produced bythe subsequent moths.By the 2 *nd* instar larval treatment,the hatchability percentages of emergence from eggs deposited by the subsequent adultsranged from 0-20,0-17and 0-18% for treatments by IKI PP145,Consult 100 ECand Consult 100 SC,respectively opposed to 88.7-89.5% hatching from eggs of the control(Tables,10-12).In cases of the 4*th* instar*S. littoralis* larval treatments, also severe effect occurred on the percentages of hatching within the subsequent eggs. Nill of the eggs deposited by female moths from larvae treated at O and 24 hrs.after treatment hatched.The respective hatchability percentages from eggs of treatments were 0-24,0-22 and 0- 24%, while those deposited by control moths showed 90% hatching (Tables, 10-12).

It is clear from Tables(10-12)and Figs.(15&16) that the severest effect of the IGR compounds on *S. littoralis* larvae occurred when treatment took place at zero time ; *i.e*, just after field application (highest larval mortality rates, least pupal weight, lowest eggs' productivity and also the least hatchability percentage). The effect decreased, gradually, by lengthening the period from application to treatment . Also , the effect appeared to be higher by feeding the larvae on treated food when they were in earlier instar ;*i.e.*,the 2*nd* instar larvae were, generally, more susceptible to treatment than those of the 4*th* instar. Comparing effectiveness of the 3 IGR compounds it could be,generally,deduced from Tables,(10-12) that IKI PP145 and Consult 100EC were nearly of the same effectiveness , while Consult 100 SC showed lower effect on the studied parameters.

These results are in harmony with the findings of Ammar *et al* (1986) who evaluated the effctiveness of 5 moult - inhibiting insect growth regulators (Dimilin, Bay SIR 8514, DOWCD 439, IKI-7899 and XRD-473) against *3rd* instar nymph of ***Brevicoryne brassicae***. The authors indicated that the compounds acted more as insecticides than as growth regulators, causing 100% delayed accumulated mortality by adult stage. Also, the compounds caused 70-100% reduction in progeny production and they found that the most effective of the compounds were IKI-7899 and X RD-473.Also, Sokar(1995) studied the efficiencies of the two IGR compounds ;*i.e.* Pyriproxyfen and Hexaflumuron against the development of 4*th* instar larvae of *S.littoralis* which were fed on treated castor-bean leaves. The author found that the comulative mortality . due to Pyriproxyfen treatments ranged from 37.3 to 91.0% at 0.1 to 100.0 ppm concentrations, while it

ranged from 32.1 to 96.1% at the same concentrations, in case of Hexaflumuron.Also, he added that the average of pupal weight ranged from 236- 288 and 286- 332 mg. by using Pyriproxyfen and Hexaflumuron, respectively opposed to 426 mg in the control.The females' fecundity was drastically affected by using either of the two IGR's at LC_{25} & LC_{50} ppm. The reduction in eggs' production / female was found dependent on the concentration of assayed compound.

2 - Biological activity of IGR compounds:

The delayed effects of IGR compounds on the surviving larvae and also the subsequent stages after treatment of the *2nd* and *4th* larval instars are shown in Tables (13-15).

A- Effect on larval period :

It could be generally concluded from Tables (13-15) that larval feeding on cotton leaves treated by either of the IGR compounds resulted in an prolongation of the larval period . Such effect varied according to the period elapsed between field application of the compound and the time of treatment,on one hand, and the used compound, on the other hand.IKI PP 145 showed the greatest effect on the larval period in both of *2nd* and *4th* instars.This period occupied 23.6-27.9 and 20-23.6 days in case of IKI PP145 treatment (Table 13), 12.8 - 26.4 and 19.7- 23.5 days for Consult 100 EC(Table 14), and 22.6 -26.6 and 9.9- 23.6 days for Consult 100 SC treatment (Table 15) of larvae in their *2nd* and *4th* instars, respectively opposed to 19.3-21.1days for the control larvae.Generally the effect of *S. littoralis* larval feeding on cotton leaves treated by IGR compounds' prolongation of the larval period) increased by shortening the period from field application of the compound to the laboratory treatment.By treatment at zero time,the longest larval periods were detected (IKI PP 145;27.9Ý0.3(25-29), Consult 100 EC ; 26.4±0.4(25-30)and Consult 100 SC;26.6± 0.3 (25-29)days for larvae treated in their *2nd*

Table (13)

Effect of " I K I PP145 " on *S . littoralis* larval and pupal durations (/days) after feeding the 2 *nd* and 4 *th* instars on treated cotton leaves after different periods from application (at 26°C and 70% R.H.) .

(d)	2 *nd* instar		4 *th* instar	
	Larval period *	Pupal duration	Larval period *	Pupal duration
zero	27.9± 0.3 (25 - 29)	20.8± 0.6 (19 -22)	23.6±0.6 (19 -28)	19.9± 0.7 (16 - 21)
1d.	26.8± 0.2 (24 - 28)	20.7±0.7 (18 -24)	22.9± 0.6 (19 - 28)	19.6±0.6 (16 -21)
2d.	26.2± 0.2 (23 - 27)	19.7± 0.7 (17 -24)	22.4±0.5 (18 - 27)	19.2± 0.4 (15 - 20)
3d.	25.6± 0.1 (23 - 26)	19.1±0.6 (16 -23)	21.9± 0.5 (17 - 26)	18.8± 0.3 (14 -19)
5d.	24.9± 0.2 (22-26)	18.5±0.3 (15 -22)	21.3± 0.4 (17 - 25)	18.2± 0.4 (13 -19)
7d.	24.3±0.2 (21 -25)	17.8±0.3 (15 -21)	20.6± 0.3 (17 - 24)	17.8± 0.4 (13 -19)
gd	23.6±0.2 (20 -25)	17.2±0.3 (14 -20)	20.0± 0.3 (17 -23)	17.2± 0.3 (11 -18)
cont	21.0±0.2 (19 -23)	16.5±0.3 (13 -19)	19.3± 0.3 (17 - 22)	16.1± 0.2 (10 -17)

* = The larval period from treatment until pupation .

Table (14)

Effect of " Consult 100 EC " on *S . littoralis* larval and pupal durations (/days) after feeding the 2 *nd* and 4 *th* instars on treated cotton leaves after different periods from application (at 26°C and 70% R.H.) .

(d)	2 *nd* instar		4 *th* instar	
	Larval period *	Pupal duration	Larval period *	Pupal duration
zero	('26.4± 0.4) (25 - 30)	('20.0± 0.7) (19 -22)	(23.5±0.7) (20 -29)	(19.7± 0.7) (18 - 21)
1d.	('25.7± 0.3) (25 - 29)	('19.5±0.7) (18 -24)	(22.7± 0.5) (19 - 28)	(19.3±0.7) (18 -21)
2d.	('25± 0.2) (24 - 29)	(18.9±0.7) (17 -24)	(22.0±0.4) (18 - 26)	(18.8± 0.5) (15 - 20)
3d.	(24.4± 0.2) (23 - 27)	(18.5±0.6) (16 -23)	(21.1± 0.4) (17 - 25)	(18.3± 0.4) (14 -19)
5d.	('23.7± 0.2) (22-26)	(18.1±0.4) (15 -22)	(20.5± 0.4) (16- 23)	(17.3± 0.2) (13 -18)
7d.	('22.9±0.2) (21 -25)	(17.3±0.3) (15 -21)	(19.9± 0.2) (17 - 22)	(17.2± 0.2) (12-17)
gd	('21.8±0.2) (20 -24)	(16.7±0.3) (14 -20)	(19.7± 0.1) (17 -21)	(16.9± 0.3) (11 -17)
cont.	('20.3±0.2) (19 -23)	(16.1±0.2) (13 -19)	(19.3± 0.2) (16 - 20)	(16.0± 0.2) (10 -16)

* = The larval period from treatment until pupation .

Table (15)

Effect of " Consult 100 SC " on *S . littoralis* larval and pupal durations (/days) after feeding the 2 *nd* and 4 *th* instars on treated cotton leaves after different periods from application (at 26°C and 70% R.H.) .

(d)	2 *nd* instar		4 *th* instar	
	Larval period *	Pupal duration	Larval period *	Pupal duration
zero	(26.6± 0.3) (25 - 29)	(20.3± 0.7) (19 -22)	(23.6±0.7) (20 -28)	(19.8± 0.9) (16- 21)
1d.	(26.0± 0.3) (24 - 28)	(19.7±0.9) (18 -24)	(22.8± 0.7) (19 - 28)	(19.5±0.7) (16 -21)
2d.	(25.5± 0.3) (23 - 27)	(18.9±0.7) (17 -24)	(22.0±0.6) (18 - 27)	(18.8± 0.5) (15 - 20)
3d.	(24.8± 0.2) (22 - 25)	(18.4±0.3) (16 -20)	(21.2± 0.5) (17 - 26)	(18.2± 0.4) (14 -19)
5d.	(24± 0.2) (22-25)	(17.9±0.5) (15 -22)	(20.6± 0.4) (17- 25)	(17.8± 0.3) (13 -19)
7d.	(23.5±0.1) (21 -24)	(17.6±0.3) (15 -21)	(20.1± 0.4) (17 - 29)	(17.2± 0.3) (13-18)
gd	(22.6±0.2) (20 -24)	(16.9±0.3) (14 -20)	(19.9± 0.3) (17 -23)	(16.9± 0.2) (11 -18)
cont	(21.1±0.2) (19 -23)	(16.4±0.3) (13 -19)	(19.5± 0.3) (16 - 22)	(16.2± 0.2) (10 -17)

* = The larval period from treatment until pupation .

instar).The same trend occurred when the *4th* instar larvae were fed on treated food (IKI PP 145 ; 23.6±0.6 (19-28), Consult 100EC ; 23.5 ±0.7 (20-29) and Consult 100SC; 3.6±0.7 (20-28) days).On the contrary , the shortest larval durations (although still longer than those of the control records) were recorded for larvae treated in the mentioned instars after 9days of IGR compounds field application, IKI PP 145. 23 ± 0.2 (20- 25) , Consult 100 EC 21.8± 0.2 (20 - 24) and Consult100SC 22.6 ±0.2(20-24)days) for larvae treated in their *2nd* instar and IKI PP145; 20.0±0.3(17-23), (Consult 100EC ;19.7±0.1(17-21) and Consult 100SC;19.9 ±0.3(17-23)days for larvae treated in their *4th* instar. As shown in Tables (13-15) intermediate records of total larval periods were detected by feeding the *2nd* and/or *4th* instar of *S. littoralis* larvae for 24 hours on IGR's treated cotton leaves after 1 - 8 days from the IGR field application .

Data illustrated in Fig., (17) demonstrate the rates of deviation (increase) in the larval period due to IGR treatments than control. The presented data show clearly that the highest increase in larval period than control (32.9%) occurred by application of IKI PP 145 and larval feeding on the cotton treated leaves just after application of the compound (at zero(time). Data, generally, indicated that IKI PP145 was the most effective, followed by Consult 100 EC and Consult 100 SC,the illustrated figure show also that the effectiveness of either of the three compounds decreased gradually (decrease in the rate of deviation in total larval period than control) as the period elapsed after the IGR application and up to starting the treatment increased.The slightest deviation % in larval period than control (7.1%)was detected when the second instar larvae were fed on treated cotton leaves after 9days of consult 100SCappliction on cotton plants in the field(Fig.17).Data illustrated in Fig.,(18)demonstrate the rates of deviation (increase) in total larval period due to *S.littoralis* 4 *th* instar larval feeding on IGR's treated cotton leaves after different periods(0-

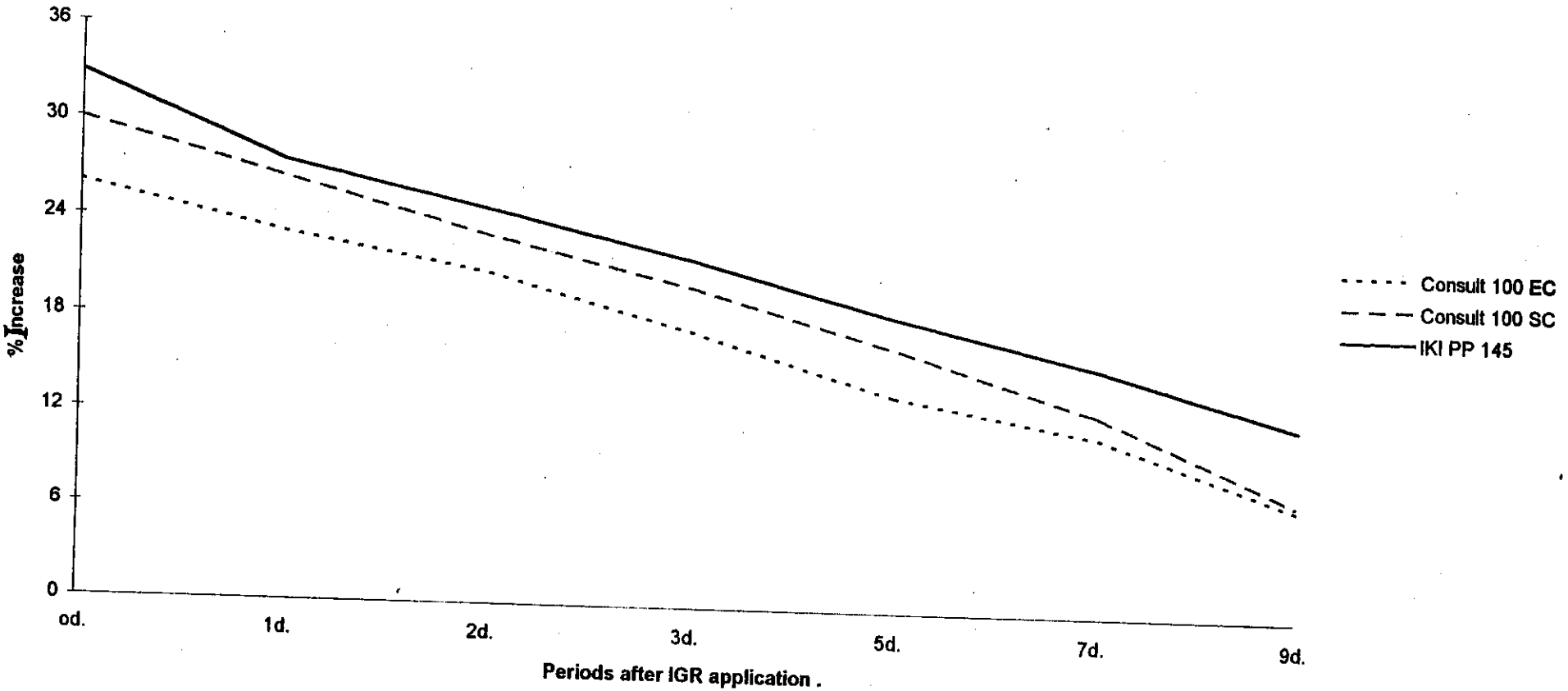


Fig. (17):Effect of *S.littoralis* 2 *nd*instar larval feeding on IGR treated cotton leaves on the rate of deviation in the total larval period than control .

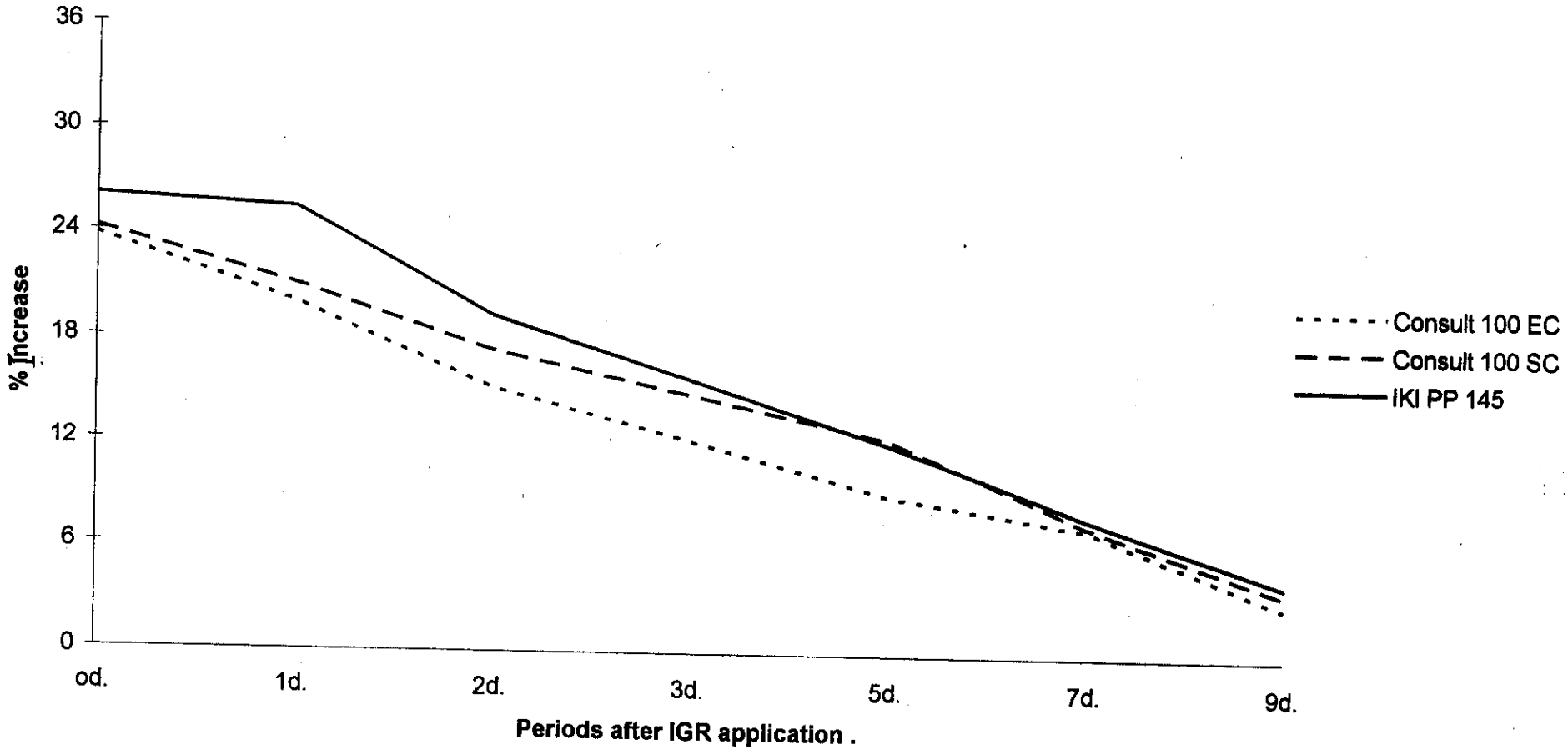
9 days) of the IGR's application than contorl. It is clear from this figure that the same trend of forementioned effect occurred by the 2nd instar treatments, was also detected in case of *S. littoralis* 4th instar larval treatment, although the rates of deviation were , generally, lower by treatment of older instar larvae *i.e.* , younger larvae were susceptible to IGR treatment than older ones. Thus indicating that the effect was mainly dependent on three factors; a- the compound used. b- the period after field application until starting treatment and c- the age of larvae at the time of treatment.

B. Effect on pupal duration:

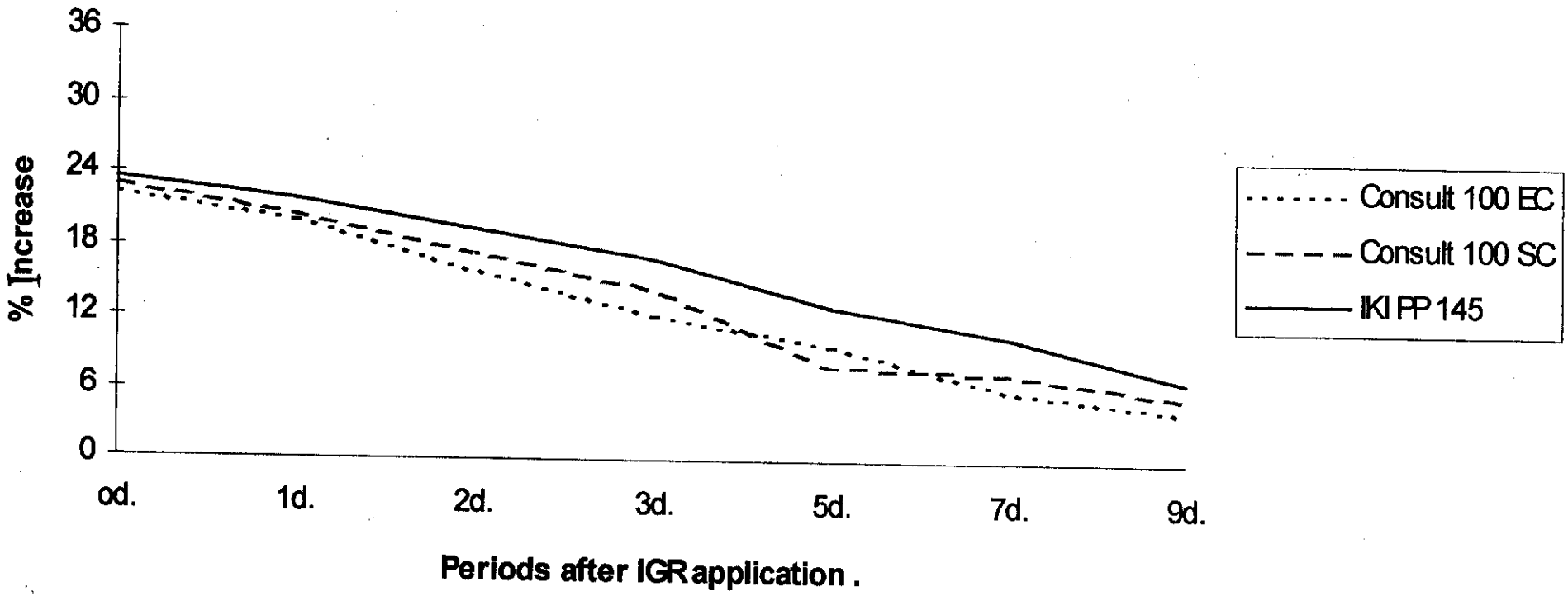
From data recorded in Tables (13,14 and 15), it is clear that feeding of *S. littoralis* 2nd or 4th instar larvae on cotton leaves contaminated by either of the three IGR compounds (IKI) PP145, Consult 100 EC or Consult 100 SC increased the durations of subsequent pupae than control. The rate of increase varied according to the applied compound and the periods after applicatioon. IKI PP 145 showed the greatest efficiency on the pupal duration by treatment in 2 nd or 4th larval instar. The longest pupal periods occurred amongst pupae that resulted from 2nd instar larvae fed for 24 hours just after IGR's application (at zero time), being 20.8 ± 0.6 days in case of IKI PP145 , 20.3± 0.7 days for Consult 100 SC and 20 ± 0.7 in case of Consult 100EC, opposed to 16.1 - 16.5 days in cases of the control pupae. When treatment took place on the 4th instar larvae, at zero time also, the recorded durations of pupal stage became shorter than those recorded in

cases of the 2nd larval instar treatments, although still longer than the control (19.9 ± 0.7, 19.8 ± 0.9 and 19.7±0.7 days for treatments by IKI PP145, Consult 100SC and consult 100 EC respectively). By longthening the period from IGR's application until larval treatment, the effect of IGR's treatment to *S. littoralis* larvae of pupal duration decreased, and the slightest effect was detected by treating the 4th instar larvae after 9 days of application (16.1 ± 0.3, 16.9 ± 0.2 and 17.2 ± 0.4 days for Consult 100 EC, Consult 100 SC and IKI PP 145 treatments , respectively , opposed to 16-16.2 days as duration of control pupae, (Tables, 13-15).

The deviations in pupal duration than control due to IGR's treatment by feeding the previous larvae on IGR's treated cotton leaves are graphically illustrated in Figs. (19&20). Both figures show clearly that the highest deviation (increase) than control in pupal duration occurred by feeding either of the 2nd or 4 th instar larvae on IGR's treated cotton leaves at zero time (just after applications) as the pupal durations became longer than that of control by 26.1 , 24.2 and 23.8% in case of second instar larval treatment (Fig. 19) and by 23.6, 23.1 and 22.2 % in case of 4th instar treatment (Fig. 20) by using IKIPP 145 , Consult 100 EC and Consult 100 SC, respectively. The deviation in pupal duration than control decreased, successively, as the period from field application to starting larval treatment became longer until reached the lowest rates when larval treatment took place after 9 days of IGR's application (4.2 , 3.7 and 3% , respectively for 2nd instar



Fig(19): Effect of *S.littoralis* 2 *nd* instar larval feeding on IGR treated cotton leaves on prolongation of pupal duration .



Fig(20): Effect of *S.littoralis* 4 *th* instar larval feeding on IGR treated cotton leaves on prolongation of pupal duration .

treatment ;(Fig. 19), and 8.6 , 5.6 and 4.3% , respectively for 4th instar treatment,(Fig, 20).

Similar results concerning the effect of IGR's larval treatment on the larval and pupal durations were obtained by previous authors. El-Sweerki, (1994) studied the short- term biological activity of Pyriproxyfen on the 4th instar larvae of *S. littoralis*. The author found that the Pyriproxyfen prolonged the larval duration than control and the prolongation rate was a concentration dependent. Khan and Serivastava (1988) indicated that treatment of larvae of *Pericallia ricini* Fabr. (Lepidoptera: Archtiidae) by Denfluron at 0.01 % caused prolongation in the larval and pupal periods by 29.52 and 38.46%, respectively. Also, Sokar, (1995), studied the effect of Pyriproxyfen (a juvenoid compound) and Hexaflumuron (an antimoulting compound) on the 4th instar larvae of *S. littoralis* by using leaves dipping technique. The author found that the two IGR compounds increased the larval duration by different proportions, the increase varied for each compound and concentration. All the Pyriproxyfen concentrations prolonged the larval duration but an obvious inverse proportion between concentration and larval duration was noticed where the lowest concentration (0.1 ppm.) caused the longest larval duration (21.82 days) compared to the untreated larvae (17.0 days) . In case of Hexaflumuron, the opposite of that trend was observed, where the increase in larval duration was augmented by increase in concentration. The deviation percentage from the normal values ranged from 3.0 to 28.4 % in case of Pyriproxyfen and 0.7 to

27.1% for Hexaflumuron treated larvae. Both IGR's prolonged the pupal duration with the same correlation, negative and positive for Pyriproxyfen and Hexaflumuron concentrations, respectively. The deviation percent than the normal ranged from + 1.2 to + 23.0 % in case of Pyriproxyfen and +2.4 to + 42.6 % for Hexaflumuron at 0.1 -100.0 ppm. concentrations , respectively.

C- Effect on pupal weight.

The freshly formed pupae that resulted from 2nd and 4th instar treated larvae, and those from control larvae were weighed and the obtained results are graphically illustrated in Figs ; (21&22). It could be generally observed from the mentioned figures that larval feeding on cotton leaves treated by either of the IGR compounds lead to pupae lighter in their weight than those from the check. The same figures also show that the pupae became heavier in their weights as the period after application until starting larval feeding became longer. It could be also deduced from Tables (10-12) that the effect of larval treatment became more pronounced on pupal weight by feeding the larvae at earlier instar; *i.e.*, more effect occurred by treatment to second instar larvae. Accordingly, it is clear that the highest effect of IGR's in reducing the pupal weight occurred by treatment the second instar *S. littoralis* larvae at zero time (weight of pupa 270, 278 and 292 mg. by using IKI PP 145 , Consult 100 EC and consult 100 SC, respectively opposed to

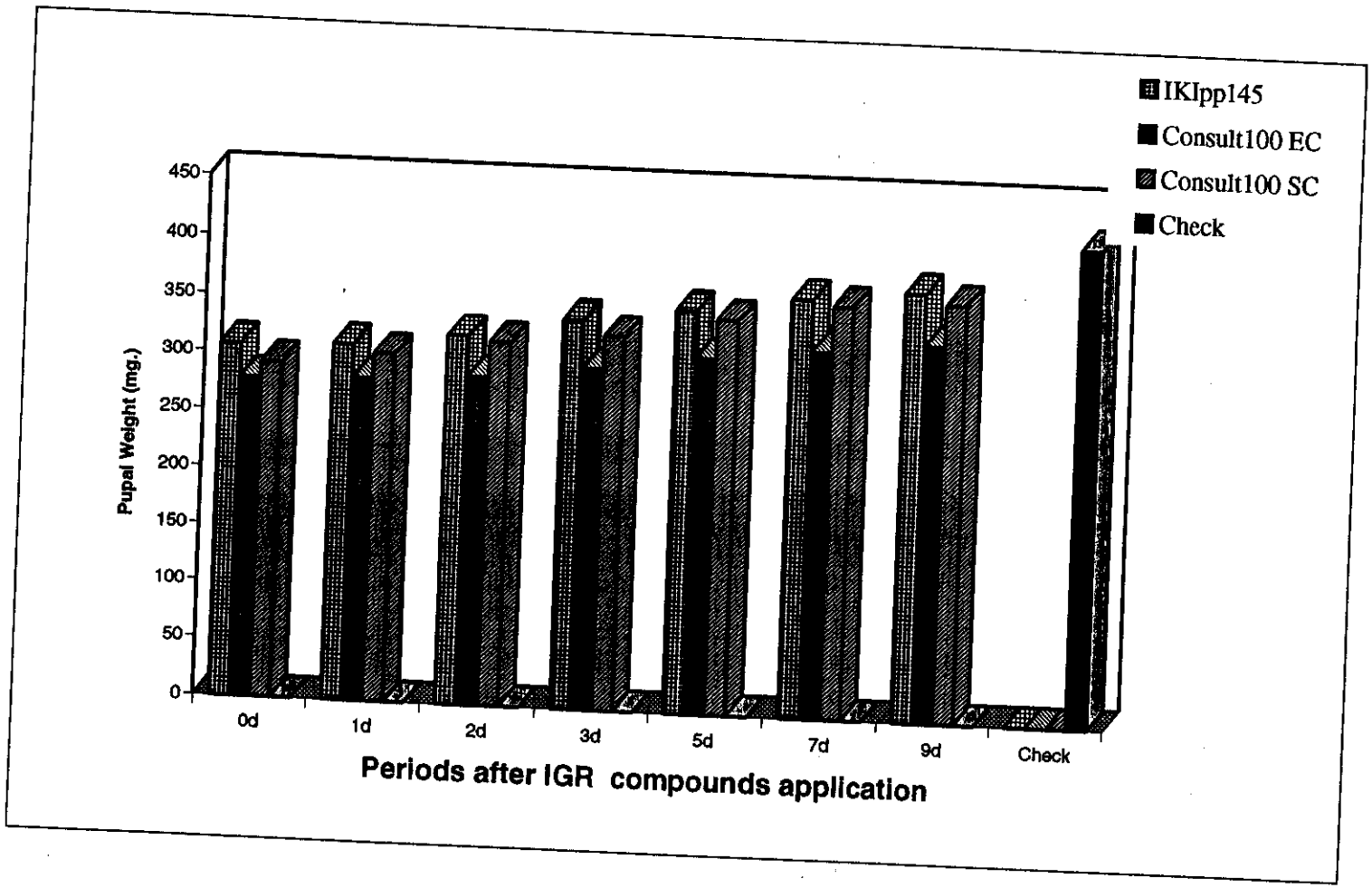


Fig. (21) : Effect of *S. littoralis* 2nd instar larval feeding on IGR's treated cotton leaves on weight of the resultant pupae.

415-416 mg. for the control pupae). By treatment of the 4th instar larvae, at zero time also, the recorded values of pupal weight were 280, 285 and 300 mg., respectively (Tables ; 10-11). On the other hand , the heaviest pupae from treatments were those resulted by feeding the 4th instar larvae on treated cotton leaves after 9 days of IGR's application (341,352 and 378 mg. from treatments by IKI PP 145 , Consult 100 EC and Consult 100 SC, respectively). The corresponding figures from treatment of 2nd instar larvae (also after 9 days of application) were 320 , 328 and 364 mg. , respectively). The efficacy of the three IGR compounds assayed in this experiment could be arranged, descendringly as IKI PP145 , Consult 100 EC and Consult 100 SC . Statistical analysis revealed highly significant differences between the efficacy of IGR compounds on pupal weight in the pupae resulting from the treated 2nd and 4th instar larvae . Also , the calculated "t" values (Tables, 10-12) indicated highly significant effect on pupal weight by lengthening the period from IGR application to the time of larval treatment, although the difference in effect on pupal weight was insignificant by treatment at zero time and after 24 hours in cases of IKI PP145 (Table, 10) and Consult 100 EC (Table, 11).

Concerning the effect of *S. littoralis* larval treatment by IGR's on subsequent pupae, El - Sayed (1984) mentioned that Diflubenzuron treatments to the fourth nstar larvae of *S. littoralis* caused decreased larval weight and reduction in subsequent pupation and adult emergence%. Sokar (1995) indicated a negative correlation between *S. littoralis* pupal weight and the increasing of

the tested concentrations of Pyriproxyfen and Hexaflumuron on which the 4th instar larvae were fed . The reduction in pupal weight resulted ranged from - 0.7 to - 18.6 % at 0.1 and 100.0 p.p.m Pyriproxyfen and - 2.9 to - 16.4 % in case of Hexaflumuron at the same concentrations respectively .

D- Effect on pupation:

The mean percentages of normally formed pupae varied amongst pupae from different treatments (28 - 84% in the 2nd instar treated larvae and 30-86% in the 4th instar treated larvae by treatment at zero time and after 9 days of IKI PP 145 field application, respectively ; Table , 16). In case of consult 100 EC the corresponding values were 26 - 80 % and 30 - 82 % , respectively (Table, 17), while in case of Consult 100 SC , the respective mean percentages of pupation varied between 26 - 82 in the 2nd instar treated larvae and 30 - 86% in the 4th instar treated larvae (Table, 18) opposed to 92 - 94% normal emergence from the control pupae . It is clear from the mentioned tables that the severest effect occurred when treatment took place just after application of IGR compounds. This effect decreased and the percentage of normally formed pupae increased by the lengthening of the period from IGR application to treatment. Data in Tables (16 -18) and Figs. (23 & 24) indicate also that the 2nd instar larvae were more susceptible than the 4th instar larvae as more normal pupae were obtained in the latter case.

Table (16)

Effect of *S. littoralis* larval treatment by IKI PP_{145} on Pupation , Emergence,Adult's longevity and Malformed stages .

Periods (d)	2 *nd* instar								4 *th* instar							
	%	%	adult longevity (days)		% Malformed stages				%	%	adult longevity (days)		% Malformed stages			
	Pupation	Emergence	M	F	L	P	A	T	Pupation	Emergence	M	F	L	P	A	T
zero	28	28.6	5.5	5	28	4	2	34	30	40	6.7	5.5	24	2	2	28
1d.	32	37.5	6	5.5	22	6	4	32	36	45.3	7.3	6.7	20	2	2	24
2d.	42	47.6	6.7	6	16	8	6	30	44	59	7.5	7	14	8	2	24
3d.	50	59.5	7.3	6.8	16	6	2	24	54	69.5	7.7	7.4	16	6	4	26
5d.	68	69.8	7.8	7.3	10	4	2	16	70	78.9	8.2	7.8	10	10	4	24
7d.	76	81.4	8.4	8	8	_	_	8	78	86.4	8.7	8.3	8	4	2	14
gd	84	88.1	8.8	8.4	4	_	_	4	86	89.7	9.3	8.7	4	2	2	8
cont	92	91.3	9.3	8.8	_	_	_	_	94	95.8	9.6	8.9	_	_	_	_

A. adult F. female L. larvae M. male P. pupae T. total

Table (17)

Effect of larval treatment by Consult 100EC on Pupation , Emergence,Adult's longevity and Malformed stages of the 2*nd* and 4 *th* instars larvae of *S. littoralis* .

Periods (d)	2 *nd* instar								4 *th* instar							
	% Pupation	% Emergence	adult longevity (days)		% Malformed stages				% Pupation	% Emergence	adult longevity (days)		% Malformed stages			
			M	F	L	P	A	T			M	F	L	P	A	T
zero	26	23.1	6	5	22	8	2	32	30	33.3	6.5	5.5	26	10	_	36
1d.	32	18.8	6.5	6	20	14	2	36	34	41.2	7	6.5	24	12	2	38
2d.	40	40	7	6.3	20	14	6	40	42	57.1	7.3	7.8	22	10	4	36
3d.	48	58.3	7.2	6.8	18	12	_	30	50	68	7.6	7.2146	20	8	4	32
5d.	66	66.7	8.1	7.7	12	10	10	32	66	76.5	8.2	7.7	12	10	2	24
7d.	76	78.9	8.7	8	8	8	8	24	76	83.3	8.7	8.1	10	8	2	20
gd	82	82.9	9.3	8.4	8	6	6	20	86	86.4	9.2	8.4	8	4	4	16
cont	92	91.3	9.4	8.5	_	_	_	_	94	95.8	9.5	8.6	_	_	_	_

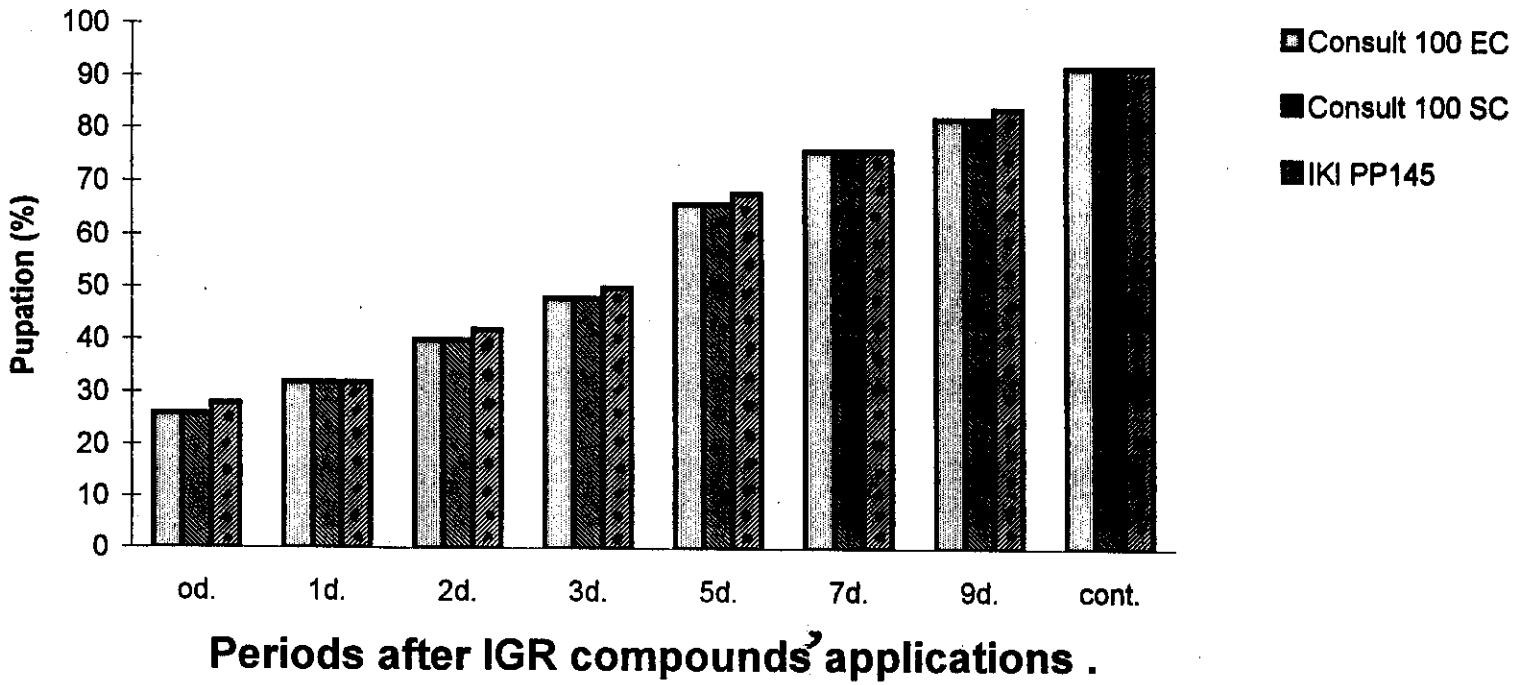
A. adult F. female L. larvae M. male P. pupae T. total

Table (18)

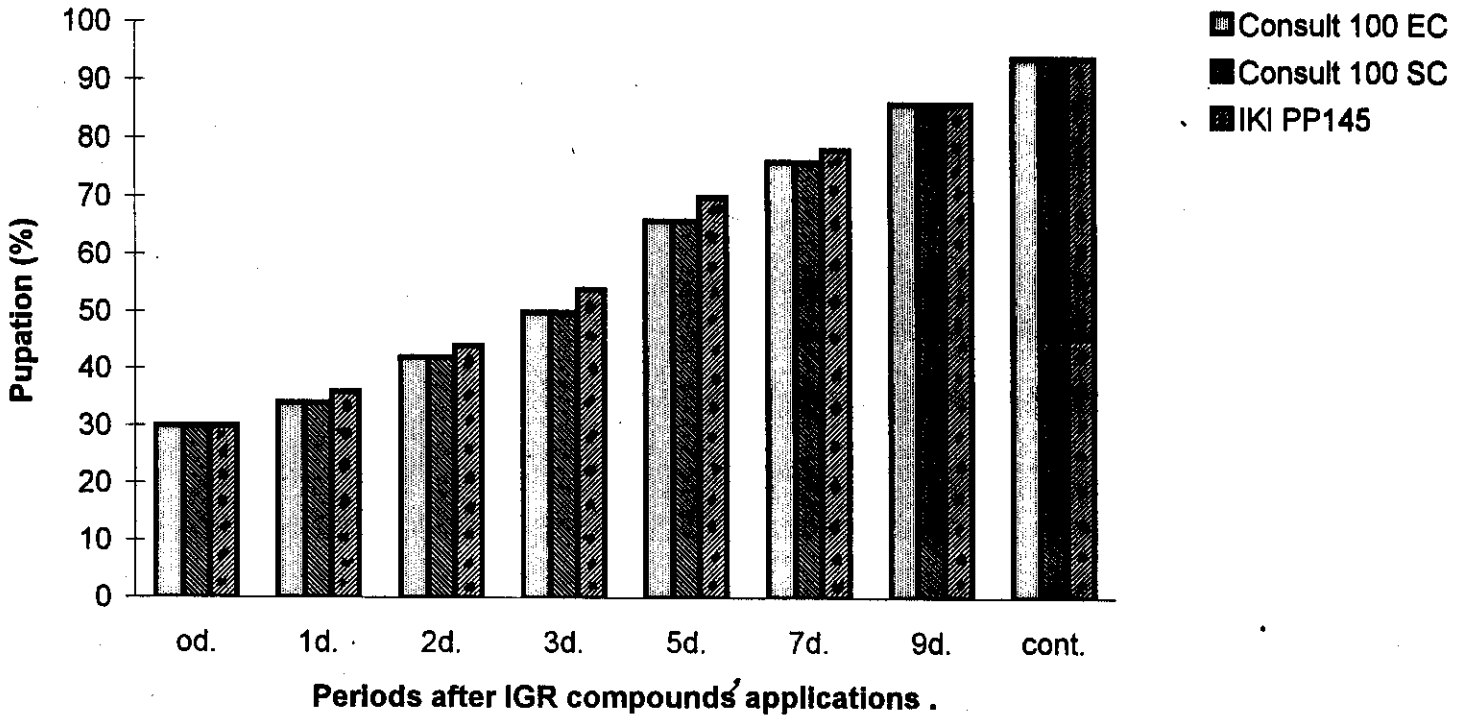
Effect of larval treatment by Consult 100SC on Pupation , Emergence,Adult's longevity and Malformed stages of the 2*nd* and 4 *th* instars larvae of *S. littoralis* .

Periods (d)	2 *nd* instar								4 *th* instar							
	% Pupation	% Emergence	adult longevity (days)		% Malformed stages				% Pupation	% Emergence	adult longevity (days)		% Malformed stages			
			M	F	L	P	A	T			M	F	L	P	A	T
zero	26	23.1	6	5	22	8	2	32	30	33.3	6.5	5.5	24	10	2	36
1d.	32	18.8	6.5	6	20	8	_	38	34	41.2	7	6.5	22	8	2	32
2d.	40	40	7	6.3	24	6	4	34	42	57.1	7.3	6.8	20	8	4	32
3d.	48	58.3	7.2	6.8	16	8	8	32	50	68	7.6	7.2	14	6	4	24
5d.	66	66.7	8.1	7.7	14	10	8	32	66	76.5	8.2	7.7	10	6	2	18
7d.	76	78.9	8.7	8	8	8	4	20	76	83.3	8.7	8.1	6	4	2	12
gd	82	82.9	9.3	8.4	8	6	2	16	86	86.4	9.2	8.4	4	2	_	6
cont	92	91.3	9.4	8.5	_	_	_	_	94	95.8	9.5	8.6	_	_	_	_

A. adult F. female L. larvae M. male P. pupae T. total



Fig(23): Percentages of pupation resulted from 2*nd* instar larval feeding on IGR's treated cotton leaves .

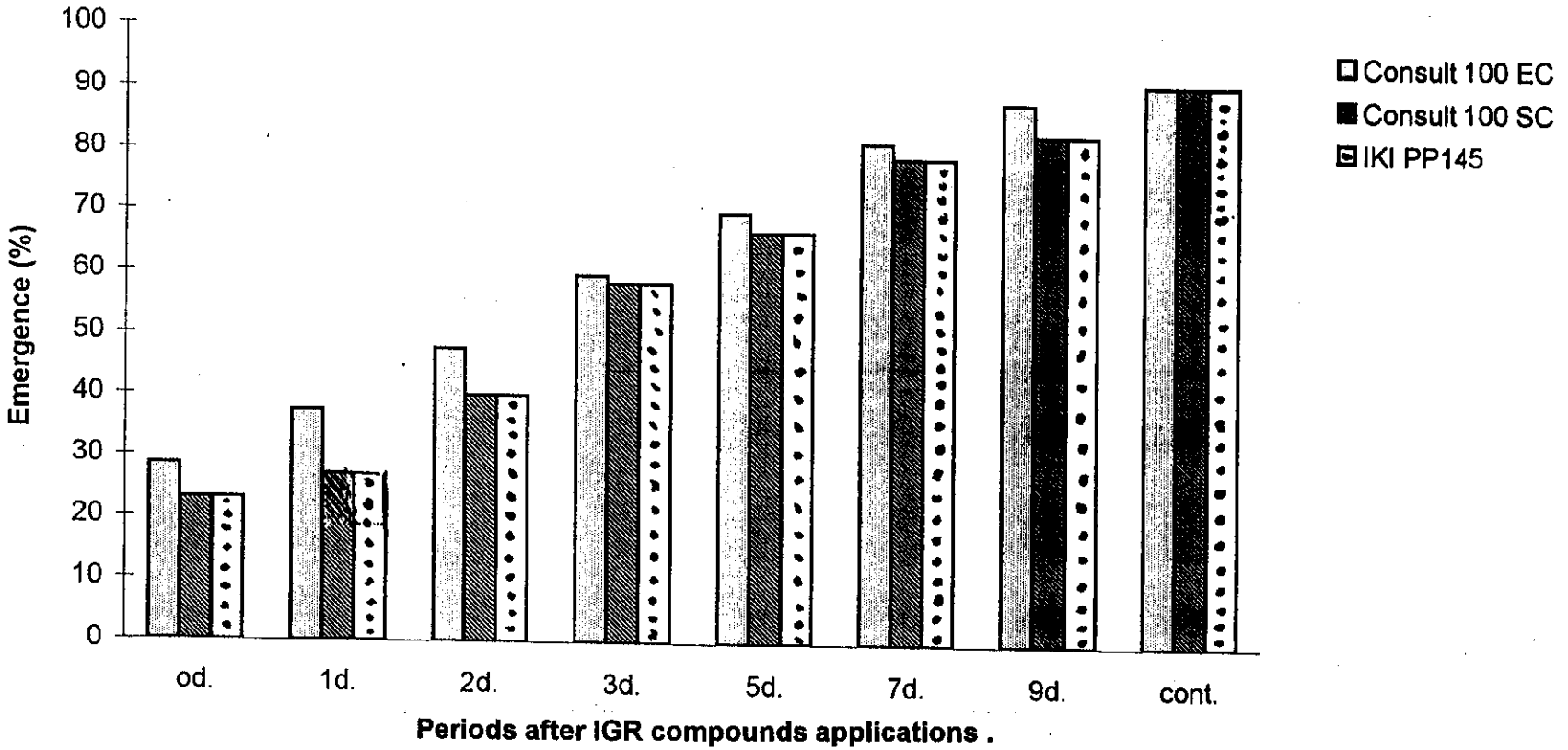


Fig(24): Percentages of pupation resulted from 4 *th* instar larval feeding on IGR's treated cotton leaves .

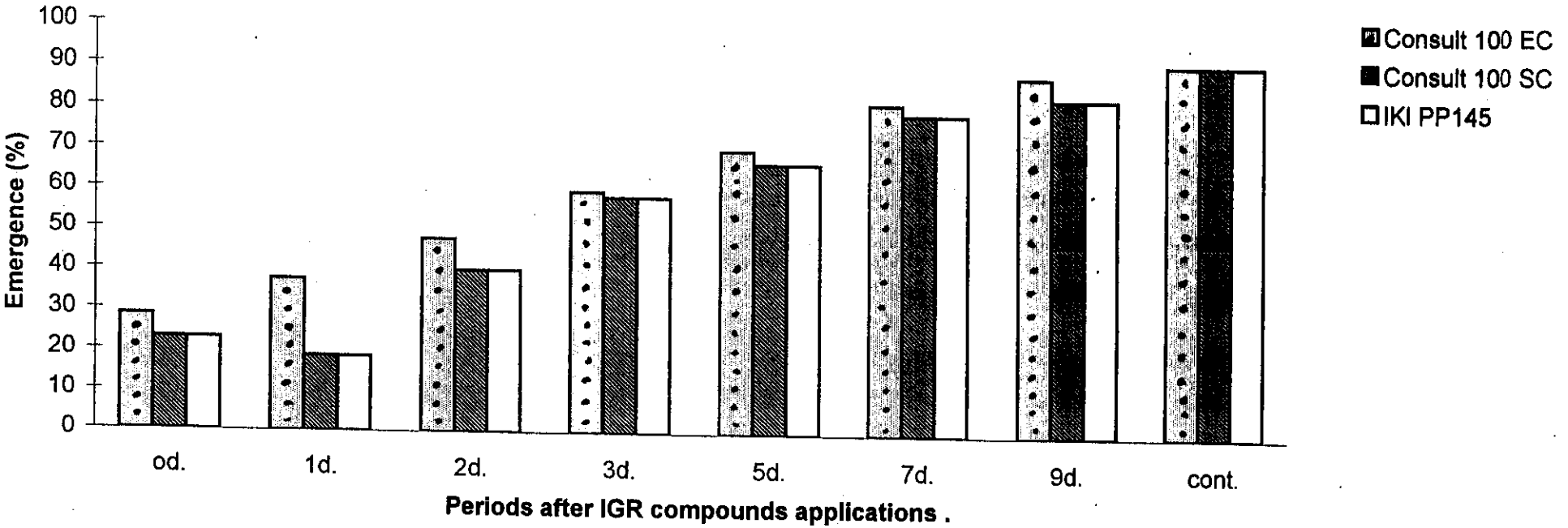
These ressults are in harmony with the findings of Mostafa and El- Attal (1985) who determined the effect of Triflumuron against 2-days old 6th instar larvae of the *S. littoralis* . They showed that the increase in Triflumuron concentration was proportional to the reduction in percentage pupation. The concentration of 130 mg./l produced the least percentage of pupation, and all pupae died and failed to continue their life-cycle. The other concentrations however showed similar to / or lower percentage of pupation compared with the control. Also, Sokar(1995) found an obvious negative relationship between the percentages of pupation and concentrations of Pyriproxyfen and Hexaflumuron against the 4th instar larvae of *S. littoralis.* Pyriproxyfen & Hexaflumuron caused failure in pupation 50.7% & 68% at 100.0 p.p.m. concentration.

E- Adults' emergence:

As shown in Tables (16-18) and Figs. (25&26),the same tendency of IGR compounds' effect on successful pupation after larval treatment was also detected on the percentages of adults' emergence (28.6 - 88.1% and 30 - 86% by treatment of the 2nd and 4th instar larvae with IKI PP 145 application, 15.4-80.5 % and 20 - 85.1% in cases of Consult 100 EC treatments, 23.1 - 82.9 % and 33.3 - 86.4% for treatment by Consult 100 SC at zerro time and after 9 days of application, respectively). Also, the effect on successful emergence of adults decreased by treatment of older instar.



Fig(25): Percentages of Emergence resulted from 2 *nd* instar larvae of S. littoralis fed on Concult 100 EC , Consult 100 SC and IKI PP_{145} .



Fig(26): Percentages of emergence resultant from 4 *th* instar *S. littoralis* larval feeding on Consult 100 EC , Consult 100 SC and IKI PP_{145} .

The obtained results are in harmony with the findings of El-Sayed (1984) who determined the effectiveness of Diflubenzuron alone or with Hostathion, against larvae and adults of *S.littoralis*.The author found that treatment with Diflubenzuron caused reduction in adults' emergence . Such effect was in proportional to the period of exposure to treated leaves and the concentration used. Also , El-Sweerki (1994) found that *S. littoralis* adults' emergence ranged from 46-76.4 % due to treatment of 4th instar lavae by Pyriproxyfen at 10.0 p.p.m. and 0.01 p.p.m. concentrations, respectively .

F. Deformations amongst different stages :

Data tabulated in Tables (16-18) , clearly, show that *S. littoralis* larval feeding on cotton treated leaves led to different degrees of malformations amongst the treated larvae, pupae and adults. Normally, the malformed stages were not able to survive. Amongst the obtained deformities, many larval - pupal and pupal - adult intermediates were observed (Figs. 27 B&D). Higher percentages of deformities occurred amongst the treated larvae (4 to 28 & 4 to 24 %) than amongst the resultant pupae (0 to 8 & 2 to 10%) and adults (0 to 6 & 2 to 4 %) by treatment of the 2nd and 4thinstars larvae at zero time and after 9 days of IKI PP 145 application, respectively .The same observation was also detected in cases of larval treatment by Consult 100 EC (8 to 24% & 8 to 22% amongst larvae; 4-12% & 6 to 14% for pupae and 0 to 4% & 0 -10 % malformed adults, and Consult 100 SC (8 to 30 % & 4 to

(A)

(B)

(C)

(D)

(E)

Fig. (27) Different morphogenic patterns induced by "IGR compounds" against different stages of S. *littoralis*.

A) Malformed larva.

B) Larval - pupal intermediates.

C) Malformed pupae.

D) Moth-pupa intermediate.

E) Malformed adults.

24% for larvae; 6 to 10 % & 2 to 10% for pupae and 0 to 8 % & 0 -4 % for adults). The total malformation percentages ranged from 4 to 34 % & 8 to 28 ; 16 to 38 % & 20 to 40 % and 16 to 38% & 6 to 36 % by treatment of the 2nd & 4th larval instars with IKI PP 145 , Consult 100 EC and Consult 100 SC, respectively . Treatment of larvae at intermediate periods after IGR compounds application led to intermediate ratios of deformities (Tables 16 -18) . No deformities occurred amongst the developing stages of control. An opposite relationship may be easily detected between the percentage of deformed stages and the period from IGR compounds application to starting treatment.

Malformations that were observed due to larval feeding on IGR treated cotton leaves may be explained in the following points:

1- The abnormal deposition of larval cuticles in some positions of the larval body.

2- The larval body was still out of the pupal cuticle and the larvae failed to complete pupation.

3- New cuticle of larvae that could ecdyse, in big batches, appeared without normal colouration.

4- The pupae had big batches of untanned cuticle.

5- Larval - pupal appearance was observed (Fig.,27 - B)

6- Pupal - adult intermediates were also observed (Fig.,27 -D)

7- Untanning of pupal cuticle and malformed pupae ·

8- Adults deformation in abdomens, legs and wings (Fig., 2 - E)

9- At the time of moulting, the ecdysal suture ruptured, a viscous excretion comes out and the larva became unable to ecdyse.

These results agree with Khan and Srivastava (1988) who recorded that 0.01 % Penfluron caused complete larval mortality when the last instar larvae of *Pericallia ricini* Fabr. (lepidoptera, Archititidae) were fed on treated leaves. The same authors indicated that treatment produced deformities among the subsequent prepupa, pupae and adults.

The deformities included larva - pupa intermediates , whereas moulting process was incomplete, inspite of the anterior region of larval mouth. Parts and thoracic legs were still present . Maximum deformity was recorded at lower concentrations. Also, El-Sweerki (1994) found that pyriproxyfen caused slight malformations in pupae resulted from treated larvae of *S. littoralis*. The percentage of deformation ranged from 1.1 to 14.0% for 5& 400 p.p.m. concentrations, respentively .

G- Effect on the resultant adults:

As the 2th and 4th instar larvae of *S. littoralis* were fed for 24 hours on IGR's treated cotton leaves, the delayed effect was also

detected on the adult stage which showed shorter life-span and decreased fecundity than control.

1- On adult's life - span:

Larvae fed in their 2nd instar on IGR treated cotton leaves, after different, periods from the IKI PP 145 field application, developed to adults that lived for 5.5 - 8.5 days in case of males and 5 - 8.4 days in case of females when treatment took place at zero time and after 9 days of the IGR field application, respectively. In case of 4th instar larval treatment by the same compound, the respective records of male and female life - span were 6.7 - 9.3 and 5.5 - 8.7 days (Table, 16). The respective longevities due toConsult 100 EC treatments were 6-9.3 and 5 - 8.4 days for 2nd instar larval treatments & 6.5 - 9.2 and 5.5 - 8.4 days for 4th instar treatment (Table,17) while by using Consult 100 SC, the coresponding periods were 6-9.3 & 5-8.4 and 6.5 - 9.2 & 5.5 - 8.4 days , respectively (Table, 18) opposed to 9.3 - 9.6 and 8.5 - 8.9 days in cases of males and females resulting from control.

It could be generally deduced from the explained data that the shortest life - span of moths from both sexes were recorded from larvae treated at zero time. By prlongation of the period after IGR compounds application, the recorded longevities rendered longer, and the least effect was detected by starting treatment 9 days after IGR compounds application .

In similar investingations, Khan and Srivastava (1988) found that *P. ricini* larval treatment by Penfluron at 0.01 % caused shortening of the adult's life - span by 54.54% . In agreement with the present results, Sokar (1995) found that *S. littoralis* larval treatment by Pyriproxyfen or Hexaflumuron at LC_{25} lead to adults that lived for 8.4 and 9.2 days in case of males and for 8 and 8.8 days in case of females, respecively opposed to 10.4 and 8.6 days for control males and females, respectively. But, in contrast to the present results, El-Sweerki, (1994), reported a prolongation in the adults' life - span due to *S. littoralis* 4th instar larval treatment.

2- On eggs reproductivity and hatchability:

As shown in Tables (10-12), female moths of the cotton leafworm, that resulted from larvae fed on IGR's treated cotton leaves deposited fewer numbers of eggs than those from moths of control. By using IKI PP 145 , Consult 100 EC and Consult 100 SC against 2nd instar larvae, the numbers of deposited eggs were 147 - 279 , 149-279 and 152 - 285 eggs /female, by treatment the larvae at zero time and after 9 days of the IGR field application, respectively showing reductions in eggs productivity than control by 8.52 - 51.8 , 8.82 - 51.3 and 6.86 - 50.3 % , respectively. In case of treatment to 4 th instar larvae, the correspondent numbers of deposited eggs were 157 - 297, 158 - 288 and 159 - 292 eggs / female, respectively indicating reductions than those deposited from a control female by 7.19 - 50.94 , 9.43 - 50.31 and 8.75 - 50.31 % , respectively.

Amongst the deposited eggs, the hatchability percentages were found to be greatly reduced due to larval treatment. The percentages of eggs' hatching after 2nd instar larval feeding on cotton leaves treated by IKI PP 145 , Consult 100 EC and Consult 100 SC were 0-20 , 0- 17 and 0- 18 % , respectively and those recorded after 4th instar larval feeding on contaminated food were 0-24 , 0-22 and 0-24 % , respectively, opposed to 88.7-90.3 % hatching eggs from control moths (Tables 10-12). It is clearly evident form the mentioned tables that treatment of 2nd instar larvae by either of the three IGR compounds for 24 hours after a period up to 2 days of the IGR application lead to female moths that deposited eggs of which nill could hatch. This effect of absolate prevention of hatching occurred also amongst eggs deposited by moths developed from 4th instar treated larvae after a period of 0-24 hours after IGR's application .

It could be clearly observed from data in Tables (10-12) that the reduction in mean total number of eggs / female and also in the hatching percentages were , positively, proportional to the period from bioinsecticidal application until starting larval feeding on the treated food. It is also evident from the same tables that treatment of larvae in earlier instar lead to higher effect than occurred by treatment of older ones , although the differences were not so great as that occurred in case of prolongation of the period from spray to treatment.

These results are in full agreement with the those recorded by Sehnal *et al.* (1986) who found that the topical applications of Diflubenzuron at 0.03 mg / larva or BAY SIR - 8514 (Triflumuron) at 0.015 mg / larva to 5th and 6th instar larvae of *S. littoralis* lead to 90.1 and 94.8% sterility in resulting adults. The authors showed that the sterilant effect was based on a reduction in fecundity by 45.8 - 75% and a low rate of egg hatch (14.4 - 37% as compared with about 80% in control) . Treatment of 5th instar larvae was slightly more effective than that of 6th instar larvae, especially in Triflumuron treatments. In laboratory evaluation, CME- 13406 (Teflubenzuron) was determined by Tuttle and Ferre (1988) they found that the consumption of potato leaflets (dipped in aqueous solutions containing that compound) by 3rd instar larvae of *Leptinotarsa decemlineata* lead to reduction in the viability of eggs deposited by the newly emerged adults for 7 days. The authors recorded also that all treated females produced fewer progeny than untreated ones.

From the previously explained results, it could be concluded that the IGR's are , generally, a potent compounds against *S. littoralis* as these compounds has considerable effects on the noxious stage (larvae) and the subsequent stages (pupae and adults) . Its delayed effect didn't stop at the adult stage, but extended to the next generation as it caused detectable reduction in the percentages hatching amongst larvae fed on leaves treated by the IGR compounds.

3 Toxicological and biological activity of *Clerodendron inerme* on *Spodoptera littoralis* :-

As previously mentioned*Clerodendron inerme* as dry powder suspension inwater was applied on cotton plants at the rate of 2 kg./fed. to be assayed against the 2*nd* and4*th* instar larvae of *S. littoralis*. Larvae were fed for 24 hrs. on cotton treated leaves after different periods from field application.Mortalities were recorded 24 hrs .after treatment and continued until prepupal stage. The surviving larvae were,afterwards, allowed to feed on fresh untreated castor-bean leaves until pupation . Emerged moths were fed on 10% sucrose solution and allowed to oviposit on oleander leaves in rearing cages.

(1) Acute toxicity:-

Data presented in Table(19) indicate that, *S. littoralis* larval feeding on cotton leaves for 24 hours after field treatment with water suspension of *Clerodendron inerme* caused higher mortality rates amongst the treaed larvae (24 - 88 % and 20- 82% by treatment in the 2*nd* and 4*th* instars, respectively compared to 12 - 14% in the control larvae) Reduction in the weight of resultant pupae (282 - 352 and 289 - 382 mg. / pupa , respectively, opposed to 410 - 414 mg. / pupa for the control pupa), and also reduction in the total eggs' productivity (means of 154 - 242 and 163 - 256 eggs female from treated larvae, respectively , opposed to 310 & 315 eggs / control female).

(2) The latent effect :-

The latent effect of the suspension of *C. inerme* extended also, to affect the viability of eggs deposited by females resulted from treated larvae. Amongst these eggs, the hatchability percentage averaged 27 - 57 and 29 - 71% when eggs were deposited by females resulted from larvae fed on

Table (19)

Effect of *S. littoralis* 2 *nd* and 4 *th* instars larval feeding on *C. inerme* treated cotton leaves on comulative larval mortality, pupal weight, eggs productivity and hatching of eggs (Results from 50 larvae / treatment) .

Periods (d.)	2 *nd* instar				4 *th* instar			
	% Comulative mortality	Average of pupal weight (mg.)	Mean no. of Eggs / female	% Eggs hatching	Comulative mortality %	Average of pupal weight (mg.)	Mean no. of Eggs / female	% Eggs hatching
zero	88.0	(282± 0.5)	(154± 0.5)	27.0	82.0	(289±0.5)	(163 ± 0.8)	29.0
1d.	84.0	(285 ± 0.5)	(158± 0.4)	29.0	80.0	(297± 0.4)	(171± 0.3)	32.0
2d.	76.0	(292± 0.8)	(167± 0.5)	34.0	72.0	(318± 0.6)	(188± 0.9)	36.0
3d.	64.0	(310± 0.5)	(189 ± 0.6)	39.0	62.0	(335 ± 0.8)	(203± 0.7)	44.0
5d.	54.0	(327± 0.5)	(203± 0.5)	47.0	48.0	(352± 0.5)	(221± 0.8)	53.0
7d.	38.0	(339 ± 0.6)	(219± 0.8)	52.0	36.0	(368± 0.6)	(238 ± 0.8)	65.0
gd	24.0	(352± 0.3)	(242± 0.7)	57.0	20.0	(382 ± 0.2)	(256 ± 0.7)	71.0
cont	14.0	(416± 0.2)	(310± 0.8)	90.0	12.0	(414± 0.2)	(315± 0.1)	91.0
F.		616**	745**			478**	635**	
L.S.D	at 1%	6.85	7.0			8.13	8.4	
	at 5 %	4.97	5.1			5.9	6.1	

** highly significant

treated cotton leaves in their *2nd* and *4th* instars, respectively, while those recorded on eggs from untreated females were 90 - 91% (Table, 19). It is clear from the same table that the severst effect of *Clerodendron* inerme on *S. littoralis* larvae occurred when treatment took place at zero time; *i.e*, just after field application (highest larval mortality % ,least pupal weight, lowest eggs' productivity and also the least hatchability percentage). This effect decreased, gradually, by lengthening the period from application to treatment. Also the effect appeared to be higher by feeding the larvae on treated food when they were in earlier instar; *i.e.*, the *2nd* instar larvae were generally, more susceptible to treatment than those of the *4th* instar .

The toxicity of plant extracts were previously reported by several authors confirming the present results.Guirguis *et al.*(1991) studied the toxicity and latent effect of solvent extracts of *Suaeda fruticosa* and *Tamarx tetragyna* against *4th* instar larvae of *S. littoralis* by topical application method. The authors showed that ethyl acetate extracts of the two plant species were toxic against larvae and the toxicity of *S. fruticosa* extract exceeded that of *T. tetragyna*, as they were 57.87 and 44. 83% as toxic as Fenpropathrin at LD_{50} level. Ethyl acetate extract of *S. fruticosa* induced.59.1, 14.7, 31 and 27.3% reductions in pupation male and female, pupal weight and adult emergence, respectively. Also, *El-Sharawy et al*. (1992) reported the toxicity action of dumb cane, *Diffenbachia picta* and bestachia, *Adhatoda vasica* leaves to *S. littoralis* larvae. Larval mortality reached 94.88 and 92.26%, respectively after 24 hrs. and reached 97% for either of the two plant species after 48 hrs. None of the few larvae that survived could ecdyce.The authors reported that larvae of the *3rd* instar were less susceptible than those of younger instars.No mortality was recorded for larvae of the 4th and

5th instars until after 48 hrs. elapsed upon feeding on the tested plants.The 6th instar larvae were more tolerant than previous instars, mortality exceeded 80% after 5 days of feeding trials and 100% by the 6th day.For all instars feeding deterrent effect produced poor relative larval growth, extended intermoult periods, mortality was high and mainly occurred at ecdysis and none of the larvae managed to moult or pupate.

(2) Biological activity:-

The delayed effects of *Clerodendron inerme* on the surviving larvae and also the subsequent stages after treatment of the 2*nd* and 4*th* larval instars are shown in Table (20).

A. Effect on larval period :-

From data recorded in Table (20), it is clear that the period of larval stage was affected due to larval feeding on *C. inerme* treated cotton leaves,whether treatment took place on the 2*nd* or the 4*th* instar larvae. The general trend of such effect was the lengthening of this period (22.2± 0.2 - 26.4 ± 0.4 days by treatment in the2*nd* instar and 19.8±0.2 - 23.3 ± 0.5 days by treatment in the 4*th* instar opposed to 21.5±0.2 and 19.4±0.2 days for the larval period of the control larvae, respectively). Such effect of prolongation of larval period increased by shortening the period from *Clerodendron inerme* application to laboratory treatment . By treatment at zero time (justy after application), the longest larval period was detected as the larval duration elapsed 26.4±0.4 (24 - 29) and 23.3 ±0.5 (19-28) days for larvae treated in their 2*nd* and 4*th* instars,respectively (Table,20) while the shortest larval durations amongst treated larvae were, on the other hand, recorded for larvae treated in the mentioned instars after 9 days of *C. inerme* water suspension field application being

Table (20)

Effect of " *C. inerme*" on S. *littoralis larval* and pupal durations (/days) after feeding the 2 nd and 4 *th* instars on treated cotton leaves after different periods from application (at 26 C and 70 % R.H .)

(d)	2 *nd* instar		4 *th* instar	
	Larval period *	Pupal duration	Larval period *	Pupal duration
zero	(26.4± 0.4) (24-29)	(19.7 ± 0.7) (17-22)	(23.3 ± 0.5) (19-28)	(19.9± 0.6) (17-22)
1d.	(26.0± 0.4) (23-29)	(19.3± 0.7) (16-21)	(22.7± 0.6)	(19.4± 0.5) (16-21)
2d.	(25.5± 0.2) (23-28)	(18.8 ± 0.5) (15-20)	(22.2± 0.2) (18-27)	(18.9 ± 0.4) (15-20)
3d.	(24.9± 0.2) (22-27)	(18.5 ± 0.4) (14-20)	(21.6± 0.4) (17-27)	(18.4 ± 0.4) (14-20)
5d.	(24.3± 0.2) (21-26)	(18.1 ± 0.3) (13-19)	(20.9± 0.5) (17-26)	(17.9± 0.3) (13-19)
7d.	(23.7± 0.3) (21-25)	(17.7± 0.2) (12-19)	(20.4± 0.3) (17-25)	(17.5± 0.3) (12-19)
gd	(22.2± 0.2) (21-25)	(17.3± 0.2) (11-18)	(19.8± 0.2) (18-24)	(17.2± 0.2) (11-18)
cont.	(21.5± 0.2) (19-24)	(17.1± 0.2) (10-18)	(19.4± 0.2) (17-22)	(16.8± 0.5) (10-18)

* = The larval period from treatment until pupation .

22.2 ±0.2 (21-25) and 19.8±0.2 (18-24) days, respectively. By treatment in the *2nd* instar after 1,2,3,5 and 7 days of field application, larval period occupied the averages of 26.0±0.4, 25.5 ±0.2, 24.9±0.2, 24.3±0.2 and 23.7±0.3 days respectively,while by treatment of *4th* instar larvae at the same time, the corresponding larval periods were 22.7 ± 0.6, 22.2 ±0.5, 21.6 ±0.4, 20.9 ±0.5 and 20.4 ±0.3 days, respectively (Table,20) indicating intermediate periods compared to those treated at zero time and after 9 days of field application. Data illustrated in Fig. (28) demonstrate the rates of deviation (increase) in the larval period due to *C. inerme* treatment than control.Such data, clearly, show that highest increase in larval period occurred when larvae of the *2nd* or *4th* instars were fed on treated leaves just after application (22.8 and 20.1% increase,respectively).The rate of deviation decreased, successively, as the period from field treatment and starting larval feeding on treated food became longer up to 9 days when the lowest rates of deviation than control were detected (3.3 and 2.1% ,respectively; Fig.28).

B. Effect on pupal duration :-

As occurred with larvae, the larval feeding on *Clerodendron inerme* treated cotton leaves caused increases in the durations of the subsequent pupae. Pupae that resulted from *S. littoralis* larvae treated in the *4th* instar showed, generally, longer pupal period than those resulted from larvae treated in their *2nd* instar (Table,20). The longest pupal period (19.9 ±0.6; 17 - 22 days) was estimated from pupae resulted after 4th istar larval feeding at the zero time (just after field applictation) on cotton treated leaves (Table,20), and consequently these pupae showed the highest rate of deviation in pupal duration than control (+ 18.5% ; Fig. 29).While on the contrary, the slightest deviation in pupal duration than control was detected amongst pupae resulted from larvae fed in their *2nd* instar for 24 hours on *C. inerme* treated cotton leaves after 9 days of the field treatment (17.3

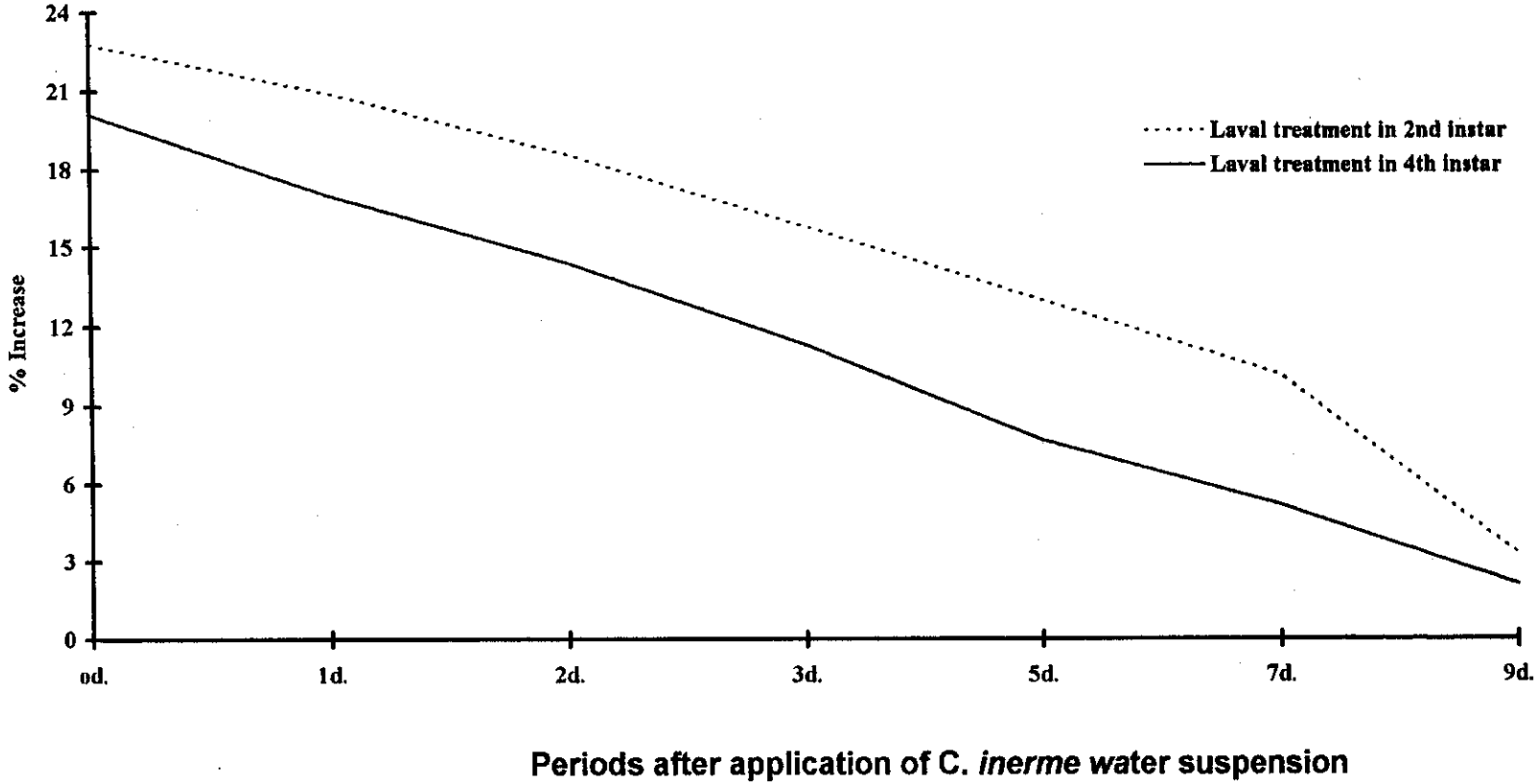


Fig. (28) : Percentages of deviation (increase) in *S. litoralis* larval duration than control due to 2nd and 4th instars larval feeding on C. inerme treated cotton leaves after diferent periods of the dry leves suspension application.

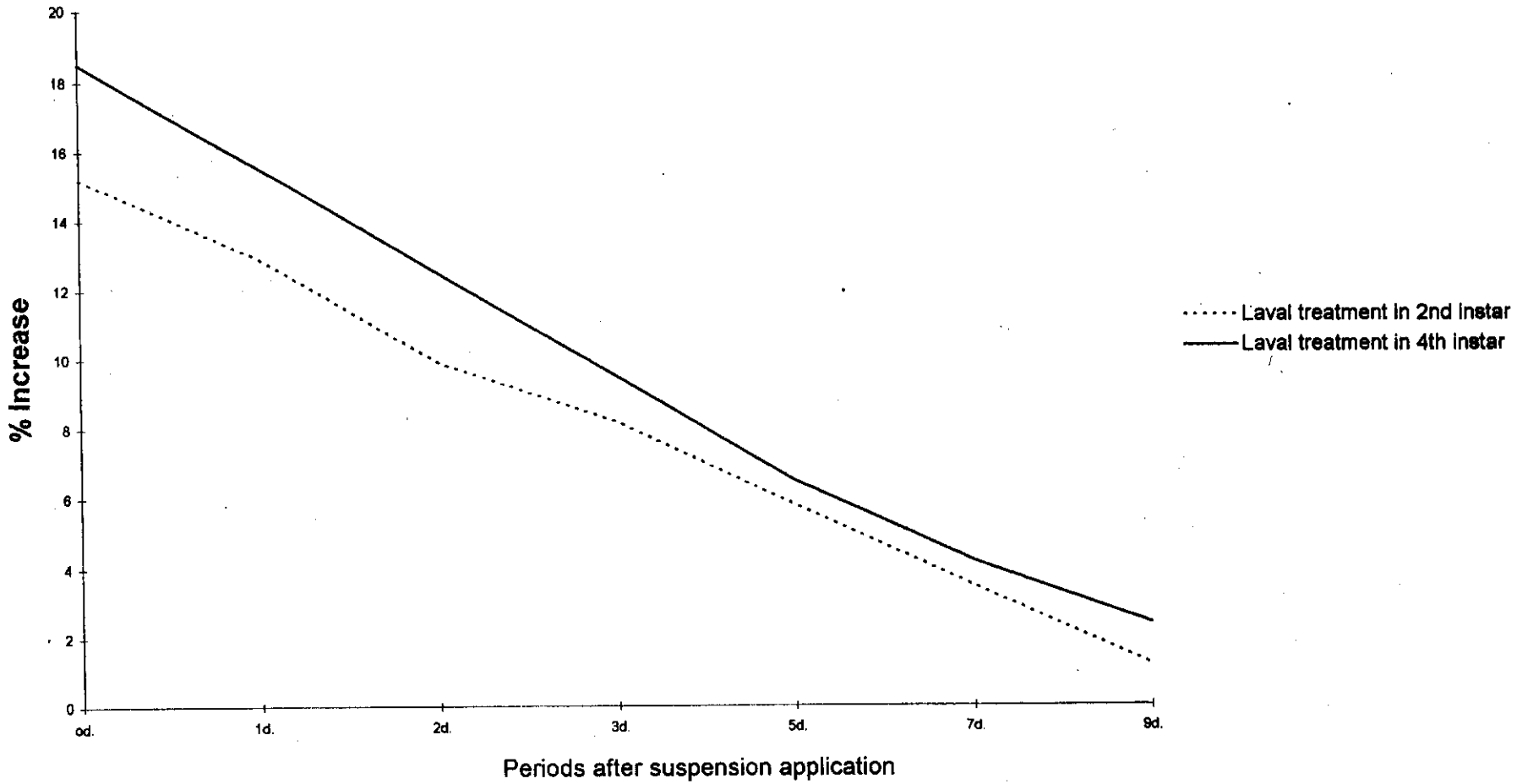


Fig. (29) : Effect of *S. littoralis* 2 *nd* 4 t*h* instar larval feeding on C. *inerme* treated cotton leaves on deviation (increase) in pupal period than control .

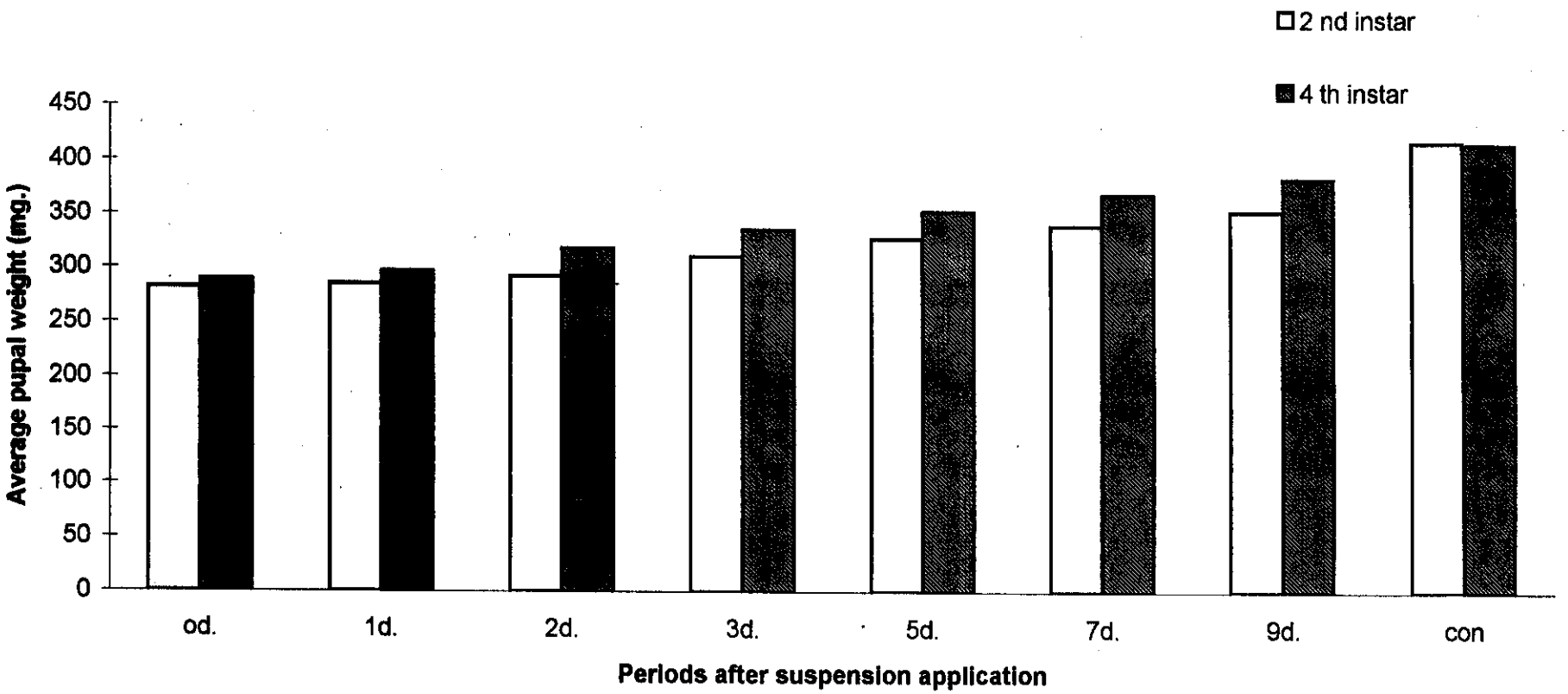
±0.2; 11-18 days indicating + 1.2% deviation than pupal duration of control, Table,20 &Fig. 29).As shown in Table (20) and Fig. (29), larval treatment after 1,2,3,5 and 7 days of the water suspension field application resulted in pupae which showed intermediate pupal durations, and subsequently intermediate deviation rates in those periods than control, although the main trend of effect remained; i.e., more effect as the period from field application of *C. inerme* to treatment became shorter.

The obtained results concerning the effect of the *C. inerme* field treatment on the cotton leafworm larval and pupal durations agree with Robenson *et al.* (1982) in Iowa (U.S.A) who found that Dimpoa (2,4 dihydroxy - 7 -methoxy - 2H-1, 4 benzoxazin - 3 (4H) one), which is a substance found naturally in maize did not affect *Ostrinia nubilalis* larval mortality but the larval stage was prolonged and developing pupae weighed less than normal. Also, Antonious *et al.* (1992) studied the effect of nine crude extracts from dumb-cane and bestachia leaves extracted by different solvents for their postingestional effects on the pupal and adult stages of *Spodoptera littoralis.* The authors found that the longest pupal duration was obtained when larvae were fed on castor bean leaves treated with phytochemical extracted by methanol, benzene, or hexane.

C. Effect on pupal weight :-

The freshly formed pupae that resulted from 2*nd* and 4*th* instar *C. inerme* treated larvae, and those from control larvae were weighed and the obtained results are graphically illustrated in Fig. (30).

Generally the average weight of pupae obtained from *C. inerme* fed larvae were less than those resulted from the control larvae. It is also clear that larval treatment in the 2*nd* instar lead to pupae less in weight than those resulted from



Fig(30): Effect of *S. littoralis* 2 *nd* and 4 *th* instsrs larval feeding on cotton leaves treated with *C. inerme* leaves suspension on the averages in weight from subsequent pupae .

larvae treated in their *4th* instar (282 - 352 mg. in the former case opposed to 289 - 382 mg. in the latter / one, Fig. 30). Thus indicating more effect by treatment of *S. littoralis* larvae in the earlier instar. The effect of larval feeding, on *C. inerme* treated cotton leaves, on the weight of resultant pupae was more pronunced when treatment took place at zero time (just after field application) where the mean weight of pupae was 282 and 289 mg. pupa for larval treatment in the *2nd* and *4th* instars, respectively. Mean weight of pupae became heavier, successively, as the period after application to treatment became longer until reached 352 and 382 mg. / pupa for *2nd* and 4th instar larval treatment, respecively when treatment took place after 9 days field application.

By larval treatment at zero time and 9 days after the *C. inerme* field application, the reduction percentage in weight of resultant pupae compared to control ones ranged from 15.38 to 32.22% in case of the *2nd* instar treated larvae and from 7.73 to 30.19% for the *4th* instar treated larvae (Table, 21)

Reduction in pupal weight due to larval treatment with plant extracts was previously reported by Guirguis *et al.*, (1991). The authors found that treatment of *S. littoralis* larvae with methyl acetate extract of *Suaeda fruticosa* and *Tamarx tetragyna* at LD_{50} lead to pupae that weighed 209.2 & 213.9 mg. in case of the former plant and 195.1 & 215 mg. in case of the latter one for males and females, respectively opposed to 245.6 and 309.9 mg. for male and female pupae of control.

D. Effect on pupation :-

The mean percentages of normally formed pupae varied amongst pupae from different treatments being 32-84% normal pupae from larvae treated in their *2nd* instar and 38-88% normally formed pupae from larvae treated at their *4th* instar at zero time and after 9 days of application of dry leaves suspension opposed to 92 and 94% pupation from the

untreated larvae (Table,21). It is clear from the same table that the severest effect occurred when treatment, took place just after field application of *C. inerme* leaves suspension. By elongation of the period from application to treatment , the effect decreased and the percentage of normally formed pupae increased to 36, 48, 66, 72 and 80% for *2nd* instar larval treatment and to 42,58,74, 80 and 84% for *4th* instar larval treatment after 1,2,3,5 and 7 days of application, respectively. Data indicate also that the *2nd* instar larvae were more susceptible than the *4th* instar ones as more normal pupae were obtained in the latter case (Table, 21 and fig.31).

These results agree with Antonious and Hegazy (1987) who studied the activities of caraway; *Carum carvi*, Santonica, *Artemisia santonicum* and warm wood; *Artemisia herbaalba* on the *5th* instar larvae of *S. littoralis*. The authors found that all the tested materials influenced the rate of pupation. Caraway was the most potent material even in low concentration. The percentage of pupation in case of using caraway at 5% , was 80% while it was 85% in case of Santonica and warm wood opposed to 100% in the control. Also, Guirguis *et al.,* (1991) studied the toxicity and latent effect of *S. fruticosa* and *T. tetragyna* against *4th* instar larvae of *S. littoralis* they found that the percentage of pupation was reduced to 38 and 24% by using the LD_{50}'s of ethyl acetate extract of *S. fruticosa* and *T. tetragyna*, respectively.

E. Adults' emergence :-

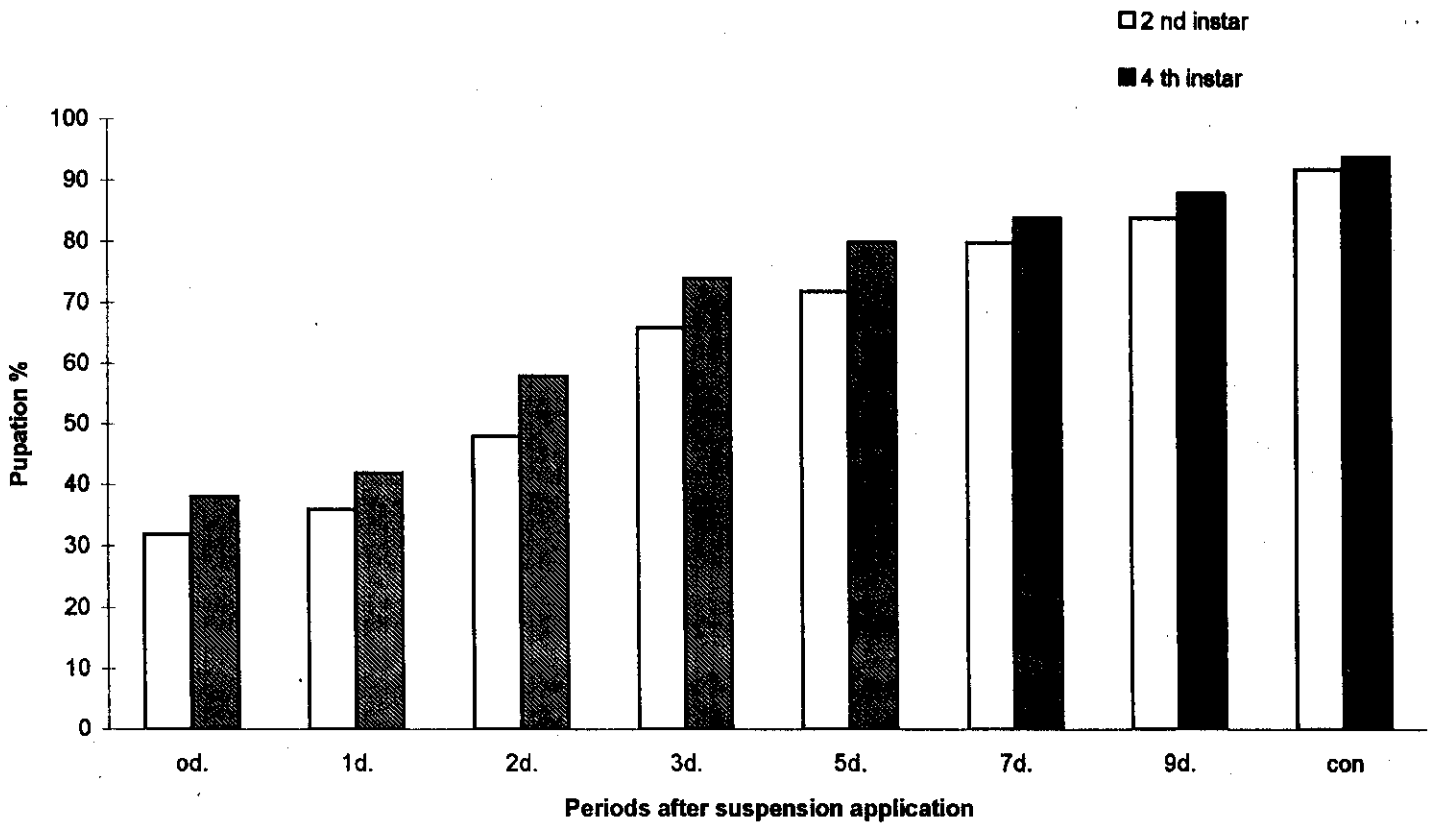
As shown in Table (21),and fig.(32) the same tendency of *Clerodendron inerme* effect on successful pupation after larval treatment was also detected on the percentages of adults' emergenece. (37.5 - 90.5% and 47.4 - 88.6% by treatment of the *2nd* and *4th* instars larvae just after the dry leaves' suspension application at zero time and after 9 days of application, respectively) . Also, the effect on successful emergene of adults decreased by treatment of older instar.

Table (21)

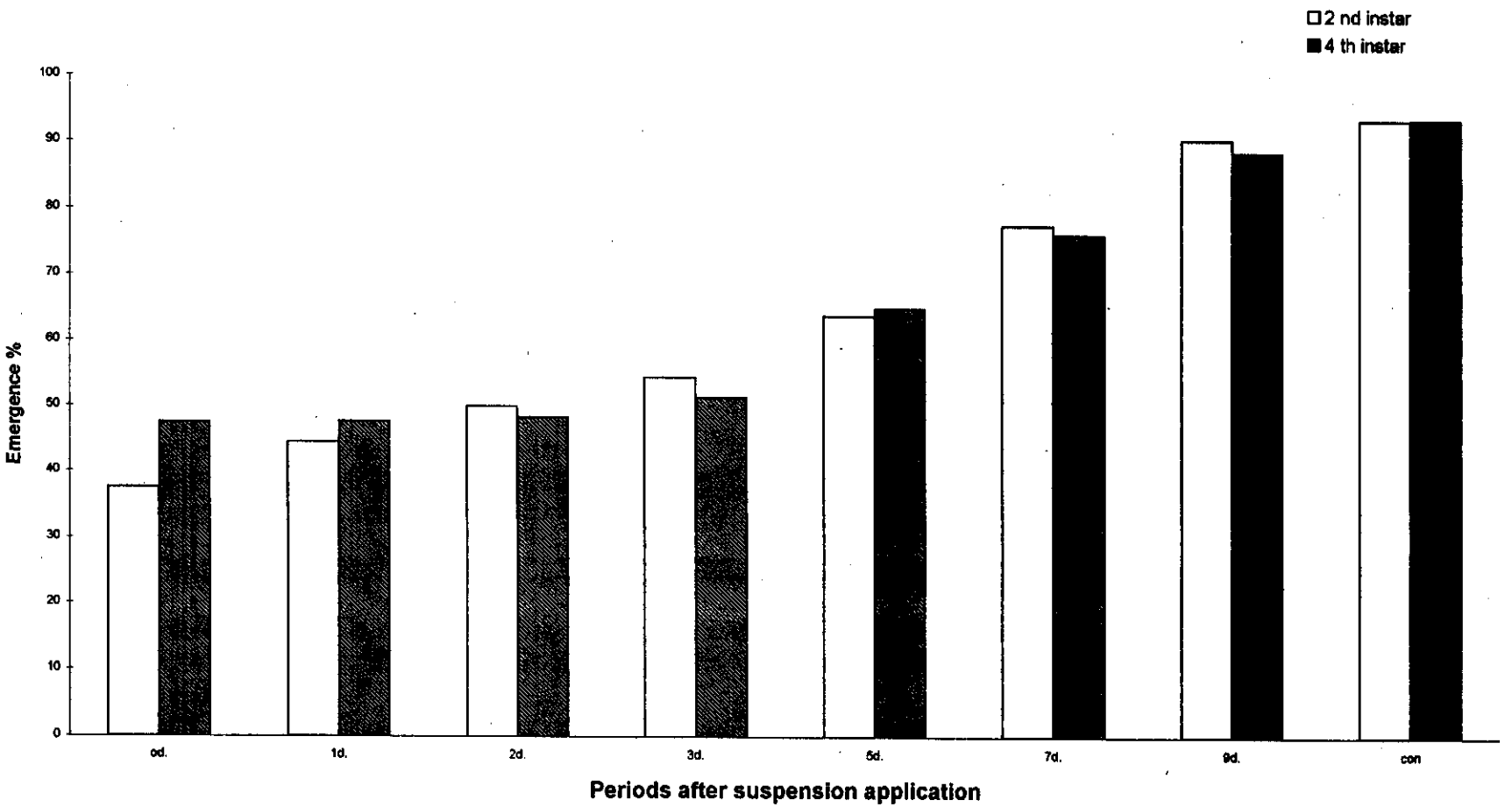
Effect of S. littoralis larval feeding on *C. inerme* treated cotton leaves on percentages of pupation , emergence , malformed stages and adults' longevity .

Periods (d)	2 *nd* instar								4 *th* instar							
	%	%	adult longevity (days)		% Malformed stages				%	%	adult longevity (days)		% Malformed stages			
	Pupation	Emergence	M	F	L	P	A	T	Pupation	Emergence	M	F	L	P	A	T
zero	32	37.5	7.3	5	2	0	2	4	38	47.4	7.4	7	0	0	0	0
1d.	36	44.4	7.8	6	4	0	2	6	42	47.6	7.9	7.3	0	0	2	2
2d.	48	50	7	6.3	4	2	2	8	58	48.3	8.3	7.7	2	0	4	6
3d.	66	54.5	8.5	6.8	8	4	4	16	74	51.4	8.5	7.9	2	2	4	8
5d.	72	63.9	8.1	7.7	12	6	8	26	80	65	8.9	8.3	4	4	6	14
7d.	80	77.5	8.7	8	16	8	10	34	84	76.2	9.3	8.6	4	4	10	18
gd	84	90.5	9.3	8.4	18	12	14	44	88	88.6	9.6	8.8	8	6	10	24
cont	92	93.5	9.8	8.5	0	0	0	0	94	93.6	9.8	8.9	0	0	0	0

A. adult F. female L. larvae M. male P. pupae T. total



Fig(31): Effect of *S. littoralis* larval treatment with *C. inerme* leaves suspension on pupation percentages .



Fig(32): Effect of *S. littoralis* larval feeding on *C. inerme* treated cotton leaves on the percentages of adults' emergence from subsequent pupae .

In agreement with these results, Guriguis *et al*:(1991) studied the latent effect of *S. littoralis* larval treatment by ethyl acetate extracts of *S. fruticosa* and *T. tetragyna*. The respective percentages of emergence by using the LD_{25}'s were 72.1 and 63.2 % and those by using the LD_{50}'s were 61.1 and 45.8% for *S. fruticosa* and *T. tetragyna*, respectively opposed to 84.1% in the control ones. Similar results were obtained by Antonious *et al.*, (1992) as they found that *S. littoralis* 4*th* instar larval treatment by ethanol, methanol, benzene and hexane extracts of dumb-cane and bestachia caused reductions in the percentages of adults' emergence, being 22,22% for dumb cane ethanol and methanol extracts, followed by benzene (44.45%) and hexane (55.56%) extracts.But, bestachia extracts were less potent than dumb-cane in reducing adults emergence (32.89, 44.45 and 50% for ethanol, methanol and hexane extracts, respectively opposed to 100% emergence from the control pupae).As shown in Fig.32

F. Deformations amongst different stages:-

Data listed in Table(21) and Fig.(33) , clearly indicate that field application of water suspension of *Clerodendron inerme* dry leaves powder on cotton plants at the rate of 2kg/ feddan and laboratory feeding of *S. littoralis* 2*nd* and 4*th* larval instars on the cotton treated leaves led to different degrees of malformations amongst the treated larvae and subsequent stages. Normally the malformed stages were not able to survive. Amongst the obtained deformities, many larval - pupal and pupal - adult intermediates were observed (Fig. 35 B & D) . More deformation percentages were recorded amongst the treated larvae (2-18 and 0.0 - 8.0%) than amongst the resultant pupae (0 - 12 and 6.0%) and adults (2.0 - 14.0 and 0.0 - 10.0 %) by larval treatment in the 2*nd* and 4*th* instars, respectively.The total percentages of malformed stages reached 4-44 by 2*nd* instar larval treatment and 0.0-24% by treatment the 4*th* instar larvae, at zero time

(C)

(D)

(E)

Fig. (33) Different morphogenic patterns induced by "Water suspension of *Clerodendron inerme*" against different stages of S. *littoralis*.

A) Malformed larvae.

B) Larval - pupal intermediates.

C) Malformed pupae.

and 9 days after *C. inerme* application, respectively. Thus indicating that the highest total percentage of malformed stages (44%) occurred by feeding the 2nd instar larvae on treated cotton leaves just after application. It could be clearly detcted that the total percentages of deformites decreased successively (indicating lower effet of the plant leaves suspension) by lengthening the period from application to starting larval feeding up to 9 days when the least effect was detected by 4th instar larval treatment as all the surviving stages appeared normal and no malformation was detected.

C. inerme treatments to S. littoralis larvae resulted in the following observations :-

1. After treatment, directly, the larvae tried to escape quickly from the treated leaves and remain motionless on the glass bottom of the jar.

2. Larvae stopped feeding and became sluggish in movement .

3. The reduction in feeding activity and larvae became stunted.

4. Reduction in pupal weight and abnormal pupae in shape (Fig.33-C).

5. Larval - pupal intermediates were observed (Fig. 33-B).

6. Moths failed to get rid of the pupal cuticle (Fig. 33-D).

7. Adults with abnormal abdomens. legs defective or curled wings and shortage in wing size (Fig. 33 - E).

These results are in a harmony with Antonious and Hegazy (1987) who studied the effect of the caraway, santonica and warm wood against the 5th instar larvae *of S.littoralis*.The authorsfound that all concentrations of warm wood noticeably affected the rate of malformed moths (25%)

while Santonica had the least effect (7% malformed moths). The deformations were severe twisting, stubby and shortage in wing size.Also, in a similar investigation, Antonious *et al.*, (1992) reported many morphological aberrations in pupae and moths emerging from *S. littoralis* larvae fed on leaves treated with extracts of dumb-cane and bestachia leaves , *i.e.* pupae retained larval thoracic legs, adults with abnormal abdomens, legs and /or defective wings.Dumb-cane methanol extracts caused the highest percentage of morphological abberations (38.89%), followed by hexane or chloroform (27.78%), ethanol or distilled water (22.22%).

G. Effect on the resultant adults:-

As the 2*nd* and 4*th* instars of *S. littoralis* larvae were fed for 24 hours on *C. inerme* treated cotton leaves, the delayed effect was also detected on the adult stage which showed shorter life - span and decreased fecundity than control.

1.Effect on adult's life - span :-

Larvae fed in their 2*nd* instar on *C. inerme* treated leaves,after different periods from field application, developed to adults that lived for 7.3 days (when treatment took place just after application) to 9.3 days (for treatment after 9 days of application) in case of males and for 5.0 - 8.4 days, respectively in case of females. The respective longevities of males and females resulted after 4*th* instar larval treatment were 7.4 - 9.6 and 7.0 - 8.8 days opposed to 9.8 and 8.9 days, respectively in case of the control moths (Table, 21).The shortest life - span of moths from both sexes were always recorded from larvae treated at zero time. By prolongation of the period after *C . inerme* the application, the recorded longevities rendered longer,and the highest effectwas detected by starting treatment after *Clerodendron* application

In similar studies Guirguis *et al.*,(1991)found thattreatment by ethyl acetate extract of *S. furticosa* and *T.*

tetragyna reduced oviposition period and abult longevity. Pronounced effect occurred by assaying the LD_{50} of *T. tetragynga* (9 and 8.1 days as life-span of male and female, respectively). While in contrast to the present resuls, Antonious *et al.* (1992) found that dumb - cane and more effect occurred by former extract (means of 9.45 - 9.63 days in comparison to 7.7 days for control insects). It was also indicated that female moths were slightly more affected than males.

2. On eggs' reproductivity and hatchability :

As shown in Table (19), female moths of the cotton leafworm deposited fewer number of eggs that ranged from 154 to 242 eggs / female by 2*nd* instar larval treatment by feeding on *C. inerme* treated cotton leaves at zero time and after 9 days of the field application , respectively opposed to mean of 310 eggs / control female . Thus indicating reduction the mean total number of deposited eggs by a 50.32 and 21.94 % , respectively than control . By treatment of *S. littoralis* larvae in their 4*th* instar, the respective percentages of reduction in mean total number of produced eggs were 48.25 and 15.87% (163 and 265 eggs / female by treatment at zero time and after 9 days of application , respectively opposed to 315 eggs / female , Table 19)

Amongst the deposited eggs, the hatchability percentages were found to be also reduced due to larval treament . These percentages were 27-57% and 29-71% in case of 2*nd* and 4*th* instars larval feeding on treated food , respectively compared to 90-91% hatching for eggs of the normally developed females from untreated larvae . Thus showing reductions in the hatchability percentages by 70&36.7% and 68.13& 21.98%, respectively .

In agreement with the present results, Ismail *et al* . (1990) evaluated the toxic action of Canna , Nettle and shoak

el - deeb extracts with three different solvents against *S. littoralis* and *Agrotis ipsilon.* The authors found that Canna extracts in ethanol and petroleum ether were the most effective against the eggs and larvae of both insect species. Also, Guirguis *et al.* (1991) found that the LD_{50} ethyl acetate extract of *S.fruticosa* and *T. tetragyna*, when assayed against the 4*th* instar larvae of *S.littoralis* induced 72 and 64.1% sterility. The percenages of hatchability of deposited eggs were 64.1 and 71.8%, respectively.

It could be clearly observed from data in Table(19) that the reduction in mean total number of eggs / female and also in the hatching percentages were, positively, proportional to the period from *C. interme* application until strating larval feeding on the treated food as, in all cases, the severest effect occurred when larvae were fed on treated food at zero time, while the lightest effect was detected when treatment took place after 9days of spraying. It is also evident from the explained results that treatment of larvae in earlier instar lead to higher effect than that occurred by treatment of older one, although the differences were not so great than that occured in case of prolongation of the period from spray to treatment.

From the previously explained results it could be generally concluded that *Clerodendeon inerme* may be considered as promising plant that may proof, in the near future, of great value in controlling the cotton leafworm. Although the present experiments were considered with larval feeding on treated cotton leaves for 24hours, the delayed effect of the dry leaves ssuspension didn't stop at the adult stage, but extended to the next generation as it caused detectable reduction in the prcentage hatching amongst eggs deposited by moths that developed from. *Clerodendron inerme* fed larvae . It might be appropriate to suggest that this palnt is promising feeding detterent origin against larval stage of *S. littoralis.* More studies are needed for separation and identification of the active ingredients included in the sap of the plant leaves.