RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSION

1. Toxicological and resistance phenomenon studies :

. Susceptibility of the cotton leafworm field populations in 6 Governorates to different insecticides :

The LC_{50}, slope (b) values and the calculated RR of the three insecticides tested against the susceptible (lab-reference) and field collected strains early before starting the chemical Control program in the six Governorates are recorded in Tables (1-3).

The data shown in Table (1) and illustrated in Fig.(1) revealed in general pronounced levels of resistance to the organophosphate Profenofos in all field strains representing different Governorates. This is indicated by the averages of the calculated RR which were 20.14, 21.14, 25.5, 30.73, 32.70 and 41.42 fold for Kafr El-Sheikh, Dakahlia, Menia, Menofia, Behera and Kalubyia Governorates, respectively.

The resistance spectrum of field population in the same Governorates after application of the recommend chemical Control program, as shown in Table (1) and Fig. (2), indicated that all tested field populations exhibited relatively remarkable, higher levels of resistance ranging between 22.8 and 68.9 fold.

However, the highly pronounced increase in resistance ratios was clearly manifested in population of Dakahlia and Behera Governorates where the RR values recorded late in the season were double of that recorded early before starting the chemical Control program, recording 43.5 versus 21.14 fold and 68.9 versus 32.7 fold in both Governorates, respectively.

The development of considrable levels of tolerance and resistance for O.P. among the different strains representing different Governorates of Egypt was previously demonstrated by several authors **(Hassan *et al.* 1977, El-Sayed 1973, Kansouh *et al.* 1978-1979)**.

Table (1): Toxicity data and resistance ratios of Profenofos tested against 4th instar larvae of *S. littoralis* collected from different Governorates during the cotton season (2000).

Strains (Governorates)	Toxicity data					
	Before spraying			After spraying		
	LC_{50} * (ppm)	Slope ± SE	RR	LC_{50} * (ppm)	Slope ± SE	RR
Laboratory	10.67 (7-14)	1.6 ± 0.28	-	10.67 (7-14)	1.6 ± 0.28	-
Kalubyia	442 (355-424)	3.03 ± 0.47	41.42	562.74 (368-922)	1.35 ± 0.29	52.7
Menofia	327.9 (248-410)	2.7 ± 0.46	30.73	489 (374-635)	2.31 ± 0.41	45.8
Dakahlia	225.6 (140-299)	2.3 ± 0.46	21.14	463.7 (363-585)	2.61 ± 0.43	43.5
Kafr El-sheikh	215 (163.8-275.6)	2.39 ± 0.41	20.14	243.6 (163-312)	2.67 ± 0.63	22.8
Behera	349 (263-457)	2.6 ± 0.60	32.70	735.8 (574-943)	2.26 ± 0.32	68.9
Menia	272.16 (156.9-384.1)	1.65 ± 0.31	25.50	364 (269.4-465.7)	2.37 ± 0.40	34.1

* LC_{50} (CL 95%)

El-Sayed *et al.* (1984) found that resistance to organophosphates was much higher to most of the methyl esters than to ethyl esters. Later on, **Rashwan *et al.* (1991)** found that several field strains representing different Governorates exhibited high resistance to organophosphates and that a strongly pronounced increase in resistance level was detected at the end of the cotton season than early in the season.

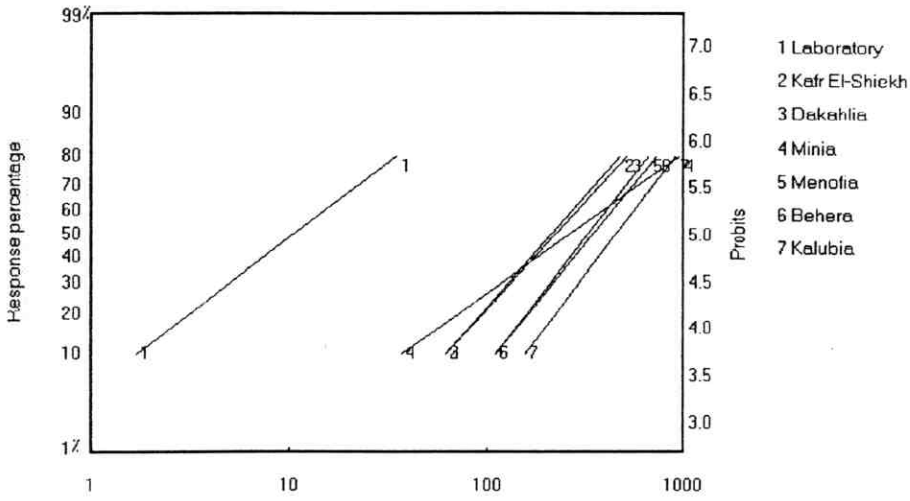


Fig.(1): Ldp-lines of Profenofos on *S. Littoralis* field strain larvae collected from different Governorates at the beginning of the cotton season

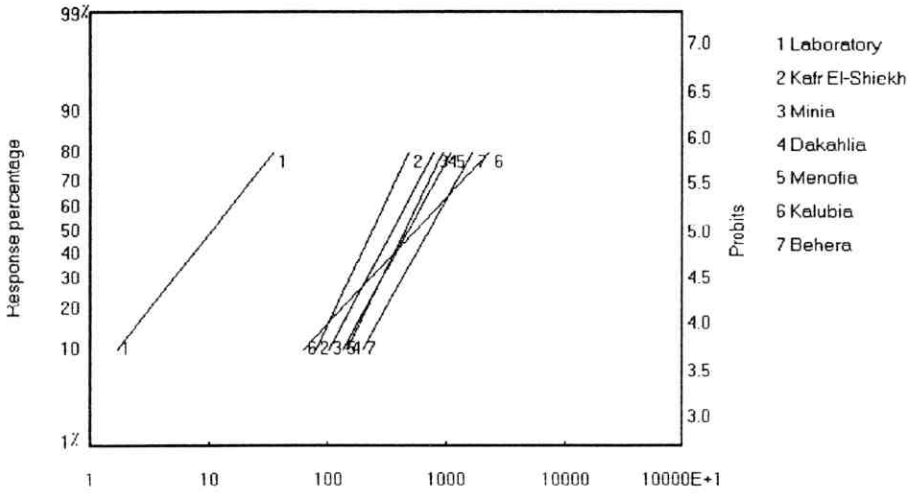


Fig.(2): Ldp-lines of Profenofos on *S. Littoralis* field strain larvae collected from different Governorates at the end of the cotton season

Data in Tables (2) includes slope of mortality regression lines, estimated LC_{50} values of Esfenvalerate and calculated resistance factor (RR) based on data of the field-collected strains early and late in the season relative to the susceptible (Lab-reference) strain whereas the same data were illustrated graphically in Figs. (3 and 4).

Table (2): Toxicity data and resistance ratios of Esfenvalerate tested against 4th instar larvae of *S. littoralis* collected from different Governorates during the cotton season (2000).

Strains (Governorates)	Toxicity data					
	Before spraying			After spraying		
	LC_{50} * (ppm)	Slope ± SE	RR	LC_{50} * (ppm)	Slope ± SE	RR
Laboratory	1.17 (0.8–1.54)	2.07 ± 0.40	-	1.17 (0.08-1.54)	2.07 ± 0.40	-
Kalubyia	170.7 (120.9-253.8)	1.69 ± 0.33	145.8	575 (445-725)	2.5 ± 0.47	491
Menofia	176 (129.4-235.9)	1.80 ± 0.28	150.4	348.92 (232-463)	2.02 ± 0.40	298
Dakahlia	364.7 (279-453)	2.83 ± 0.47	311.7	478.8 (346-800)	1.74 ± 0.38	409.2
Kafr El-sheikh	171 (106-260)	1.20 ± 0.26	146	352 (254-451)	2.40 ± 0.43	300.8
Behera	337.6 (241-432)	2.42 ± 0.44	288	523.8 (375-772)	1.52 ± 0.27	447.7
Menia	187.69 (145.7-240.5)	2.23 ± 0.32	160.4	293 (185.6-391)	2.09 ± 0.42	250

* LC_{50} (CL 95%)

In general the results of early season indicate that resistance to the tested synthetic pyrethroid Esfenvalerate is wide spread and sever in the field-collected population of the cotton leafworm although such compound is one of the newly introduced insecticides in chemical Control program.

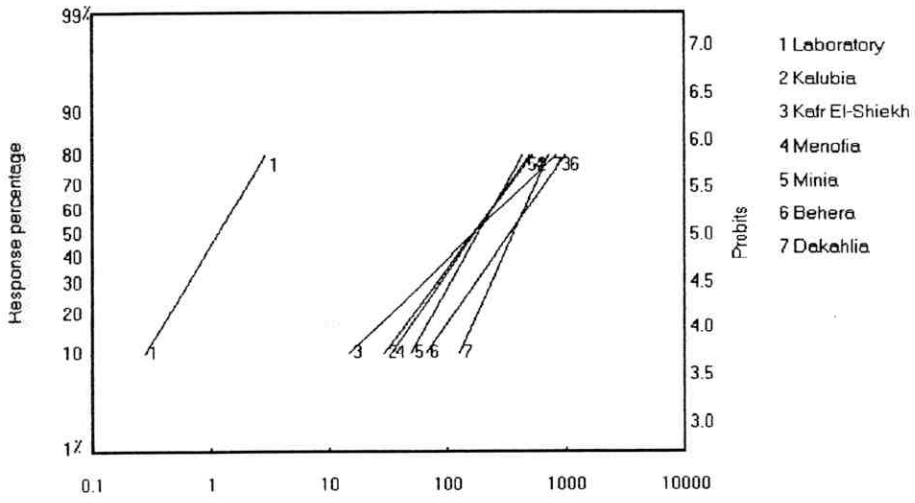


Fig.(3): Ldp-lines of Esfenvalerate on *S. Littoralis* field strain larvae collected from different Governorates at the beginning of the cotton season

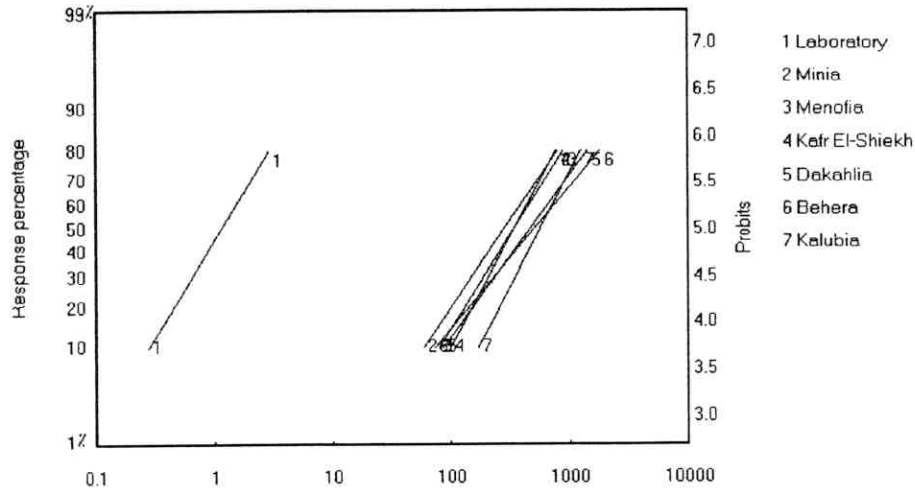


Fig.(4): Ldp-lines of Esfenvalerate on *S. Littoralis* field strain larvae collected from different Governorates at the end of the cotton season

The estimated resistance factor demonstrate that Dakahlia (RR = 311.7 fold) followed by Behera (RR = 288 fold) exhibited the highest resistance rate whereas relatively less resistance factors but still high, were evoked for field-collected population of Menia, Menofia, Kafr El-Sheikh and Kalubyia recording RR of 160.4, 150.4, 146 and 145.8 fold, respectively.

As for the late season susceptibility it was obvious that the cotton leafworm field populations of different Governorates exhibited similar response, expressed as high resistance rate but of higher magnitude. In this respect, the populations in Kalubyia followed by Behera and Dakahlia Governorates revealed the highest resistance ratios, reached 491, 447.7 and 409.1 fold, respectively whereas the least resistance ratios of 300.8 and 298 fold were recorded in Kafr El-Sheikh and Menofia, respectively.

El-Guindy *et al.* (1982) found that resistance to pyrethroids had already been established in field strains of *S. littoralis* in most of the Egyptian Governorates. They added that the differenr levels of significant resistance to pyrethroids exhibited by the field strains are the result of cross resistance with other groups of insecticides and not due to intensive or prolonged applications of these newly used compounds since their use in *Spodoptera* control first started in 1977 cotton season only and were and are still used once/year. In agreement, increased levels of methyl parathion resistance were accompanied by pyrethroid cross-tolerance before the wide spread introduction of the pyrethroids into the cotton fields of Arizona and California **(Crowder *et al.*, 1979** and **Twin and Reynolds, 1980).**

However, monitoring for resistance carried out by **El-Bermawy *et al.* (1992)** indicated that most of the tested field strains developed high levels of resistance averaged 50.9-6667.7 fold early in the cotton season versus 142.5-1738.8 fold late in the season for 5 out of 7 tested synthetic pyrethroids. Recently **Kim *et al.* (1998)** found that while field populations of *S. littoralis* showed resistance to commonly used insecticides ranged from 100- to 2700-fold for pyrethroids and ranged from 2- to 32-fold for organophosphates, they concluded that the broad spectrum of insecticide resistance observed was due to multiple resistance mechanisms, including increased detoxification of insecticides and insensitive acetylcholinestrase.

Data in Tables (3) and illustrated graphically in Fig. (5 and 6) represent the susceptibility of the cotton leafworm populations collected from cotton fields in different Governorates to the ecdysteroid agonist Tebufenozide (mimic).

Based on LC_{50} values early in the season (Table 3) the resistance spectrum in general was remarkably lower (RR = 8.53 – 26.8 fold) than that (Table, 1) for the organophosphate Profenofos (RR = 20.14 – 41.42 fold) and RR of 145.8 – 311.7 fold for the synthetic pyrethroid Esfenvalerate (Table 2). Such behaviour could be due to that cotton field in Egypt are not yet sprayed (as of the time this thesis was prepared) with Tebufenozide and though resistance to Tebufenozide can be attributed to cross-resistance.

The highest resistance ratio (RR = 26.8 fold) early in the season was recorded for Behera Governorate whereas resistance in population of Menia Governorate was marginal, recording the least ratio of resistance (RR = 8.53 fold). However, resistance ratios for

Tebufenozide in other tested Governorates exceeded the critical level (10-fold) recording 11.13 fold in Dakahlia, 11.66 fold in Menofia, 15.44 fold in Kafr El-Sheikh and 18.87 fold in Kalubyia respectively.

Table (3): Toxicity data and resistance ratios of Tebufenozide tested against 4th instar larvae of *S. littoralis* collected from different Governorates during the cotton season (2000).

Strains (Governorates)	Toxicity data					
	Before spraying			After spraying		
	LC_{50} * (ppm)	Slope ± SE	RR	LC_{50} * (ppm)	Slope ± SE	RR
Laboratory	1.23 (0.58-2.25)	0.52 ± 0.07	-	1.23 (0.58-2.25)	0.52 ± 0.07	-
Kalubyia	23.22 (3.9-1718)	0.338 ± 0.15	18.87	36.87 (24-59)	1.08 ± 0.2	29.97
Menofia	14.35 (7-28.8)	0.58 ± 0.12	11.66	20.09 (15.08-25.6)	1.45 ± 0.19	16.33
Dakahlia	13.7 (7-29)	0.54 ± 0.09	11.13	18 (14.5-21.8)	2.03 ± 0.22	14.63
Kafr El-sheikh	19 (9-33)	0.69 ± 0.15	15.44	22 (16.9-28.6)	1.42 ± 0.19	17.88
Behera	33 (24-46)	1.50 ± 0.22	26.8	42.9 (34-55)	1.63 ± 0.20	34.87
Menia	10.50 (7.06-15.14)	1.10 ± 0.14	8.53	15.53 (11.63-19.55)	1.63 ± 0.21	12.62

* LC_{50} (CL 95%)

As for the late season spectrum of resistance, it is obvious that slight increase occurred in the resistance ratios and cotton leafworm population in Behera Governorate still recorded the highest resistance ratios (RR = 34.87 fold) while Menia population recorded the least resistance ratio (RR = 12.62 fold). Other Governorate recorded intermediate resistance ratios.

Based on the LC_{50}'s, the resistance ratios of the field strains (field/laboratory ratio) for the 4th instar mortality early in the season in different Governorates were 20.14-41.42, 145.8-311.7 and 11.13-26.8

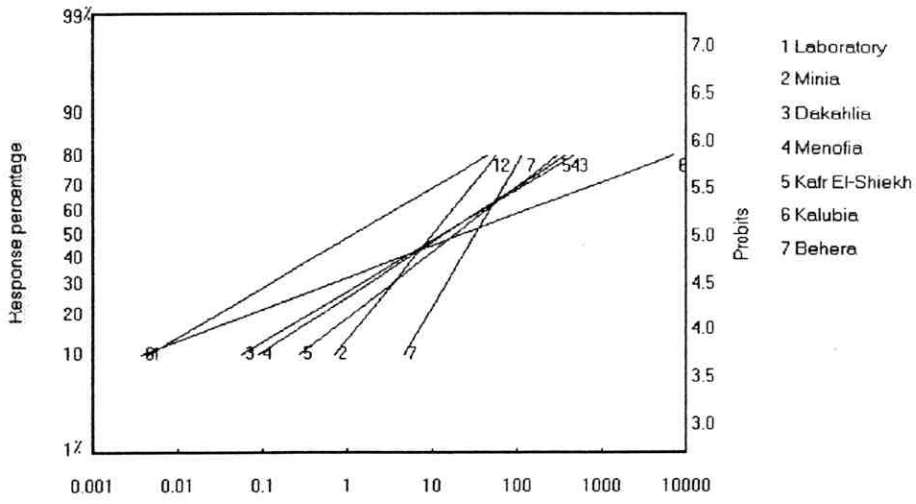


Fig.(5): Ldp-lines of Tebufenozide on *S. Littoralis* field strain larvae collected from different Governorates at the beginning of the cotton season

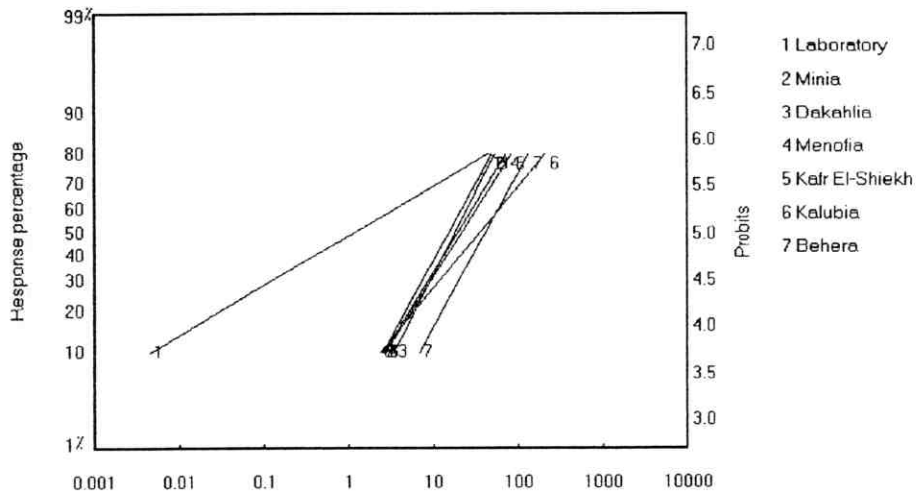


Fig.(6): Ldp-lines of Tebufenozide on *S. Littoralis* field strain larvae collected from different Governorates at the end of the cotton season

for organophosphates, pyrethroids and ecdysteroid agonist, respectively (Tables 1,2 and 3), indicating a slight reduction in susceptibility of larvae to Tebufenozide in the multiresistant field strain.

Because cotton fields in Egypt are sprayed heavily with conventional insecticides it was expected that insects collected from such fields would be multiresistant. In this respect, **Ishaaya and Klein (1990)** found that *S. littoralis* larvae collected from a cotton field that was heavily sprayed with conventional insecticides showed strong resistance to organophosphates and pyrethroids and showed a mild tolerance to benzoylphenyl urea, indicating that multiresistant factors caused by field application of various groups of insecticides may confer tolerance to Teflubenzuron.

Detailed data of change in the tolerance rate (TR) within the season (before to after) for each insecticide and Governorate presented in Table (4) demonstrate, in general, different patterns of change in tolerance rate. However, a tendency toward increase in tolerance rates was recorded for Profenofos in population of Dakahlia (2.05 X) and Behera (2.12 X). As for the pyrethroid Esfenvalerate a remarkably higher increase (3.36 X) in tolerance rate was recorded in Kalubyia Governorate whereas relatively less increase in tolerance rate was recorded in population of Kafr El-Shiekh (2.06 X) and Menofia (1.98 X) Governorate. It was of interest to note that relatively slight increase in tolerance rate ranging between 1.16 X and 1.58 X was recorded for the ecdysoid agonist Tebufenozide in population of different tested Governorates.

Table (4): The change in tolerance rate of *S. littoralis* field strains representing different Governorates to organophosphates, pyrethroids and insect growth regulators after applying the recommended chemical Control program.

Governorates	Tolerance rate (TR)*			
	Profenofos	Esfenvalerate	Tebufenozide	Mean
Kalubyia	1.27	3.36	1.58	2.07
Menofia	1.49	1.98	1.40	1.62
Dakahlia	2.05	1.31	1.31	1.55
Kafr El-Sheikh	1.13	2.06	1.16	1.45
Behera	2.12	1.55	1.30	1.65
Menia	1.27	1.56	1.48	1.43
Means	1.55	1.97	1.37	

* TR = LC_{50} after chemical Control program / LC_{50} before chemical Control program.

Generally, it was believed, based on the prementioned data, that the changes in tolerance rates resulting in enhancement of resistance in some Governorates more than others can be explained in terms of: (1) the previous history of insecticide use in these specific Governorates and (2) the type and sequence of insecticides used during the same season **(Rashwan *et al.* 1991-1992)**.

. **Development of resistance and cross-resistance in the cotton leafworm to ecdysteroid agonist Tebufenozide :**

Results in Table (5) demonstrated that a continues treatment selection through exposure and feeding on leaves treated with concentration representing LC_{25} of Tebufenozide over 8 generations of *S. littoralis* Behera-field strain, obtained late in the season, did not result in remarkably shift in susceptibility of *S. littoralis* larvae to Tebufenozide. An LC_{50} of 42.9 ppm Tebufenozide was estimated at the initiation of the selection pressure testes. However, after 4

generations of continuous treatment the LC_{50} of Tebufenozide against the 4th instar larvae increased by only 1.27 times to reach 54.69 ppm.

Table (5): Development of resistance against ecdysteroid agonist Tebufenozide in the cotton leafworm *S. littoralis*

Generations	LC_{50} (CL 95%) (ppm)	Slope ± SE	RR	Increase in T.R.
Lab-Strain	1.23	0.52		
Control *	42.9 (34.5-55.11)	1.63 ± 0.20	34.87	
G1	45.12 (33.05-58.52)	1.27 ± 0.15	36.68	1.050
G2	43.33 (33.89-54.17)	1.61 ± 0.19	35.22	1.008
G3	48.95 35.80-68.15)	1.01 ± 0.14	39.79	1.139
G4	54.69 (43.29-67.64)	1.58 ± 0.16	44.46	1.272
G5	65.58 (53.10-78.69)	2.15 ± 0.23	53.31	1.526
G6	60.30 (46.21-76.85)	1.34 ± 0.50	49.02	1.403
G7	70.62 (54.92-89.72)	1.36 ± 0.15	57.41	1.643
G8	72.42 (46.5-126)	1.85 ± 0.28	58.87	1.685

* Behera Governorate strain collected late in the season was used as Control for development of resistance study

Furthermore, that value increased by only 1.68 times and reached a level of 72.42 ppm after the prolonged treatment of Tebufenozide over 8 generations.

Though, it was promising that the continuos treatment of *S. littoralis* larvae with Tebufenozide did not significantly increase the tolerance of the insect larvae to this compound.

Similarly no shift in susceptibility of *S. exigua* last instars to RH 5849 was recorded after continuous treatments over 7 generations in separate experiments.

The results obtained can be discussed in the light of our past experience with resistance to IGR's in field strains of *S. littoralis*. Also, the information on resistance development to diflubenzuron and its related IGR's in laboratory of *S. littoralis* strains can contribute a lot in this respect.

El-Guindy *et al.* (1983) clearly demonstrated that laboratory selection for diflubezuron in the cotton leafworm indicate 300-fold resistant compared with the original strain. The authors added that the resistant strain was also chrachterized by levels of cross-resistance to organochlorines, organophosphates, carbamates and particularly pyrethroids. In contrast, **Van Laecke (1993)** recorded a 2- to 3 fold increase in tolerance to the benzoylurea teflobenzuron in *S. exigua* under comparable conditions after only 4 generations.

In laboratory studied carried out by **Smagghe and Degheele (1997)** to examine whether tolerance can be induce after continuous application of the nonsteroidal ecdysteroid (mimic) Tebufenozide at about LC_{30} over 5 generations of *S. littoralis*. They found that after 2 and 4 generations, toxicity data showed that such continuous treatment did not result in a shift of insect susceptibility even after 4 generations. In addition toxicity data compared with activity of several insecticides belonging to different groups against 3rd instars of a laboratory and multiresistance field strains showed that the resistance with Tebufenozide is difficult to achieve, however, further research on

tolerance and cross-resistance is required before definitive conclusion can be drawn .

Data based on LC_{50} values (Table 6) revealed that after 8 successive generations of selection the Tebufenozide-selected strain exhibited considerable resistance ratio of 58.87 fold relative to susceptible strain. On the other hand the same strain (Tebufenozide-selected) resulted in remarkably higher resistance ratios reached 79.19 and 370.8 fold in response to both the organophosphate, Profenofos and the pyrethroid Esfenvalerate, respectively. Such behaviour in response could be explained in view of considerable cross-resistance, where the pattern of cross-resistance represents an important factor in planing pest management programs, i.e, the extent to which resistance induced by exposure to one compound extend to other compounds to which the insect was not subjected to it yet.

Table (6): Cross-resistance pattern tested in the 8th generation to Profenofos and Esfenvalerate in the Tebufenozide-resistant strain of *S. littolaris*

Insecticide	Tested strain				Resis-tance Ratio (RR)	Cross Tolerance Ratio
	Laboratory (Susceptible)		Tebufenozide-resistant			
	LC_{50} (ppm) (CL 95%)	Slope ± SE	LC_{50} (ppm) (CL 95%)	Slope ± SE		
Profenofos	10.67 (7-14)	1.6 ± 0.28	845 (690-1084)	3.17 ± 0.52	79.19	1.34
Esfenvalerate	1.17 (0.8–1.54)	2.07 ± 0.40	433.9 (343-581)	2.58 ± 0.44	370.8	6.29
Tebufenozide	1.23 (0.58-2.25)	0.52 ± 0.07	72 (46.5-126)	1.85 ± 0.28	58.87	1.00

Reviewing the literature, several cases of cross-resistance between different insecticides were recorded in the cotton leafworm **(Rizk,**

1972; El-Deeb *et al.* 1980; El-Guindy *et al.* 1984-85; Ahmed *et al.*, 1987; El-Ghareeb, 1994).

Up to new only few experiments have been conducted on cross-resistance for insect growth regulators. **Ishaaya and Klein (1990) and Ishaaya *et al.* (1995)** found that an Israel-field strain of *S. littoralis* being > 100 fold resistant to organophosphates and pyrethroids, showed a mild cross-resistance of 5-fold to teflubenzuron. **Ishaaya (1992)** claimed this should be induced by an elevated level of detoxifying enzymes. However, the current results in addition to target pest selectivity, new and novel mode of action, ecotoxicological safety and safety to beneficial arthropods make these insecticides (ecdysteroid agonists) valuble tools for integrated pest and resistance management programs.

2. Physiological studies :

The quantitative aspects of insect nutrition between susceptible and more tolerable or resistant population, however, received less attention, and there have been few studies on the rates of intake and the efficiency of food utilization.

It seems apControl that adaptive nutritional differences must be sought on a quantitative level and that a meaningful comparative nutrition of insect of different population will not emerge until quantitative studied are emphasized.

However, differences in food efficiency can be demonstrated only by measuring intake and growth. Digestibility should also be measured since it can be expected to vary widely with tolerance level of insect (susceptible VC. tolerant or resistance).

Poor growth may not be due to the nutritional inadequacy of the food but to a low rate of intake due to food contamination with certain pesticides. However, measures of intake and utilization can give an indication of this, since patterns of utilization may be different.

Schroeder (1976) indicated that when the insect diet include compound which act as repellent may suffer shortage in their nutritional requirements leading to some physiological changes in the normal consumption and conversion of the food to the larvae tissue.

In this respect **Waldbauer (1968)** pointed out that an overall understanding of the utilization of a food requires basic information for the calculation of the rate of feeding the digestibility and efficiency of conversion of food to body substance.

Utilization data are most useful if they are reduced to terms which allow one to compare the effects by environmental factors such as food (leaves) contamination by insecticides, on utilization. Various indices of consumption, digestibility and efficiency of conversion in insect have been discussed by **Gordon (1959)**. However, the results indicating the effect of sublethal concentrations of different pesticides on different physiological parameters in larvae of susceptible and resistant populations were calculated on fresh weight basis and recorded in Tables (7-13) while illustrated graphically in figs. (7-13).

2.1. Antifeeding activity of different pesticides against larvae of field and laboratory populations of the cotton leafworm:

Based on resistance spectrum calculated from the LC_{50} values resulted in the susceptibility tests of *S. Littoralis* 4th instar larvae representing population of 6 different Governorates relative to the

susceptible laboratory strain, only populations of Kalubyia and Behera Governorates were chosen, as the most resistant populations, to be used in studying the effect of sublethal concentartions (contamination) of certain pesticides on feeding activity as a vital physiological aspect in insect life.

Data in Table (7) and illustrated in Fig.(7), shows the deterrent effect against *S. Littoralis* 4th instar larvae after feeding for 48hr leaves treated with sublethal concentrations (LC_0 and LC_{10}). It was obvious that the IGR Tebufenazide revealed significantly the highest mean antifeedant activity (89.26 - 89.52 %) against the lab-susceptible strain, whereas both insecticides Profenofas and Esfenvalerate exhibited significantly less antifeeding activity, recording 38.86 - 43.26 and 40.62- 53.3 % for both compounds at LC_0 and LC_{10}, respectively.

Similar performance but of relatively less magnitude was almostly achieved in case of both heighly resistant population of Kalubyia and Behera Governorates. It is of interest to note that larvae of the most resistant strain (Behera) exhibited the least response (antifeeding activity) for the 3 investigated insecticides when used at sublethal concentration.

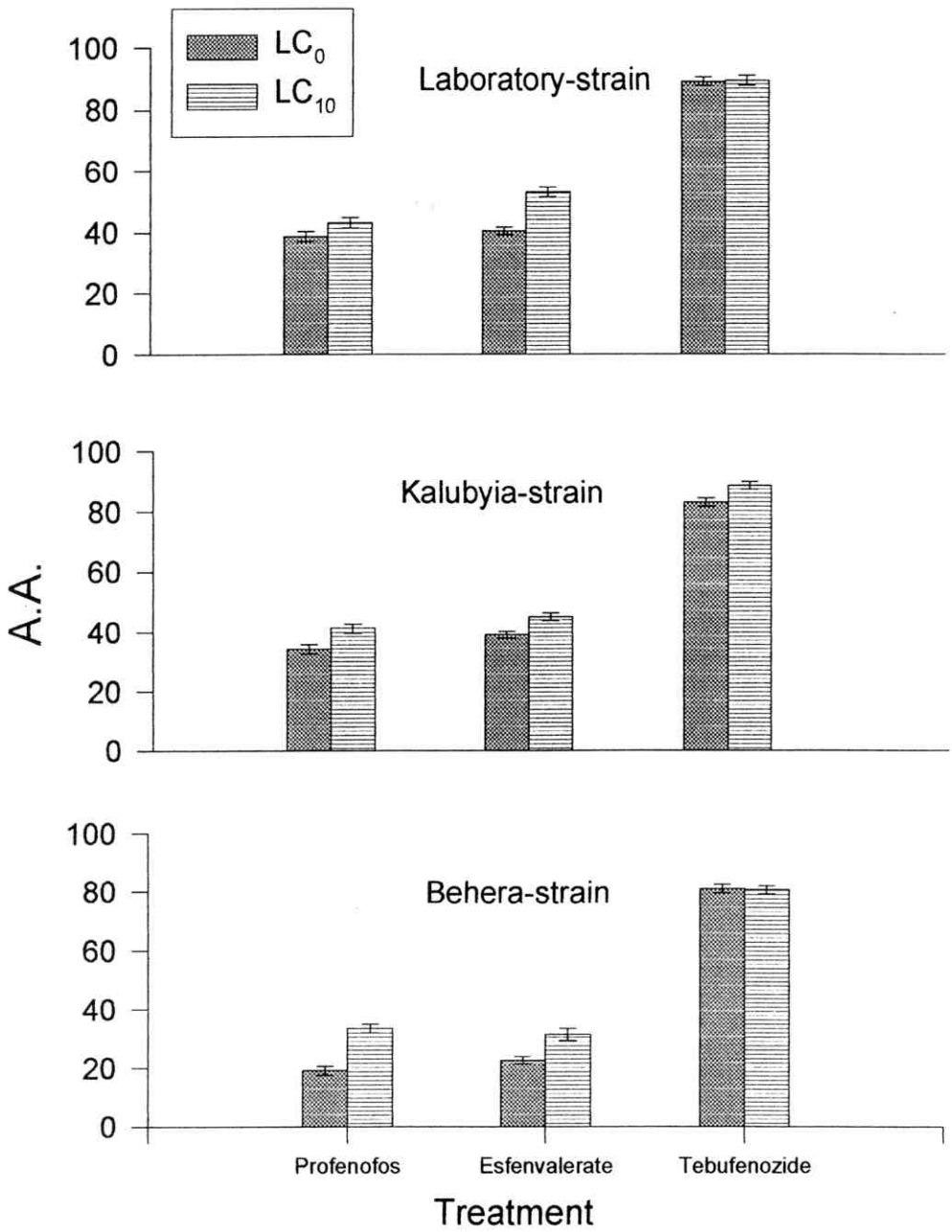
The highest antifeeding activity of the IGR Tebufenozide recorded in the present study came in agreement with findings of **Abo-Elghar (1985)** who found that the feeding of 4th instar larvae of *S. littoralis* on unlethal (LC_0) or sublethal (LC_{50}) of the IGR triflumuron or diflubenzuron showed extremely decrease in consumed food compared with control. The low weight of consumed food indicated the occurrence of feeding inhibition. However, inhibition of feeding in response to IGR such as diflubenzuron **(Sudaramurthy, 1977)** or

JHA, methoprene **(Sudaramurthy, 1978)** has been reported when the last instar larvae of *Spodoptera littoralis* were fed on leaves treated with the prementioned compounds. He suggested that such feeding inhibition might be due to abnormally shaped mouth parts than to blockage of transmission of feeding stimuli through the central nervous system. Also, similar performance was obtained in larvae of *Earias insulana* when treated with diflubenzuron **(Abid *et al.* 1978)**.

Table (7): Antifedant activity (AA) for *S. littoralis* larvae after feeding of 4th instar for 48 h on castor bean leaves treated with sublethal concentration of certain insecticides.

Treatments	Concen. ppm	Time (Days) Means* ± SE					
		1 st.	2 nd.	3 rd.	4 th.	5 th.	Mean*
Laboratory strain							
Profenofos LC0	0.380	23.6	32.0	34.0	46.4	58.3	38.86 ± 1.64 b
LC10	1.700	27.3	33.0	40.0	51.6	64.4	43.26 ± 1.72 b
Esfenvalerate LC0	0.088	33.9	36.0	37.0	43.1	53.1	40.62 ± 1.24 b
LC10	0.280	39.9	45.0	56.0	60.7	64.9	53.30 ± 1.53 b
Tebufenozide LC0	4.8×10^{-5}	78.0	82.0	95.7	95.4	95.2	89.26 ± 1.31 a
LC10	4.6×10^{-3}	71.0	85.0	97.8	96.2	97.6	89.52 ± 1.52 a
LSD 0.05							14.94
Kalubiya field strain							
Profenofos LC0	10.67	17.6	26.5	33.6	37.0	55.8	34.10 ± 1.68 b
LC10	63.33	26.1	33.6	39.6	49.9	57.3	41.30 ± 1.57 b
Esfenvalerate LC0	67.0	30.4	36.6	39.0	41.0	48.5	39.10 ± 1.14 b
LC10	176.0	34.9	41.9	42.7	50.3	56.5	45.26 ± 1.28 b
Tebufenozide LC0	0.26	72.0	74.7	82.7	91.7	95.1	83.24 ± 1.42 a
LC10	2.42	76.3	86.5	91.1	96.9	93.5	88.86 ± 1.26 a
LSD 0.05							13.45
Behera field strain							
Profenofos LC0	68.8	5.5	9.30	21.1	21.5	38.1	19.10 ± 1.58 c
LC10	199.0	18.5	28.1	34.4	37.6	48.5	33.42 ± 1.49 b
Esfenvalerate LC0	15.35	10.9	17.9	26.6	24.6	33.3	22.66 ± 1.31bc
LC10	74.94	22.1	26.8	27.4	31.5	49.1	31.38 ± 2.09bc
Tebufenozide LC0	1.63	68.8	82.5	80.5	86.1	86.4	80.86 ± 1.43 a
LC10	7.08	73.6	86.9	90.2	98.5	93.3	88.50 ± 1.36 a
LSD 0.05							13.15

* Means followed by the same letter in each column are not significantly different according to Duncan's multible range test.



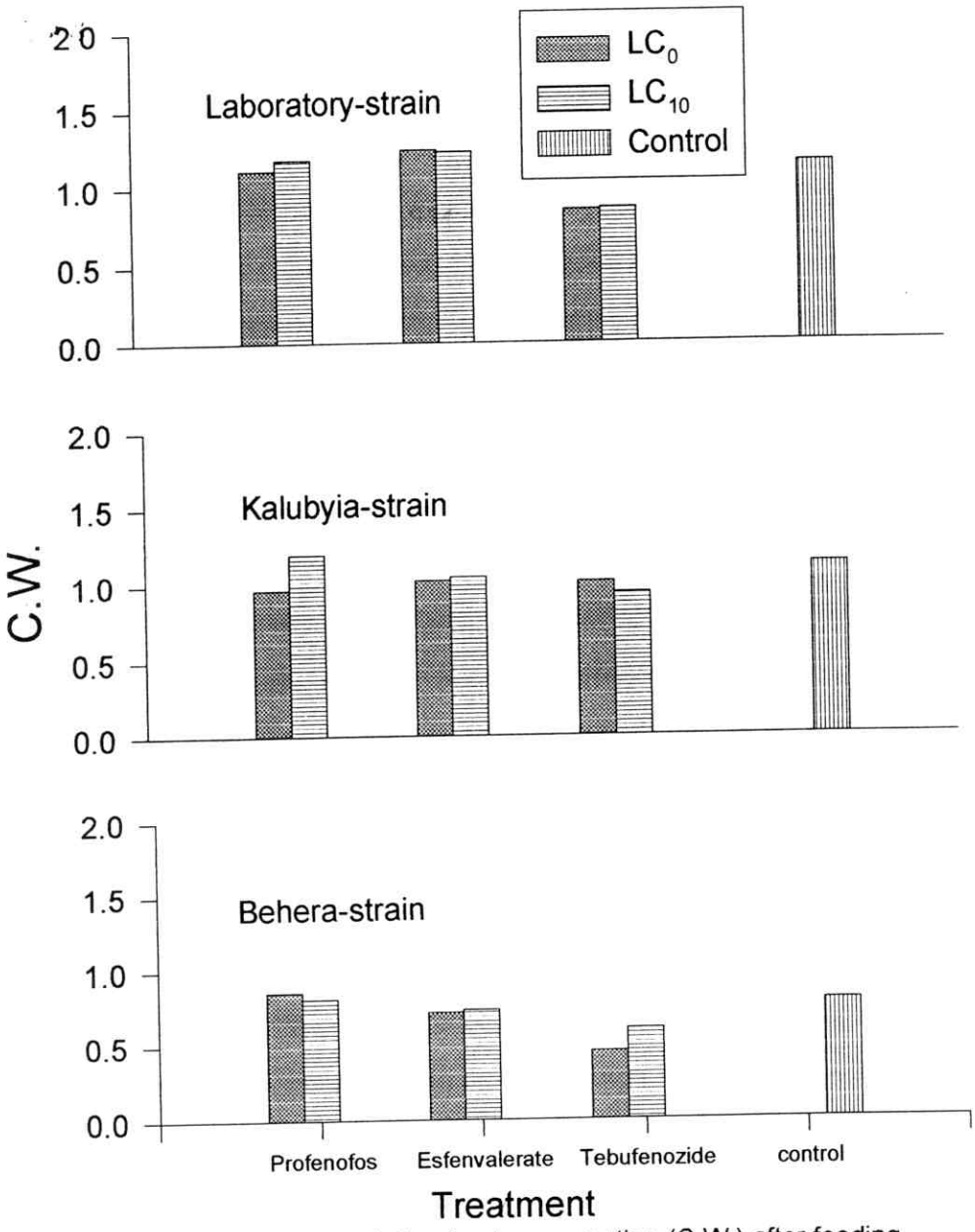
Fig(7): Effect of feeding sublethal concentrations of Profenofos, Esfenvalerate and Tebufenozide on daily mean antifedant activity (A.A.) of *S. littoralis* 4th instar larvae during the experimental period

2.2. Weight of foosd consumed (C.W.)

Data in Table (8) and Fig. (8) show that, on a weight basis, the cumulative food consumed was remarkably higher for larvae of lab-strain that fed on untreated leaves when compared with larvae in both field resistant strains fed also on untreated leaves, recording an overall cumulative mean of 1.155 g/larvae for Lab-strain versus 1.127 and 0.79 g/larvae for Kalubyia and Behera strains, respectively.

Table (8): Daily cumulative food consumption (C.W.) after feeding of *Spodoptera littoralis* 4th instar larvae for 48 h. on leaves treated with sublethal concentrations of different insecticides

Treatments	Concen. ppm	Daily cumulative mean weight of food consumed (g/larvae) at the indicated day				
		1 st.	2 nd.	3 rd.	4 th.	5 th.
Laboratory strain						
Profenofos LC0	0.380	0.0975	0.2725	0.4850	0.8250	1.115
LC10	1.700	0.0850	0.2875	0.4975	0.8275	1.1825
Esfenvalerate LC0	0.088	0.0950	0.2725	0.5225	0.8425	1.2425
LC10	0.280	0.0900	0.2825	0.4550	0.8025	1.2325
Tebufenozide LC0	4.8×10^{-5}	0.1025	0.2100	0.3950	0.6100	0.8525
LC10	4.6×10^{-3}	0.1650	0.2675	0.4125	0.6600	0.8625
Control		0.1050	0.2925	0.5400	0.8600	1.1550
Kalubiya field strain						
Profenofos LC0	10.67	0.1025	0.2900	0.4500	0.7200	0.9675
LC10	63.33	0.1025	0.2850	0.4550	0.6625	1.1950
Esfenvalerate LC0	67.0	0.0775	0.2475	0.4250	0.6300	1.0250
LC10	176.0	0.0750	0.2350	0.4050	0.6700	1.0450
Tebufenozide LC0	0.26	0.1125	0.2925	0.4250	0.6525	1.0125
LC10	2.42	0.1175	0.3000	0.4125	0.5950	0.9425
Control		0.1025	0.2900	0.4650	0.7550	1.1275
Behera field strain						
Profenofos LC0	68.8	0.1025	0.2350	0.4275	0.1625	0.8550
LC10	199.0	0.1025	0.2375	0.4100	0.5725	0.8100
Esfenvalerate LC0	15.35	0.1025	0.2275	0.3825	0.5500	0.7175
LC10	74.94	0.0900	0.2200	0.4000	0.5550	0.7350
Tebufenozide LC0	1.63	0.1000	0.1525	0.2775	0.3650	0.4500
LC10	7.08	0.0875	0.1500	0.2500	0.4025	0.6050
Control		0.0900	0.2175	0.4000	0.4140	0.7925



Fig(8): Daily cumulative food consumption (C.W.) after feeding of *S. littoralis* 4th instar larvae for 48 h. on leaves treated with sublethal concentrations of different insecticides

Also, in general, a decrease in the cumulative food consumed was recorded for lab-strain larvae fed on leaves treated with sublethal (LC_0 and LC_{10}) concentrations of Mimic Such behaviour was also recognized in larvae of both field strains where it was remarkably more observed in Behera-strain, which highly tolerate the tested IGR (RR= 26.8 fold for mimic), than in Kalubyia-strain (RR= 18.37 for mimic).

However it was of interest to note here that the O.P. resistant (RR= 32.7) larvae of field strain of Behera that survived and already can resist the sublethal concentrations (LC_0 and LC_{10}) of the tested organopho-sphate, Profenofos seemed to be more active in feeding than control or/and the other treatments as manifested by the relatively higher cumulative consumed feeding (0.81-0.85 g/larvae) during the experimental period compared with 0.79 g/larvae fed on untreated food (control).

Previous reports have indicated that insect growth disruptors interfere with feeding **(Mulder and Giswijt, 1973; Ascher and Nemny 1976; Abid *et al.*, 1978, Radwan *et al.*, 1986)**. It was also confirmed that an IGR such as diflubenzuron acts on the peritrophic membrane by affecting its chitin-protein structure, hindering its role in protecting secreting cell from any damage **(Clarke *et al.*, 1977).**

2.3. Consumption index (C.I.)

One of the factors associated with feeding rates is the consumption index (C.I.).

Valid comparisons between different strain and treatments can be made on the basis of the rate of intake relative to the mean weight of

the animal during feeding period. In this respect an average of daily weights will give an almost accurate value of consumption index. However, **Legagy (1957)** proposed mg of food eaten per g of insect (initial weight) per day.

Data in Table (9) and Fig.(9) show that the consumption index (C.I.) at 24 h post-treatment was statistically unaffected for laboratory (Susceptible) strain larvae fed on sublethal concentrations (LC_0 and LC_{10}) of different tested compounds. However, continuous feeding the susceptible strain larvae for 48 h led to considerable decrease in C.I. for larvae fed Tebufenozide-treated leaves, such decrease was significant at the higher sublethal concentration (LC_{10}) when compared with other treatments and the control. Regarding the overall daily mean after larval feeding for five days (2 day treated leaves + 3 day untreated leaves), it was obvious that the mean C.I. was insignificant in all treatments as well as in control, in spite of the remarkable decrease in both treatments of Tebufenozide.

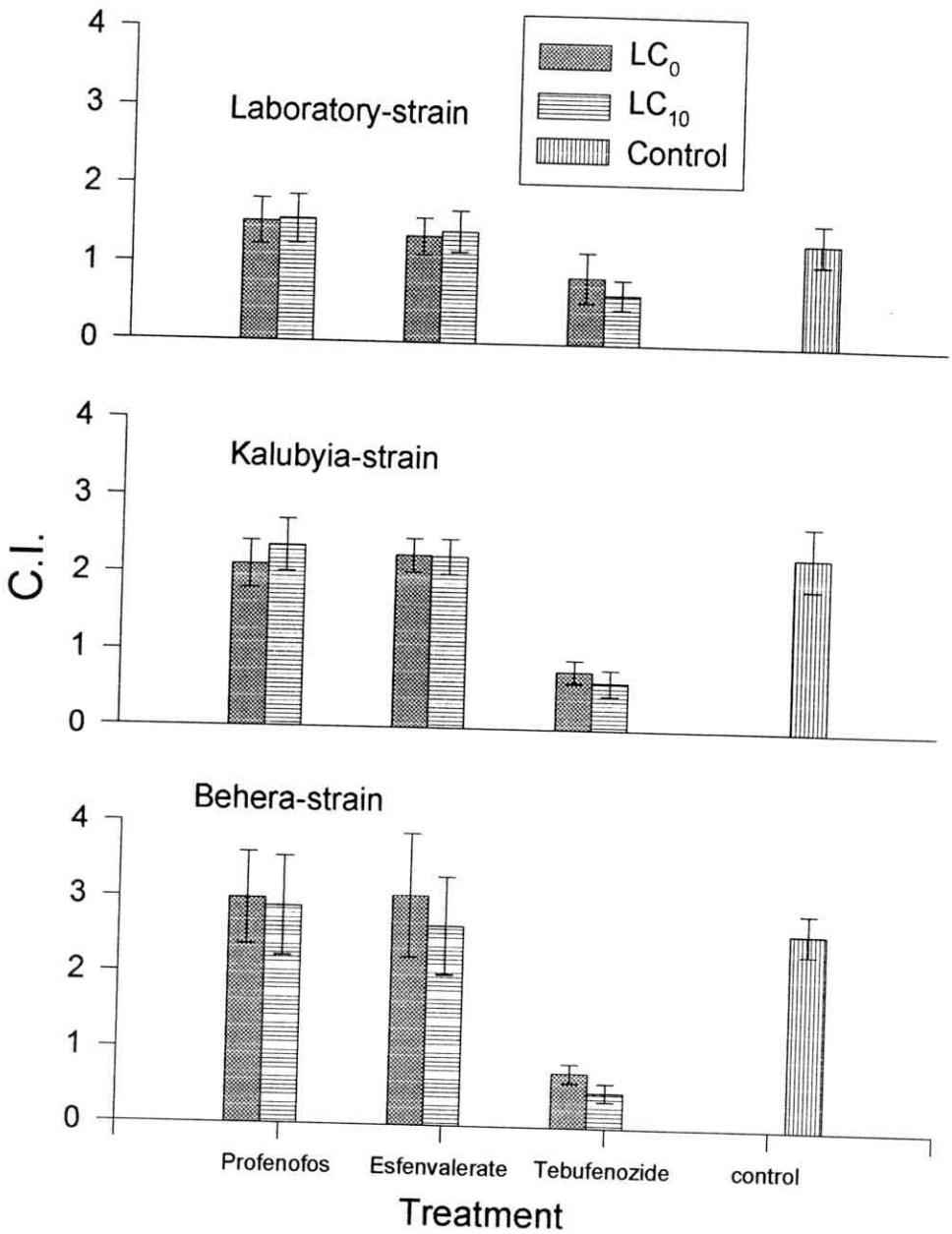
As for the highly resistant larvae (RR 29.97 – 52.7 and 34.87 – 68.9 fold) representing the field population of Kalubiya and Behera Governorates, respectively a remarkably different behaviour was exibited, where almostly similar and insignificant C.I. was recorded after 24 h feeding the larvae on leaves treated with sublethal concentrations of the O.P. Profenofos and the pyrethroid Esfenvalerate as well as for larvae fed on untreated leaves in control. In contrast feeding the field population larvae for 24 h on leaves treated with both concentrations (LC_0 and LC_{10}) of Tebufenozide resulted in C.I. significantly lower than other treatments and control. Continuous feeding for 48 h on treated leaves exhibited similar behaviour where the

C.I. values were significantly decreased in Tebufenozide than in the treatments of the two other insecticides and the control, in which insignificant C.I. values were achieved. Comparison on the basis of mean C.I. obtained after 5 days of larval feeding revealed significant decrease in Tebufenozide treatments compared with other treatment including control. However, the decrease in C.I. values was relatively

Table (9): Consumption index (CI) for *S. littoralis* larvae after feeding of 4th instar for 48 h on castor bean leaves treated with sublethal concentration of certain insecticides.

Treatments	Concen. ppm	Time (Days) Means* ± SE					
		1 st.	2 nd.	3 rd.	4 th.	5 th.	Mean
Laboratory strain							
Prof. LC0	0.380	1.48 ± 0.11 a	2.62 ± 0.37 ab	1.50 ± 0.10 a	1.40 ± 0.07 a	0.67 ± 0.04 ab	1.53 ± 0.29 a
LC10	1.700	1.23 ± 0.08 ab	2.95 ± 0.29 a	1.37 ± 0.12 a	1.42 ± 0.10 a	0.82 ± 0.04 a	1.56 ± 0.31 a
Esfen. LC0	0.088	1.15 ± 0.05 b	2.25 ± 0.11 bc	1.62 ± 0.02 a	1.05 ± 0.05 b	0.71 ± 0.10 ab	1.36 ± 0.23 a
LC10	0.280	1.20 ± 0.10 b	2.73 ± 0.12 ab	1.36 ± 0.02 a	1.03 ± 0.05 b	0.85 ± 0.09 a	1.43 ± 0.26 a
Tebu. LC0	4.8×10^{-5}	1.15 ± 0.15 b	1.67 ± 0.04 c	1.05 ± 01 b	0.32 ± 0.21 c	0.16 ± 0.07 c	0.87 ± 0.32 a
LC10	4.6×10^{-3}	1.30 ± 0.06 ab	0.91 ± 0.17 d	1.02 ± 0.07 b	0.07 ± 0.02 d	0.04 ± 0.14 c	0.66 ± 0.19 a
Control		1.30 ± 0.09 ab	2.25 ± 0.15 bc	1.50 ± 0.13 a	1.05 ± 0.02 b	0.59 ± 0.03 b	1.34 ± 0.26 a
LSD 0.05		0.23	0.63	0.25	0.16	0.17	0.87
Kalubiya field strain							
Prof. LC0	10.67	3.41 ± 0.08 ab	4.00 ± 0.34 a	1.36 ± 0.08 a	1.25 ± 0.10 bc	0.59 ± 0.15 c	2.12 ± 0.31 a
LC10	63.33	3.92 ± 0.25 a	3.97 ± 0.42 a	1.42 ± 0.09 a	1.08 ± 0.10 cd	1.48 ± 0.10 a	2.37 ± 0.34 a
Esfen. LC0	67.0	3.16 ± 0.57 ab	4.25 ± 0.25 a	1.59 ± 0.13 a	1.12 ± 0.08 cd	1.18 ± 0.13 ab	2.26 ± 0.22 a
LC10	176.0	2.79 ± 0.36 b	4.23 ± 0.58 a	1.56 ± 0.12 a	1.48 ± 0.11 ab	1.17 ± 0.10 ab	2.25 ± 0.23 a
Tebu. LC0	0.26	1.27 ± 0.03 c	0.71 ± 0.13 b	0.91 ± 0.08 b	0.83 ± 0.03 d	0.19 ± 0.19 d	0.78 ± 0.15 b
LC10	2.42	1.26 ± 0.03 c	0.55 ± 0.15 b	0.82 ± 0.03 b	0.50 ± 0.06 e	0.11 ± 0.42 d	0.64 ± 0.17 b
Control		3.41 ± 0.28 ab	3.83 ± 0.43 a	1.51 ± 0.19 a	1.59 ± 0.13 a	1.14 ± 0.05 b	2.30 ± 0.41a
LSD 0.05		0.86	1.06	0.34	0.28	0.29	1.23
Behera field strain							
Prof. LC0	68.8	5.00 ± 0.20 ab	4.20 ± 0.25 a	2.92 ± 0.13 a	1.58 ± 0.07 a	1.29 ± 0.13 a	2.99 ± 0.61a
LC10	199.0	5.12 ± 0.13 ab	3.72 ± 0.36 ab	2.85 ± 0.45 a	1.54 ± 0.09 a	1.26 ± 0.19 a	2.89 ± 0.59 a
Esfen. LC0	15.35	6.37 ± 1.21 a	3.17 ± 0.19 b	2.89 ± 0.34 a	1.42 ± 0.14 a	1.40 ± 0.23 a	3.05 ± 0.82 a
LC10	74.94	4.50 ± 0.20 b	3.47 ± 0.27 ab	2.95 ± 0.39 a	1.21 ± 0.08 a	1.14 ± 0.03 a	2.65 ± 0.65 a
Tebu. LC0	1.63	1.95 ± 0.90 c	0.83 ± 0.48 c	0.60 ± 0.23 b	0.14 ± 0.21 b	0.09 ± 0.06 b	0.72 ± 0.13 b
LC10	7.08	1.38 ± 0.92 c	0.68 ± 0.12 c	0.12 ± 0.12 b	0.12 ± 0.15 b	0.07 ± 0.02 b	0.47 ± 0.12 b
Control		4.25 ± 0.58 b	3.45 ± 0.33 ab	2.57 ± 0.47 a	1.66 ± 0.30 a	1.14 ± 0.07 a	2.61 ± 0.27 a
LSD 0.05		1.53	0.71	0.93	0.41	0.37	1.82

* Means followed by the same letter in each column are not significantly different according to Duncan's multible range test.



Fig(9):Effect of feeding sublethal concentrations of Profenofos, Esfenvalerate and Tebufenozide on daily mean consumption index (C.I.) of *S. littoralis* 4th instar larvae during the experimental period

more remarkable in Bahera strain (RR for O.P. = 68.9 fold) than Kalubiya strain (RR for O.P. = 52.7 fold), particularly at the high sublethal concentration (LC_{10}).

In this respect **Sundaramurthy (1977)** stated that feeding final-instar larvae of *Spodoptera littoralis* on leaves of castor been treated with sublethal concentration of diflubenzuron reduced the amount of food ingested, and weight gain by the larvae. Similarly, **Radwan *et al.*, (1986)** found that larvae of *Spodoptera littoralis* fed on diflubenzuron-treated leaves showed a reduction in the consumed food and consequently the consumption index (C.I.).

Recently, **Arora and Sidhu (1993)** found that the consumption index were lower for larvae fed on leaves treated with the LC_{10}, LC_{50} and LC_{90} of diflubenzuron compared with those for larvae fed untreated leaves during the 1st few days of the experiment. Also **Nathan and Srivastava (1997)** found that feeding 3rd instar larvae of *Pericalla ricini* on castor been leaves treated with higher concentration of diflubenzuron resulted in increased reduction in food consumption.

2.4. Growth Rate (G.R.):

Data in Table (10) and Fig.(10) show that feeding the laboratory (susceptible) strain for 24 h on leaves treated with sublethal concentration of different treatments resulted in significantly reduction of growth rate than control whereas differences between each other were insignificant.

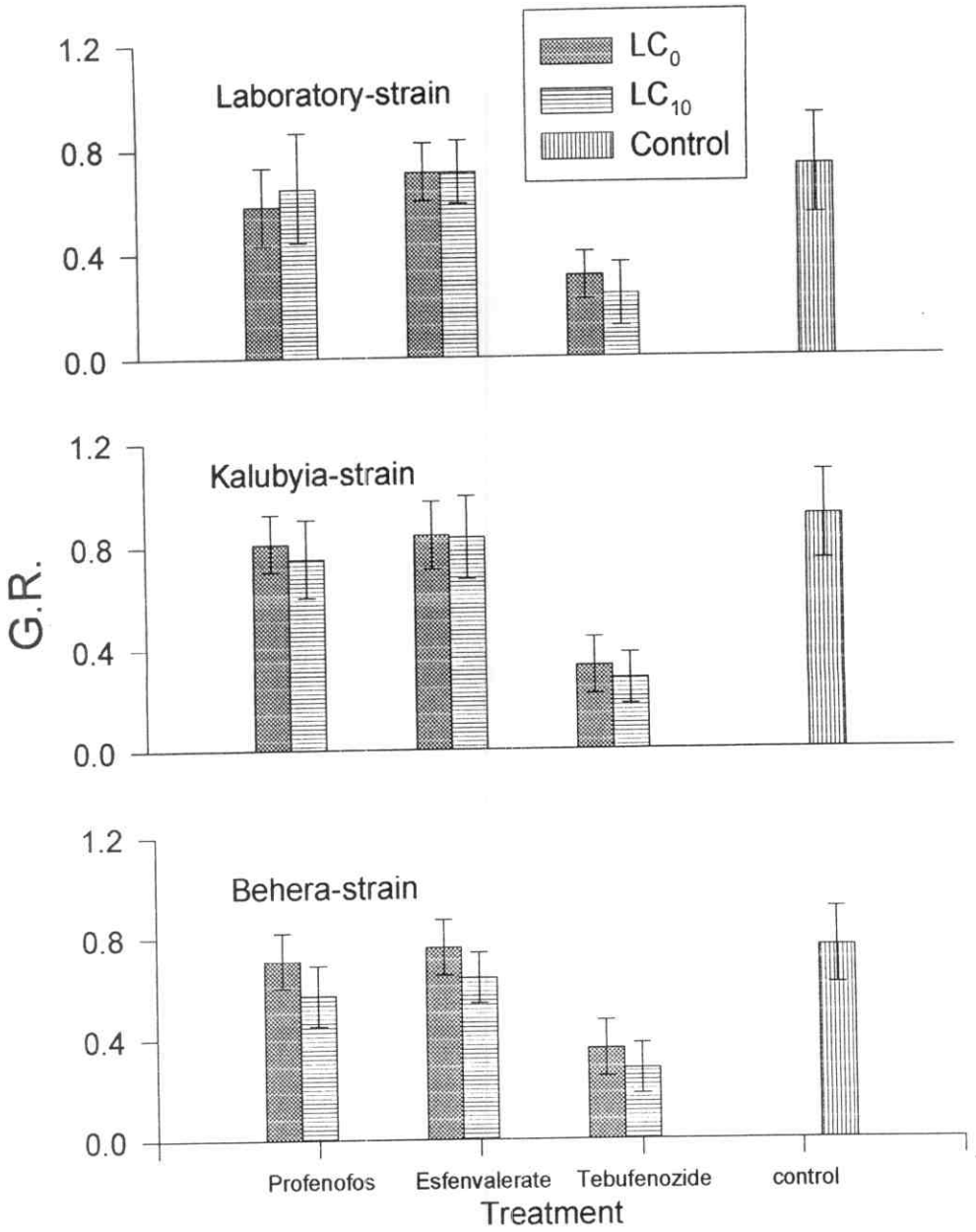
Continuous feeding for 48 h on treated leaves exhibited a more pronounced effect of Tebufenozide at both concentrations tested where a significantly lower growth rate was recorded. However, such trend

was confirmed when means after 5 days feeding were considered. particularly at the high sublethal concentration of Tebufenozide.

Table (10): Growth rate (GR) for *S. littoralis* larvae after feeding of 4th instar for 48 hrs. on castor bean leaves treated with sublethal concentration of certain insecticides.

Treatments	Concen. ppm	Time (Days) Means* ± SE					
		1 st.	2 nd.	3 rd.	4 th.	5 th.	Mean
Laboratory strain							
Prof. LC0	0.380	0.35±0.09 b	0.85± 0.06 b	0.68± 0.05 b	0.77± 0.04 bc	0.27 ± 0.09 b	0.58±0.15 abc
LC10	1.700	0.33 ± 0.07 b	1.22 ± 0.07 a	0.61 ± 0.06 b	0.87 ± 0.08 ab	0.23 ± 0.05 b	0.65 ± 0.21 ab
Esfen. LC0	0.088	0.53 ± 0.07 ab	1.00 ± 0.12 ab	0.97 ± 0.07 a	0.85 ± 0.08 ab	0.19 ± 0.02 b	0.71 ± 0.11 ab
LC10	0.280	0.43 ± 0.1 ab	1.23 ± 0.02 a	0.63 ± 0.02 b	0.96 ± 0.07 a	0.28 ± 0.08 b	0.71 ± 0.12 ab
Tebu. LC0	4.8×10^{-5}	0.38 ± 0.06 b	0.47 ± 0.06 c	0.32 ± 0.11 c	0.25 ± 0.13 d	0.15 ± 0.12 b	0.31 ± 0.09 bc
LC10	4.6×10^{-3}	0.30 ± 0.10 b	0.33 ± 0.04 c	0.25 ± 0.10 c	0.20 ± 0.05 d	0.13 ± 0.02 b	0.24 ± 0.12 c
Control		0.65 ± 0.05 a	0.97 ± 0.10 b	0.87 ± 0.11 a	0.62 ± 0.04 c	0.55 ± 0.02 a	0.73 ± 0.19 a
LSD 0.05		0.20	0.24	0.18	0.17	0.14	0.36
Kalubiya field strain							
Prof. LC0	10.67	0.57 ± 0.08 ab	1.85 ± 0.09 a	0.59 ± 0.05 a	0.82 ± 0.04 a	0.23 ± 0.06 c	0.81 ± 0.11 a
LC10	63.33	0.58 ± 0.16 ab	1.55 ± 0.11 ab	0.60 ± 0.05 a	0.83 ± 0.12 a	0.20 ± 0.02 c	0.75 ± 0.15 a
Esfen. LC0	67.0	0.66 ± 0.19 ab	1.81 ± 0.12 a	0.62 ± 0.04 a	0.84 ± 0.07 a	0.26 ± 0.01 bc	0.84 ± 0.13 a
LC10	176.0	0.54 ± 0.08 ab	1.86 ± 0.31 a	0.63 ± 0.01 a	0.77 ± 0.03 a	0.37 ± 0.07 b	0.83 ± 0.16 a
Tebu. LC0	0.26	0.49 ± 0.13 b	0.35 ± 0.16 c	0.28 ± 0.05 b	0.27 ± 0.03 b	0.26 ± 0.14 bc	0.33 ± 0.11 b
LC10	2.42	0.38 ± 0.05 b	0.30 ± 0.08 c	0.20 ± 0.03 b	0.24 ± 0.02 b	0.28 ± 0.23 bc	0.28 ± 0.10 b
Control		0.91 ± 0.15 a	1.33 ± 0.16 b	0.59 ± 0.04 a	0.80 ± 0.13 a	0.95 ± 0.03 a	0.91 ± 0.17 a
LSD 0.05		0.35	0.44	0.11	0.21	0.12	0.26
Behera field strain							
Prof. LC0	68.8	0.62 ± 0.13 b	1.02 ± 0.12 a	0.79 ± 0.08 ab	0.59 ± 0.07 a	0.52 ± 0.06 a	0.71 ± 0.11 a
LC10	199.0	0.56 ± 0.02 b	0.70 ± 0.12 ab	0.71 ± 0.16 ab	0.50 ± 0.13 ab	0.42 ± 0.05 ab	0.57 ± 0.12 ab
Esfen. LC0	15.35	1.37 ± 0.24 a	0.68 ± 0.06 ab	0.79 ± 0.16 ab	0.59 ± 0.08 a	0.39 ± 0.05 ab	0.76 ± 0.11 a
LC10	74.94	0.87 ± 0.13 b	0.66 ± 0.05 ab	0.82 ± 0.25 a	0.49 ± 0.04 ab	0.36± 0.19abc	0.64± 0.10 ab
Tebu. LC0	1.63	0.57 ± 0.05 b	0.35 ± 0.10 bc	0.35 ± 0.09 bc	0.28 ± 0.02 b	0.28 ± 0.19 bc	0.36 ± 0.11 bc
LC10	7.08	0.55 ± 0.25 b	0.27 ± 0.02 c	0.18 ± 0.01 c	0.24 ± 0.01 b	0.18 ± 0.17 c	0.28 ± 0.10 c
Control		0.78 ± 0.21 b	0.98 ± 0.25 a	0.82 ± 0.06 ab	0.67 ± 0.01 a	0.53 ± 0.08 a	0.76 ± 0.15 a
LSD 0.05		0.38	0.37	0.41	0.21	0.18	0.27

* Means followed by the same letter in each column are not significantly different according to Duncan's multible range test.



Fig(10): Effect of feeding sublethal concentrations ofdifferent insecticides on daily mean growth rate (G.R.) of *S. littoralis* 4th instar larvae during the experimental period

As for both field resistent strains of Kalubyia and Behera Governorates, almostly similar trend was achieved where Tebufenozide resulted in the highest decrease in growth rate. However, the data recorded her show a proportional relationship between values of consumption index and growth rate, particularly in case of Tebufenozide treatments. In this respect **Woodring *et al.*, (1978) and Sundramurthy (1977)** indicated that the amount of growth reduction was proportional in general to reduced food consumption.

The growth rate (G.R.) of the *Spodoptera littoralis* larvae that fed leaves treated with sublethal concentrations of Tebufenozide was significantly lower than both control and other treatments and came in agreement with results of **Abo Elghar (1985)** who found that growth rate (G.R.) in *Spodoptera littoralis* larvae treated with LC_0 and LC_{50} of diflubenzuron was less than the control. Such reduction in growth rate could be explained is view that some or large percent of it was used in another physiological process such as energy for movement, respiration

and also could be undigested totally and excerted in the form of faeces **(Gordon, 1959).** Moreover, **Reese and Beck (1976 a, b, c,)** and **Dalhman (1977)** suggested that growth inhibition could be also caused by reducing efficiency conversion of assimilated food (E.C.D) and the efficiency conversion of ingested food (E.C.I.).

2.5. Efficacy conversion of ingested food (E.C.I.):

The E.C.I. is an over-all measure of an insect s ability to utilize for growth the food, which it ingests. The E.C.I. will vary with both the digestibility of a food and the proportional amount of the digestible

protein of that food, which are, on one hand, converted to body substance and, on the other hand, metabolized for energy to maintain life. Thus, the E.C.I. will rise and fall with the A.D. (approximate digestibility) and the E.C.D. (efficiency of conversion of digested food to body substance).

Data in Table (11) and Fig.(11) reveal that feeding the lab-strain larvae on leaves treated with sublethal concentrations of Profenofos or/and Esfenvalerate for 24 and 48 h resulted in E.C.I. values almostly similar to those of control larvae. In contrast, feeding larvae on Tebufenzid-treated leaves resulted in E.C.I. significantly lower than Control. Comparison based on means recorded after feeding, the larvae for 5 days (2 days treated leaves + 3 days untreated leaves) demonstrated similar trend.

Regarding the response of the more tolerant or / and resistant (field) strains it was obvious that Kalubiya and Behera Governorates stains performed almostly similar to the laboratory strain regardless the treatments tested, and that in general the more resistant the strain (population) the lower the E.C.I. achieved, particularly within the first two days. Also it was obvious that Tebufenozide resulted in E.C.I. significantly lower than either both other insecticides or/and the control. However, the effect was much pronounced for larvae fed on the higher (LC_{10}) sublethal concentration of Tebufenozide.

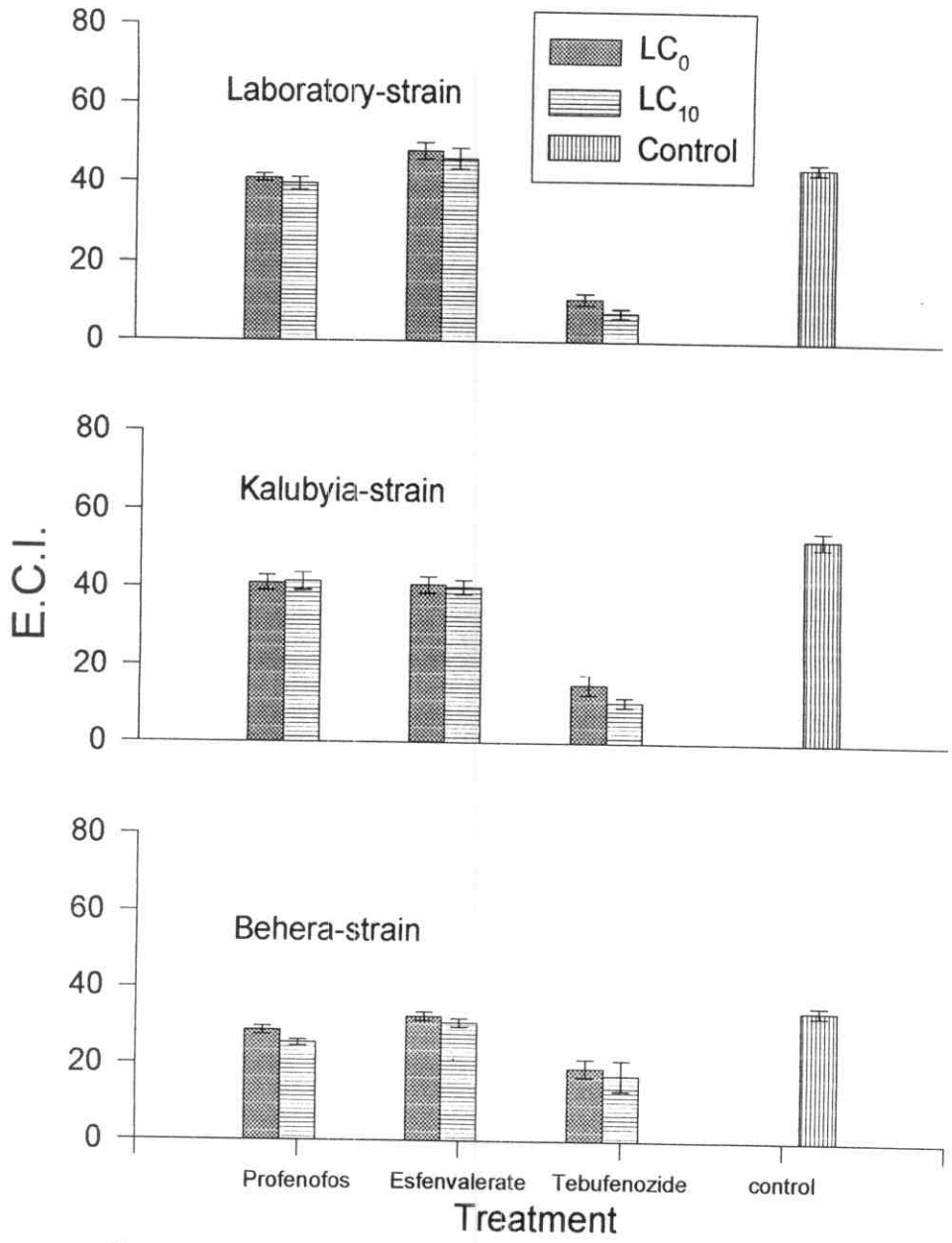
Generally, it was of interest to note that there is a tendency for the E.C.I. to decrease with age where the highest decrease in E.C.I. was recorded at the 5th day of feeding were the larvae reached the 6th or/ and last larval instar.

Our data are in agreement with **Evans (1939b)** finding where he found that E.C.I. increased from the 1st to the 4th instar of *Pholera* and

Table (11): Efficiency of conversion of ingested food to body tissue (ECI) after feeding 4th instar larvae of *S. littoralis* for 48 hrs. on castor bean leaves treated with sublethal concentration of certain insecticides.

Treatments	Concen. ppm	Time (Days) Means* ± SE					
		1 st.	2 nd.	3 rd.	4 th.	5 th.	Mean
Laboratory strain							
Prof. LC0	0.380	31.0 ± 4.77 a	41.25 ± 4.04 a	45.50 ± 2.21 b	55.75 ± 1.79 b	32.00± 10.71 a	41.1 ± 1.02 a
LC10	1.700	20.75± 4.26 ab	42.00± 1.77 a	45.25 ± 0.85 b	62.50 ± 5.69 b	27.50 ± 5.85 a	39.6 ± 1.63 a
Esfen. LC0	0.088	29.50 ± 3.68 a	44.00 ± 3.24 a	59.50 ± 5.5 a	79.25 ± 8.53 a	28.50 ± 4.57 a	48.15 ± 2.14 a
LC10	0.280	27.50± 3.75 ab	46.67 ± 1.52 a	46.67 ± 3.78 b	88.67 ± 6.26 a	21.67 ± 6.33 a	46.23 ± 2.62 a
Tebu. LC0	4.8×10^{-5}	17.50± 2.87 bc	10.00± 2.12 b	10.25 ± 4.6 c	11.25 ± 8.29 c	5.50 ± 1.03 b	10.90 ± 1.40 b
LC10	4.6×10^{-3}	9.50 ± 3.57 c	5.25 ± 0.43 b	8.25 ± 5.46 c	9.25 ± 4.21 c	4.25 ± 0.61 b	7.30 ± 1.21 b
Control		28.75 ± 1.75 a	44.50 ± 3.88 a	56.75 ± 4.78 a	57.75 ± 4.32 b	33.00 ± 6.49 a	44.15 ± 1.32 a
LSD 0.05		9.95	7.84	9.12	12.91	14.10	20.31
Kalubiya field strain							
Prof. LC0	10.67	20.75 ± 1.5 bc	46.75 ± 2.93 b	50.25 ± 3.88 b	66.75 ± 6.63 b	20.50± 3.57 bc	41.0 ± 2.01 a
LC10	63.33	21.75 ± 3.0 b	40.0 ± 2.38 b	42.5 ± 2.59 bc	78.5 ±10.46 ab	24.0 ± 1.83 b	41.35 ± 2.27 a
Esfen. LC0	67.0	22.25 ±2.78 b	42.75± 2.8 b	39.50 ±2.5 c	75.25± 5.67 ab	23.25 ±3.59 b	40.6 ± 2.14 a
LC10	176.0	18.25± 2.01 bc	44.0 ± 5.6 b	41.5 ± 3.6 c	67.5 ± 0.5 b	28.75± 2.59 ab	40.0 ± 1.85 a
Tebu. LC0	0.26	16.5 ± 1.7 bc	15.5 ± 3.22 c	18.25± 6.34 d	13.75± 0.47 c	11.67± 5.39 cd	15.13± 2.53 b
LC10	2.42	15.0 ± 1.22 c	12.0 ± 1.22 c	11.75± 2.9 d	9.75 ± 2.56 c	4.75 ± 5.51 d	10.65± 1.19 a
Control		30.5 ± 4.4 a	54.75± 1.31 a	59.75± 3.22 a	84.5 ± 1.85 a	33.75± 3.03 a	52.65± 2.19 a
LSD 0.05		5.49	7.85	8.04	15.30	9.16	23. 09
Behera field strain							
Prof. LC0	68.8	13.0 ± 3.0 a	24.0 ± 2.38 ab	27.25± 2.59 b	38.25± 5.75 ab	41.25± 23.9 ab	28.75± 1.1 abc
LC10	199.0	16.75± 4.15 a	18.25± 2.21 b	24.25± 1.17 b	35.5± 4.84 b	33.0± 1.15 abc	25.55± 0.8abc
Esfen. LC0	15.35	21.75± 1.75 a	21.5 ± 2.53 ab	32.5 ± 4.33 ab	42.0 ± 6.72 ab	44.75± 8.13 a	32.5 ± 1.09ab
LC10	74.94	19.0 ± 2.38 a	19.0 ± 2.3 ab	36.0± 1.35 a	40.5 ± 3.32 ab	39.75± 15.6ab	30.85±1.11ab
Tebu. LC0	1.63	20.75± 5.1 a	16.5 ± 1.89 b	16.25± 4.04 c	20.5 ± 1.25 c	20.75± 4.97bc	18.95± 2.35bc
LC10	7.08	23.0± 1.8 a	15.5± 0.5 b	12.5 ± 1.44 c	18.5 ± 1.66 c	15.5 ± 1.08 c	17.0 ± 3.96 c
Control		17.75± 4.76 a	28.25± 6.38 a	30.25± 0.75 ab	49.25± 2.78 a	45.75±13.09a	34.25±1.30 a
LSD 0.05		10.24	9.09	7.94	12.41	20.21	12.31

* Means followed by the same letter in each column are not significantly different according to Duncan's multible range test.



Fig(11): Effect of feeding sublethal concentrations of different insecticides on daily mean efficiency of conversion of ingested food to body tissue (E.C.I.) of *S. littoralis* 4th instar larvae during the experimental period

decrease in the 5th in this respect. **Carne (1966)** suggest that decrease in the E.C.I. values are associated with energy consuming physiological

However, the variation in concentration level tested did not show significant change in E.C.I. although the E.C.I. values at the higher concentration were almostly lower than at the lower one. In the present study the E.C.I. was directly proportional to the E.C.D. and inversely proportional to AD. Similar trend was obtained by **Abo-Elghar (1985)** and **Assal (1975).**

2.6. Approximate digestibility (A.D.):

The Approximate digestibility in insect is based on differences between the weight of food ingested and the weight of the faces, actually represents the food which is stored or metabolized, less metabolic wastes discharged in the urine or as facal metabolic products. The magnitude of the difference depends upon the relative amount of urine in the faces. Analysis of the faces of the phytophagous insect indicate a low uric acid content which can be neglected in calculation of approximate digestibility. A.D. values determined on a fresh weight basis would be somewhat low if there was a loss of moisture from the faces.

A.D. also varies within instars, where A.D. is at its highest in the first instar, but the food intake of this instar is only 0.08 %of the total. The food intake of the 5th instar is 85 % of the total, but A.D. is at its lowest in this instar **(Hiratsuka, 1920)**.

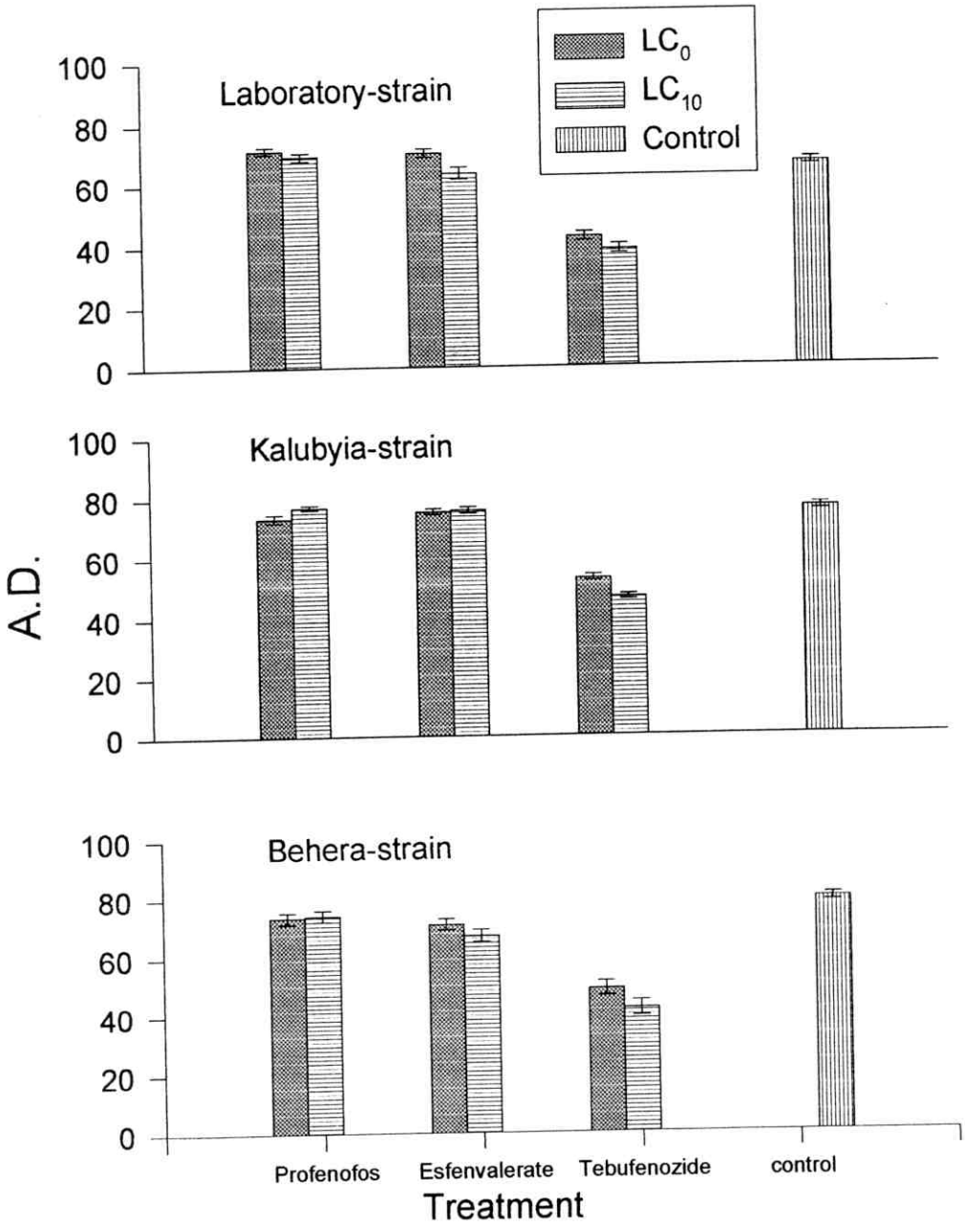
Data in Table (12) and illustrated graphically in fig.(12) reveal that the approximate digestibility (A.D.) values recorded for larvae of

laboratory susceptible or/and field resistant strains fed for 24 and 48 h leaves treated with the tested sublethal concentrations of Profenofos

Table (12): Approximate digestability (AD) of *S. littoralis* larvae after feeding of 4th instar larvae of for 48 hrs. on castor bean leaves treated with sublethal concentration of certain insecticides.

Treatments	Concen. ppm	Time (Days) Means* ± SE					
		1 st.	2 nd.	3 rd.	4 th.	5 th.	Mean
Laboratory strain							
Prof. LC0	0.380	87.5± 1.84 a	76.0 ± 3.16 a	75.75± 2.01 a	59.5± 2.21 a	59.0± 6.96 a	71.55± 1.21 a
LC10	1.700	85.5 ± 2.63 a	75.25± 3.03 a	75.5 ± 4.4 a	52.25± 2.92 ab	51.0 ± 6.25 ab	69.45± 1.35 a
Esfen. LC0	0.088	89.5 ± 0.5 a	77.25 ± 3.66 a	71.25± 2.25 a	55.5 ± 2.66 a	58.5 ± 5.1 a	70.4 ± 1.39 a
LC10	0.280	85.75± 3.59 a	73.67 ±2.02 a	72.0 ± 2.59 a	43.33± 6.65 bc	43.0± 5.07 b	63.55±1.93 a
Tebu. LC0	4.8×10^{-5}	60.25± 1.03 b	51.5 ± 0.5 b	41.25± 2.39 b	35.25± 4.21 c	24.0 ± 3.67 c	42.45± 1.41 b
LC10	4.6×10^{-3}	57.0± 2.97 b	49.5± 4.48 b	34.25± 3.06 b	32.0± 1.73 c	19.5± 4.01 c	38.45± 1.48 b
Control		85.25± 3.27 a	69.0± 4.98 a	67.25± 2.39 a	54.5 ±4.97 ab	57.75± 2.86 a	66.75± 1.2 a
LSD 0.05		7.83	10.25	8.38	11.17	14.84	21.54
Kalubiya field strain							
Prof. LC0	10.67	90.25± 0.25 a	74.5± 1.89 b	80.75 ±3.27 a	61.75± 0.85 a	59.5± 8.06 a	73.35±1.29 a
LC10	63.33	81.0± 4.43 b	80.5± 1.85 a	82.25± 1.7 a	63.0± 4.56 a	78.0± 4.02 a	76.95±0.79 a
Esfen. LC0	67.0	85.75± 2.56 ab	80.75± 0.25 a	81.25± 1.88 a	62.25± 1.65 a	66.75± 1.8 a	75.35± 1.02 a
LC10	176.0	88.25± 2.39 ab	76.5± 0.86 ab	84.25± 2.81 ab	65.75± 1.12 a	64.0± 8.66 a	75.75± 1.08 a
Tebu. LC0	0.26	62.5± 2.72 c	54.75± 2.01 c	62.0± 0.71 b	49.0± 0.41 b	36.5± 4.29 b	52.95 ± 1.07 b
LC10	2.42	56.5± 0.5 c	46.75± 1.1 d	51.25 ±0.25 c	44.25± 3.44 b	34.0± 2.38 b	46.55±0.84 b
Control		90.0± 1.8 a	79.25± 2.66 b	81.5± 1.66 a	69.0± 2.86 a	62.5± 9.56 a	76.25±1.08 a
LSD 0.05		7.1	4.99	5.92	7.51	18.43	13.45
Behera field strain							
Prof. LC0	68.8	90.0± 0.4 a	87.0± 1.73 a	78.5± 3.79 ab	77.25± 1.1 b	43.0±1.0 b	73.35±1.87 a
LC10	199.0	88.0± 2.0 ab	84.0± 1.15 a	83.25± 1.6 a	74.25±2.13 bc	40.75±4.53 b	74.05± 1.92 a
Esfen. LC0	15.35	88.0± 2.0 ab	80.25± 3.14 ab	76.75± 1.65 b	70.5± 3.47 bc	39.0± 2.04 b	70.9 ± 1.89 ab
LC10	74.94	88.75±0.62 ab	72.75± 4.74 bc	75.5± 1.04 b	67.0± 3.48 c	31.5 ± 2.95 bc	67.1± 2.14 ab
Tebu. LC0	1.63	84.0± 2.04 bc	65.0± 4.14 cd	38.75±1.97 c	30.25± 3.57 d	26.75 ±5.76 cd	48.95±2.46 ab
LC10	7.08	81.25 ± 0.75 c	61.0± 2.12 d	32.5± 2.5 d	19.0± 2.54 e	16.5 ± 1.84 d	42.05± 2.81 b
Control		88.5 ± 1.55 ab	77.00± 5.15 ab	84.75± 0.25 a	88.25± 2.01 a	58.00± 4.69 a	79.3 ± 1.27 a
LSD 0.05		4.4	10.37	6.18	8.11	10..72	27.29

* Means followed by the same letter in each column are not significantly different according to Duncan's multible range test.



Fig(12): Effect of feeding sublethal concentrations of Profenofos, Esfenvalerate and Tebufenozide on daily mean approximate digestability (A.D.) of *S. littoralis* 4th instar larvae during the experimental period

and Esfenvalerate were almostly similar to those of control without any significant differences in both cases of laboratory (susceptible) or/and field (resistant) strains. In contrast, Tebufenozide treatments exhibited remarkable reduction in A.D. values, which was significantly different when compared with other treatments including Control.

Further feeding for additional 3 days on untreated leaves exhibited remarkable decline in A.D. values with time elaps and proceeding in larval instar. However, the trend did not vary with that recorded in case of the first two days, where still A.D. values of Tebufenozide treatment were significantly lower than those in other treatments and control. In this respect **Nagy (1953)** found that A.D declines during the larval or nymphal stage.

However, the reasons for decline of A.D. are not entirely clear. With chewing insects it could be argued that small leaf-feeder might ingest a greater proportion of easily digested broken cell **(Biederman, 1919)** while larger larvae, eat almost the whole leef. Thus it is likely a larger proportion of indigestible fiber.

Similar results were observed in other insect such as *Schistocerca gregasia* **(Hussian *et al.*, 1946)** *Melonoplus biliturodus* **(Smith, 1959)** and *Attacus ricini* **(El-Garhy, 1974).**

Also in agreement with **Waldbauer (1968)** and **Assal (1975)**, the A.D. was inversely proportional to efficiency of conversion of digested food (E.C.D.).

The approximate digestibility (A.D.) of *Agrotis ipsilon* larvae fed on sublethal concentrations of pyriproxyfen, decreased below that of triazophos or/and control. **(El-Dessouki and Omar, 2000).**

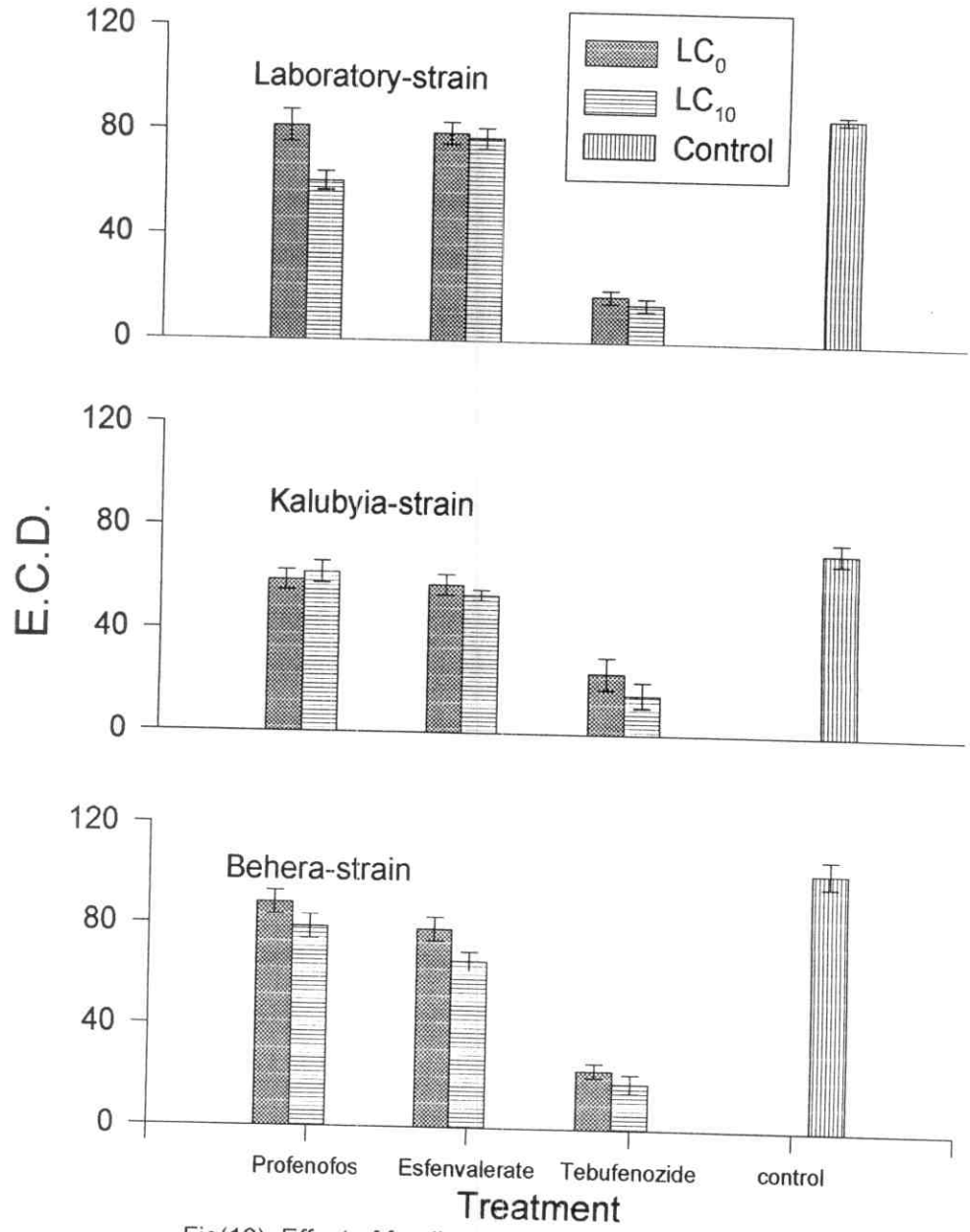
2.7. Efficacy conversion of digested food (E.C.D.):

The metabolic efficiency with which digested food is converted to body substance (E.C.D.) is affected by factors which influence the amount of energy devoted to the maintenance of physiological

Table (13): Efficiency of conversion of digested food to body tissue (ECD) after feeding of 4th instar larvae of *S. littoralis* for 48 hrs. on castor bean leaves treated with sublethal concentration of certain insecticides.

Treatments	Concen. ppm	Time (Days) Means* ± SE					
		1 st.	2 nd.	3 rd.	4 th.	5 th.	Mean
Laboratory strain							
Prof. LC0	0.380	25.25± 2.72 bc	47.5 ± 1.65 b	60.75± 4.87 b	94.0± 2.27 c	180.3± 14.89 a	81.56± 6.05 a
LC10	1.700	21.5± 4.17 cd	56.25± 4.5 ab	58.75± 5.6 b	119.3± 9.4abc	47.0 ± 7.69 c	60.56± 3.59 ab
Esfen. LC0	0.088	32.75± 4.28 b	58.25± 6.79 ab	83.75± 9.43 a	144 ± 16.53 a	77.25±14.86 b	79.2 ± 4.12 a
LC10	0.280	27.5 ±2.46 bc	63.67± 3.51 ab	66.67± 6.6 ab	135.3± 10.0ab	93.67± 6.44 b	77.36 ± 4.0 a
Tebu. LC0	4.8×10^{-5}	19.50± 3.37 cd	18.25± 3.03 c	19.75± 5.32 c	15.25± 10.45 d	14.25±10.78 d	17.4 ± 2.5 b
LC10	4.6×10^{-3}	17.0± 2.12 d	14.5± 7.32 c	14.75± 8.66 c	10.5 ± 6.39 d	15.5 ± 11.24 d	14.45 ± 2.41 b
Control		89.0 ± 2.04 a	66.5 ± 10.26 a	83.5± 5.8 a	107.8±12.17bc	85.5± 5.73 b	86.46 ± 1.47 a
LSD 0.05		8.97	15.84	16.45	27.55	26.38	45.14
Kalubiya field strain							
Prof. LC0	10.67	18.75± 2.63 bc	62.75±4.67 a	63.0 ± 6.41 ab	120.8± 18.49 a	30.5± 1.65 b	59.16± 3.96 ab
LC10	63.33	37.5± 5.95 a	49.75± 3.82 b	51.75± 3.57 bc	136.3±15.36 a	35.75± 1.65 b	62.21± 4.2 ab
Esfen. LC0	67.0	26.25± 8.5 ab	50.25± 3.79 b	48.75± 4.11 c	128.5± 13.62 a	35.0± 6.04 b	57.75± 4.07 ab
LC10	176.0	26.25± 4.94 ab	57.5± 6.6 ab	50.25± 4.63 c	83.75± 3.77 b	51.25± 8.22 a	53.8± 2.05 ab
Tebu. LC0	0.26	28.75± 1.31 ab	30.0± 1.47 c	26.75± 3.35 d	19.5± 0.65 c	16.0 ± 1.8 c	24.2 ± 6.12 b
LC10	2.42	17.5 ± 1.03 c	23.75± 1.49 c	12.25± 2.59 e	11.25± 1.37 c	15.25± 1.54 c	16.0± 4.98 b
Control		35.0± 3.58 ab	64.0 ± 2.38 a	64.5 ± 3.59 a	140.25± 3.88 a	54.0± 4.33 a	71.55± 4.02 a
LSD 0.05		13.82	10.71	11.67	31.0	11.78	41.26
Behera field strain							
Prof. LC0	68.8	24.25± 3.59 a	77.5 ± 1.89 b	84.75± 2.25 a	155.25±3.03 b	99.75±23.91 b	88.3± 4.7 a
LC10	199.0	19.25± 5.22 a	76.0± 1.75 b	82.5 ± 0.5 a	149.0± 9.89 c	68.0± 1.15 b	78.95± 4.64 a
Esfen. LC0	15.35	24.75±2.75 a	77.25±4.49 a	43.25± 5.15 b	108.75±7.36 d	137.25±8.13 a	78.25±4.61 a
LC10	74.94	20.75± 3.32 a	76.5 ± 3.27 b	35.0± 3.78 b	105.5± 2.72 d	91.5± 15.61 b	65.85± 3.65ab
Tebu. LC0	1.63	24.25±6.61 a	22.25± 0.75 c	20.75± 5.91 c	22.25± 1.6 e	28.25± 4.97 c	23.55± 2.9 b
LC10	7.08	17.25± 1.75 a	16.25±1.25 d	16.75± 0.63 c	17.25± 1.6 f	25.0± 1.08 c	18.5± 3.65 b
Control		24.25± 3.75 a	88.5± 10.24 a	92.5± 0.64 a	162.5±20.14 a	143.0± 13.09 a	102.15±5.39a
LSD 0.05		11.35	1.85	10.06	4.38	33.51	50.78

* Means followed by the same letter in each column are not significantly different according to Duncan's multible range test.



Fig(13): Effect of feeding sublethal concentrations of different insecticides on daily mean efficiency of conversion of digested food to body tissue (E.C.D.) of *S. littoralis* 4th instar larvae during the experimental period

functions or the support of activity. However, it dose vary also with the level of nutrient intake. Consequently, the proportion of food available for growth will decrease as intake decrease.

The data in Table (13) and illustrated graphically in Fig (13) elucidate that feeding the larvae of either susceptible or/and field resistant strains for 48 h on leaves treated with sublethal concentrationsof Profenofos or/and Esfenvalerate were almostly similar to those of control. In contrast, feeding the 4th instar larvae on Tebufenozide-treated leaves resulted in significant decrease in E.C.D. value which was more obvious at the higher sublethal concentration (LC_{10}) than at the lower (LC_0) one when the overall mean during the whole testing period was considered. Regarding the daily E.C.D. values was obvious during the first four days followed by clear drop in E.C.D. values at the 5th indicating that the efficiency of utilization is likely to differ from stage to stage, from instar to instar or even within an instar.

Data in this respect came in agreement with **Evans (1939b)** findings which indicate that the fresh weight E.C.D. values of *Phalera* was rising from the 1st to the 4th instar and dropping sharply in the last instar. One of the possible causes of the decrease in E.C.D. values associated with Tebufenozide-treatment, is a reduced food (nutrient) intake due to the antifeeding effect of the compound. Such decrease in E.C.D. values could be explained in view of **Gordon (1959)** data that the E.C.D. is normally effected by factors which influence the amount of energy devoted to the maintenance of physiological functions or the support of activity.

3. Biochemical studies:

In this part we studied the toxic effect of LC_{25} of each of the OP (Profenofos), the pyrethroid (Esfenvalerate) and the IGR (Tebufenozide) compounds on the enzymes activities of field *S. littoralis* strains collected before spraying season (early season) and after spraying season (late season), and also on the IGR-resistant (R) and IGR-laboratory (L) strains. The tested compounds were applied on the 4th larval instar for 24 hours for the OP and pyrethroid compounds and for 24 and 48 hours for the IGR The data of enzyme activity represented in this study are expressed as percentages of increase or decrease in the activity relative to control

3.1. Non-specific esterases (α-E) and (β-E):

Table (14) and Figs. (14, and 15) refers to the changes in alpha-esterase (α-E) and beta-esterase (β-E) activities resulted from insecticides treatment. The data obtained from Kalubyia strain before spraying season showed that the three tested insecticides after 24 hours from treatment gave about equal amount of reduction in α-E activity less than control. While the IGR after 48 hours from treatment gave about the same level of the enzyme activity of control. On the other hand, insecticidal treatment of larvae collected after spraying season showed less reduction in their α-E activity for Esfenvalerate and Tebufenozide while the reduction was highly pronounced in case of OP insecticides. However, the tested IGR at 48 hours after application caused an increase in α-E activity.

Table (14): Changes in α-E and β-E activities in Field strains of *S. littoralis* and IGR-R and IGR-L strains post treatment with insecticides.

Insecticides	α-E				β-E			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity**	%	Activity**	%
Kalubyia-Strain								
Profenofos-24	42.90 ± 0.59	53.0	2.5 ± 0.73	4.2	24.71 ± 0.24	38.7	1.91 ± 0.29	3.9
Esfenvalerate-24	44.95 ± 0.70	56.1	53.24 ± 0.73	89.6	42.76 ± 0.29	66.9	58.99 ± 0.37	121.1
Tebufenozide-24	44.26 ± 0.37	55.3	54.2 ± 0.39	91.2	43.98 ± 0.26	68.9	59.45 ± 0.64	122.0
Control-24	80.09 ± 0.24	100	59.41 ± 0.40	100	63.86 ± 0.43	100	48.71 ± 0.22	100
Tebufenozide-48	59.82 ± 0.51	103.9	78.14 ± 0.87	123.2	64.1 ± 0.33	166.7	88.75 ± 0.27	134.3
Control-48	57.58 ± 1.00	100	63.44 ± 1.15	100	38.44 ± 0.22	100	66.1 ± 0.35	100
Dakahlia-Strain								
Profenofos-24	28.69 ± 0.08	45.6	35.15 ± 0.24	121.16	28.74 ± 1.73	118.6	11.32 ± 0.26	25.15
Esfenvalerate-24	63.27 ± 1.06	100.6	86.89 ± 0.3	299.6	52.07 ± 1.05	107.4	117.62 ± 3.1	261.37
Tebufenozide-24	144.67 ± 1.31	230.1	51.56 ± 0.49	177.7	108.78 ± 1.08	224.4	45.3 ± 1.54	101.37
Control-24	62.86 ± 0.44	100	29.01 ± 0.47	100	48.47 ± 0.32	100	45.0 ± 0.1	100
Tebufenozide-48	238.0 ± 0.78	450.1	64.26 ± 0.55	99.1	243.66 ± 9.63	550.6	56.38 ± 2.05	140.7
Control-48	52.88 ± 0.73	100	64.86 ± 9.33	100	44.25 ± 3.53	100	40.08 ± 1.54	100
Menofia-Strain								
Profenofos-24	1.56 ± 8.0	3.2	0.59 ± 0.24	0.86	3.86 ± 0.47	11.4	2.68 ± 0.48	6.6
Esfenvalerate-24	94.47 ± 8.7	193.8	54.74 ± 0.64	79.8	51.85 ± 1.45	153.6	57.11 ± 0.76	66.8
Tebufenozide-24	38.05 ± 2.86	78.1	51.30 ± 0.47	74.8	30.34 ± 0.36	89.9	48.81 ± 0.30	120.3
Control-24	48.75 ± 0.45	100	68.62 ± 0.56	100	33.76 ± 0.29	100	40.59 ± 0.11	100
Tebufenozide-48	64.72 ± 0.59	34.0	53.65 ± 1.05	52.2	44.28 ± 0.17	44.4	53.27 ± 0.63	89.6
Control-48	190.81 ± 1.72	100	102.81 ± 0.58	100	99.84 ± 42.86	100	59.45 ± 0.18	100
Kafr El-Sheikh-Strain								
Profenofos-24	1.18 ± 0.18	3.9	1.63 ± 0.34	7.33	0.95 ± 0.3	3.1	1.2 ± 0.18	4.55
Esfenvalerate-24	48.57 ± 0.55	160.3	51.25 ± 0.45	230.6	32.8 ± 0.64	105.9	45.02 ± 0.53	171.5
Tebufenozide-24	19.73 ± 0.24	65.1	43.99 ± 0.45	198.0	14.1 ± 0.73	45.5	34.1 ± 2.28	129.4
Control-24	30.29 ± 0.5	100	22.22 ± 0.47	100	30.96 ± 0.7	100	26.35 ± 3.53	100
Tebufenozide-48	29.75 ± 0.43	118.7	74.87 ± 0.25	114.0	27.14 ± 2.0	184.1	80.2 ± 0.41	154.5
Control-48	25.06 ± 0.75	100	65.59 ± 0.2	100	14.74 ± 0.56	100	51.89 ± 1.12	100
Behera-Strain								
Profenofos-24	5.4 ± 0.25	27.34	4.86 ± 0.33	9.1	1.17 ± 0.4	6.8	1.54 ± 0.24	3.6
Esfenvalerate-24	73.65 ± 0.39	372.91	109.66 ± 0.82	204.4	69.09 ± 0.22	402.4	88.93 ± 1.2	210.0
Tebufenozide-24	75.92 ± 0.49	384.4	91.02 ± 1.22	169.6	68.41 ± 0.28	398.4	69.12 ± 0.7	163.2
Control-24	19.75 ± 1.68	100	53.65 ± 0.59	100	17.17 ± 0.19	100	42.34 ± 0.31	100
Tebufenozide-48	46.76 ± 0.51	252.7	106.62 ± 0.43	272.7	46.84 ± 0.68	152.8	90.66 ± 0.48	308.5
Control-48	18.5 ± 3.21	100	39.09 ± 1.38	100	30.65 ± 0.38	100	29.39 ± 0.14	100

Continued Table (14)

Insecticides	α-E				β-E			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity**	%	Activity**	%
Menia-Strain								
Profenofos-24	2.77 ± 0.55	4.4	3.18 ± 0.46	4.3	2.16 ± 0.16	4.5	3.38 ± 0.27	7.3
Esfenvalerate-24	51.65 ± 0.63	82.2	72.33 ± 0.73	98.3	36.10 ± 0.56	74.5	57.27 ± 0.22	123.8
Tebufenozide-24	81.09 ± 6.34	129.1	110.79 ± 0.57	150.5	57.64 ± 0.38	118.9	74.72 ± 0.19	161.6
Control-24	62.86 ± 0.44	100	73.60 ± 0.67	100	48.47 ± 0.32	100	46.25 ± 0.30	100
Tebufenozide-48	61.90 ± 0.72	40.0	55.37 ± 0.88	45.2	40.79 ± 0.33	21.5	122.14 ± 0.37	171.8
Control-48	154.70 ± 0.03	100	122.62 ± 0.41	100	189.68 ± 3.16	100	71.09 ± 0.42	100

Insecticides	α-E				β-E			
	Laboratory		Resistant		Laboratory		Resistant	
	Activity*	%	Activity*	%	Activity**	%	Activity**	%
Profenofos-24	2.77 ± 0.24	25.8	3.36 ± 0.51	9.2	1.54 ± 0.03	25.9	1.66 ± 0.05	3.9
Esfenvalerate-24	18.01 ± 0.69	167.5	33.53 ± 0.61	91.8	25.82 ± 2.22	434.7	56.87 ± 3.59	134.0
Tebufenozide-24	33.33 ± 0.83	310.1	28.39 ± 0.43	77.8	31.61 ± 1.67	532.2	40.19 ± 0.94	94.7
Lab. -24	10.75 ± 0.75	100	36.51 ± 0.48	100	5.94 ± 0.97	100	42.44 ± 0.43	100
Tebufenozide-48	31.80 ± 0.26	188.1	44.21 ± 2.68	162.7	38.74 ± 1.58	171.0	53.48 ± 1.57	185.5
Lab.-48	16.91 ± .88	100	27.17 ± 0.33	100	22.65 ± 0.46	100	28.83 ± 0.64	100

* α-E activity = µg α-naphthol released / larvae / min.

** β-E activity = µg β-naphthol released / larvae / min.

The same trend was obtained for β-E enzymes of insects collected before spraying season, the three tested compounds at 24 hours after application gave variable degrees of reduction in the enzyme activity while at 48 h post treatment the IGR exhibited great increase in the enzyme activity. In the case of larvae collected during late season, the insecticidal treatment showed an increase in β-E activity for all tested compounds with exception to the OP compound which recorded markedly high reduction in the enzyme activity more than control.

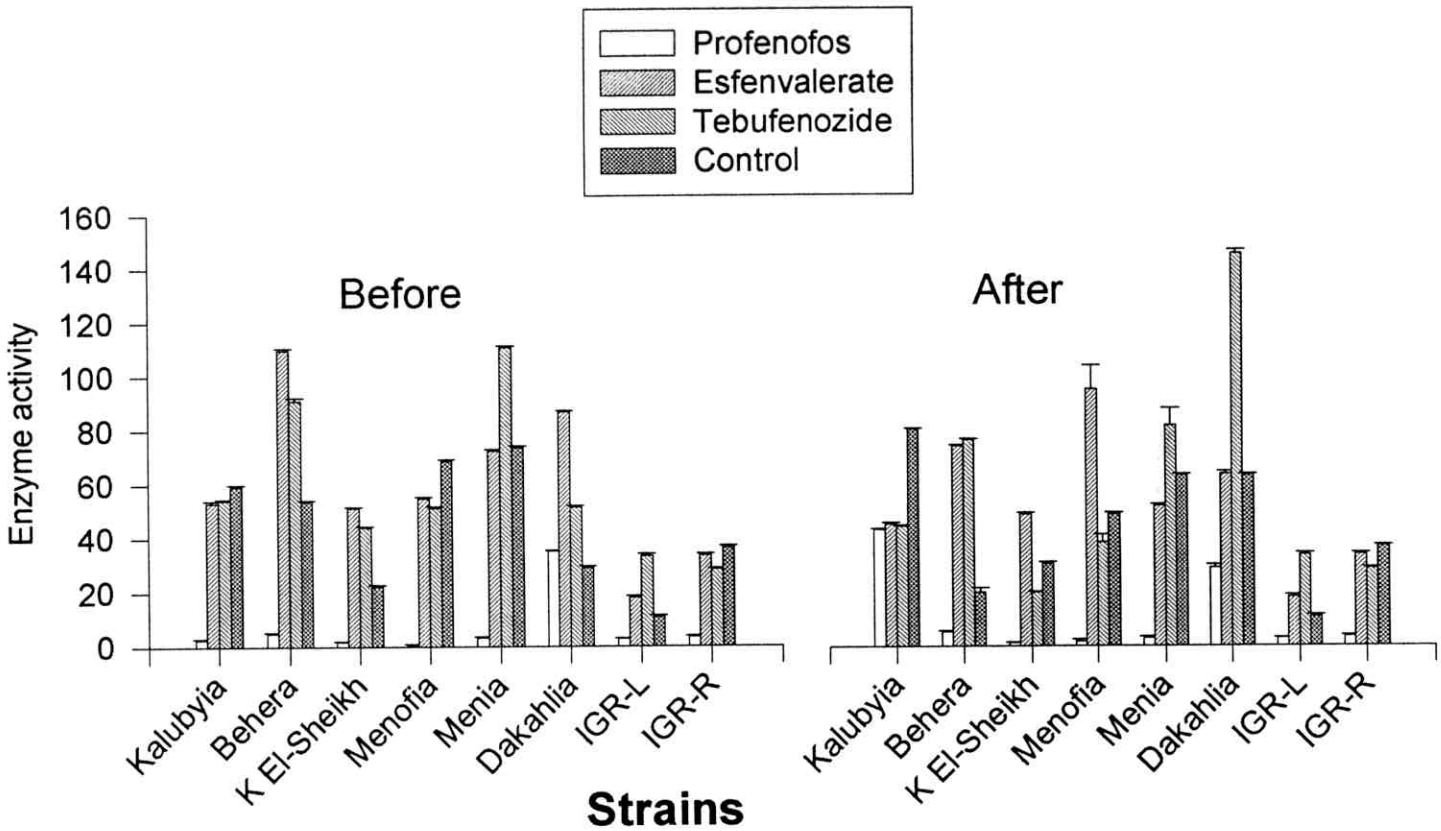


Fig.(14): Changes in a-E activity of *S.littoralis* larvae field strains representing early and late season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

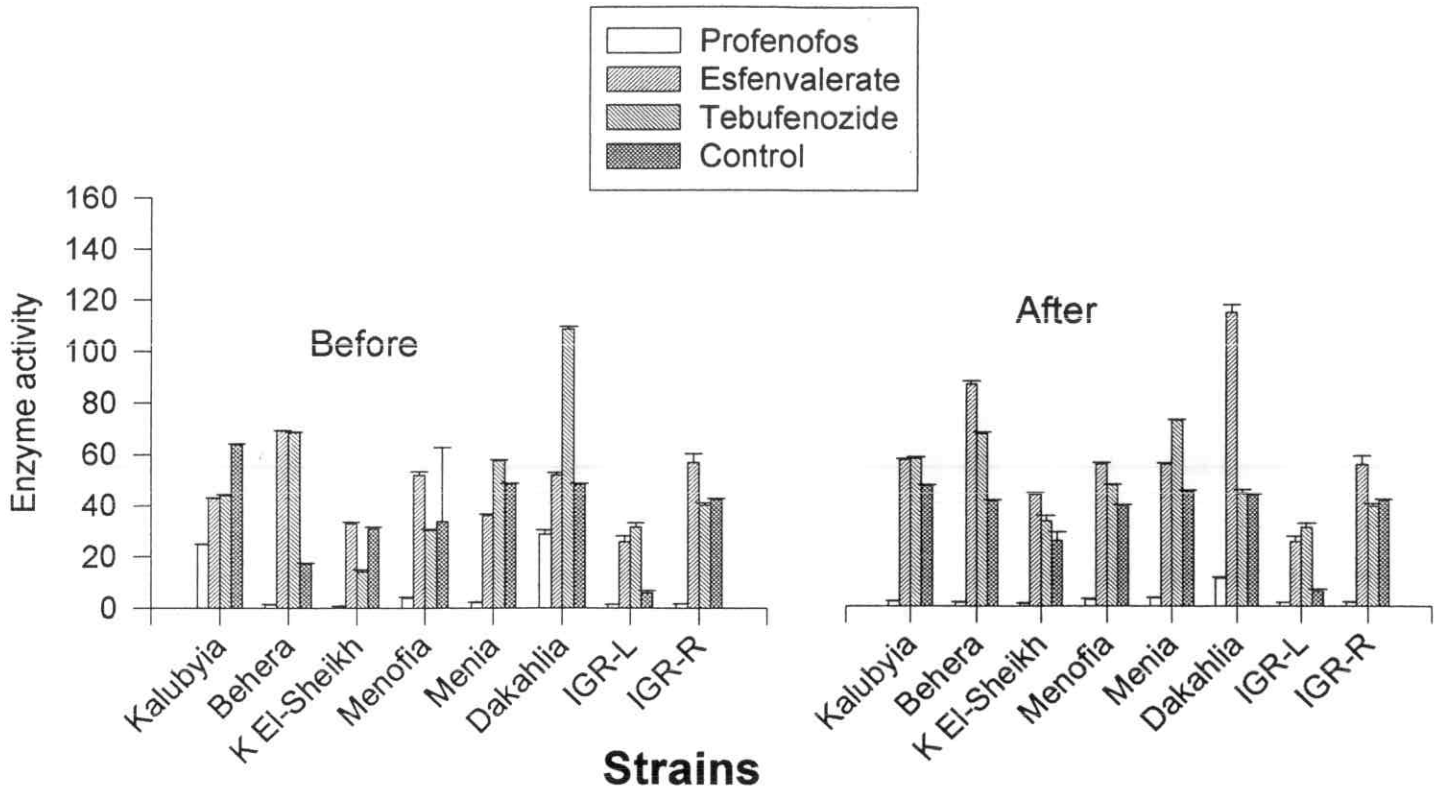


Fig.(15): Changes in B-E activity of *S.littoralis* field strains larvae representing early and late season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

In Dakahlia strain, the insecticidal treatment caused a great increase in α-E activity of larvae collected before and after spraying season with exception the OP insecticide gave great decrease in α-E activity of insects collected before spraying season. The same results were obtained for β-E enzymes, the three tested insecticides caused an increases in the enzyme activity of Dakahlia strain collected before and after spraying season with exception the Profenofos gave a great reduction in β-E activity at the late season.

In contrary, Menofia strain collected before and after spraying season revealed great reduction in its α-E activity as a result of insecticidal treatment with exception the pyrethroid, gave an increase in the enzyme activity of larvae collected before spraying season. The same trend was found in β-E activity, the three tested insecticides caused reduction in the enzyme activity of the larvae collected early and late season with exception pyrethroid insecticide before spraying season and IGR at 24 h after application recording increase in the enzyme activity of larvae collected after spraying season higher than control.

The toxic effect of the tested compounds on the Kafr-El-Shekh strain collected before and after spraying season revealed that, the OP insecticide caused great reduction in α-E activity of insects collected early and late season, the opposite trend was obtained from pyrethroid compound. On the other hand, the IGR insecticide at 24 hours after application caused reduction in α-E activity of larvae collected before spraying and gave an increase in the enzyme activity of larvae collected after spraying, while, at 48 hours after application gave an increase in α-E of the larvae collected before and after spraying season. In the case

of β-E enzyme treatment the larvae of Kafr-El-Shikh strain with the OP insecticide resulted in high reduction in the enzyme activity of larvae collected before and after spraying season. In contrast, the pyrethroid and IGR compounds caused an increases in β-E activity of larvae collected early and late season with exception of the IGR at 24 h post treatment which showed decrease in the enzyme activity of larvae collected before spraying season.

Regarding to Behera strain treated with OP insecticide it was obvious that remarkable reduction in both α-E and β-E activities was recorded for the larvae collected before and after spraying season, while the pyrethroid and IGR insecticides caused increase in the activity of the two enzymes.

Both OP and pyrethroid insecticides gave reduction in α-E and β-E activity of Menia strain collected before and after spraying season. On the other hand, the IGR insecticide at 24 hours after application gave an increase in α-E activity, while at 48 hours after application showed a great reduction in the enzyme activity of the larvae collected before and after spraying.

As shown in Table (14) the effect of the tested insecticides on α-E and β-E activities of IGR-R and IGR-L strains, revealed in general that in normal case, the R-strain was characterized by higher titter of both enzymes activities than L-strain. However, treatment with the tested insecticides caused reduction in α-E activity of R-strain much greater than L-strain, also the OP insecticides caused great reduction in α-E of both R- and L-strain while the two other compounds gave a decrease in α-E activity of R-strain and an increase in α-E activity of L-strain compared to control. The same trend was obtained for β-E

enzymes with exception of the pyrethroid which gave an increase in β-E activity of R-strain.

In general it was obvious from the previous results that the field strains larvae of *S. littoralis* and also the resistance strain in normal state were characterized by higher titer of non specific esterases compared to the laboratory strain, also larvae collected after spraying season had non-specific esterase activity higher than that collected before spraying season. The elevation of non-specific esterases in all field strains of *S. littoralis* larvae indicated that these enzymes might play an important role in the resistance of the cotton leafworm to insecticides. The high titer of esterases in the field strains was also found by **Harold and Ottea (1997)** in larvae of the tobacco budworm, *Heliothis virescens*. They showed high frequencies of Profenofos resistance in all field-collected strains and this resistance was strongly correlated with esterase (EST) activity toward a-naphthyl acetate. Also, **Harold *et al.* (1999)** found that the Profenofos-resistanct strain and also the field strains of the tobacco budworm, *Heliothis virescens* characterized by higher titer in its esterase activity compared with the susceptible strain

The data revealed also that poisoning larvae collected before spraying season revealed great reductions in their α-E activity post treatment with the OP insecticide, while that treated with pyrethroid and IGR gave an increase in their α-E activity. On the other hand, the larvae collected after spraying season showed change in α-E activity closed to control in all tested strain except Dakahlia strain gave greater increase in its α-E activity as a result of pyrethroid and IGR treatment. The same trend was obtained for β-E enzymes, the data revealed that

the OP insecticide caused reduction in the enzyme activity of larvae collected before spraying season for all strains with exception of Dakahlia strain where the insecticide caused no change in the enzyme activity compared to control. After spraying season, the tested insecticides caused increases or decreases in β-E activity closed to control for all tested strain with exception of Dakahlia strain where the tested insecticides caused an increase in the enzyme activity higher than control.

The reduction in non-specific esterases during the course of poisoning larvae was also observed by **Abdel-Fattah *et al.* (1986)** on *S. littoralis* larvae when treated with the LC_{15}, LC_{30} and LC_{50} with diflubenzuron. **El-Saidy *et al.* (1989)** found that there was a positive correlation between diflubenzuron metabolism inhibition and toxicity. Moreover, **El-Saidy *et al.* (1990)** studied esterase activity in larval gut homogenates of a susceptible (S) strain and an organophosphorus-multiresistant strain (MR) of the noctuid *Spodoptera littoralis*. The MR strain had >172-fold resistance to monocrotophos and 20-fold resistance to Profenofos. Esterase activity was 2.6 times as high in the MR as in the S strain, and about 50% of the esterase activity was due to cholinesterase, as compared with 30% in the S strain. Profenofos was the most potent among the esterase inhibitors studied in vitro for both strains, followed by DEF and monocrotophos. However, with Profenofos the esterase activity of the S strain was 20 times as susceptible to inhibition as the MR strain; only a 1.9 times susceptibility in the S strain was found with DEF and monocrotophos. The in vivo study indicated that inhibition of midgut homogenate

esterases was very rapid and higher with sublethal dosages, and the recovery was only partial.

3.2. Acetylcholineesterase (AchE):

Cholinesterase (ChE) is a vital enzyme, judged by the fact that its severe inhibition is usually associated with death (**O'Brien, 1967**). In general many good inhibitors of ChE are very toxic and many bad inhibitors are not.

Data in Table (15) and Fig. (16) showed the changes in acetylcholine esterase (AchE) activity of *S. littoralis* R- and L-strain and also F-strain collected before and after spraying season from different Governorates. The 4th instar larvae were treated with the LC_{25} of each of Profenofos, Esfenvalerate and Tebufenozide, the enzyme activity was determined after 24 h for the three insecticides in addition at 48 h for Tebufenozide in the whole larval homogenate.

Regarding the effect of the three tested insecticides on AchE activity of Kalubyia strain collected early in the season, it is clearly obvious that there was completely inhibition in the enzyme activity comparing to control. The level of inhibition was pronounced for OP treatment. In contrary, the insecticidal treatment exihibited higher increases in AchE activity of Kalubyia strain collected late in the season, the highest level of increase in AchE activity was found for Tebufenozide treatment at 48 hours and after OP treatment.

Regarding to Dakahlia strain, it as obvious that insecticidal treatments resulted in highly pronounced increases in AchE activity in insects collected before and after spraying season with exception to

Table (15): Changes in ChE and AliE activities in field strains of *S. littoralis* and IGR-R and IGR-L strains post treatment with insecticides.

Insecticides	ChE*				AliE*			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity**	%	Activity**	%
Kalubyia-Strain								
Profenofos-24	0.07 ± 0.04	15.9	0.84 ± 0.06	46.0	4.93 ± 0.06	57.2	0.16 ± 0.06	3.2
Esfenvalerate-24	0.23 ± 0.08	52.0	0.23 ± 0.08	12.77	5.95 ± 0.01	68.4	6.54 ± 0.11	131.8
Tebufenozide-24	0.34 ± 0.05	77.0	0.56 ± 0.04	31.11	4.69 ± 0.16	54.0	4.29 ± 0.09	86.5
Control-24	0.44 ± 0.05	100	1.80 ± 0.11	100	8.70 ± 0.10	100	4.96 ± 0.11	100
Tebufenozide-48	0.8 ± 0.02	190.0	0.76 ± 0.10	63.33	4.85 ± 0.10	46.3	6.19 ± 0.10	103.0
Control-48	0.42 ± 0.06	100	1.2 ± 0.03	100	10.48 ± .09	100	6.01 ± 0.09	100
Dakahlia-Strain								
Profenofos-24	5.68 ± 0.04	270.48	1.00 ± 0.06	123.45	11.15 ±0.08	122.5	8.40 ± 0.11	166.9
Esfenvalerate-24	6.42 ± 0.09	305.71	0.86 ± 0.12	106.17	14.33 ±0.09	157.5	11.92 ±0.05	236.9
Tebufenozide-24	13.15 ± .11	626.19	1.20 ± 0.04	148.14	30.98 ±0.28	340.4	9.91 ± 0.05	197.0
Control-24	2.10 ± 0.10	100	0.81 ± 0.05	100	9.10 ± 0.76	100	5.03 ± 0.09	100
Tebufenozide-48	9.91 ± 0.08	364.3	0.83 ± 0.05	16.6	23.68 ± .05	246.7	10.19 ±0.07	107.8
Control-48	2.75 ± 0.10	100	5.00 ± 0.07	100	9.60 ± 0.03	100	9.45 ± 0.02	100
Menofia-Strain								
Profenofos-24	2.45 ± 0.09	226.8	0.77 ± 0.16	52.4	5.32 ± 0.08	71.9	3.25 ± 0.11	30.1
Esfenvalerate-24	1.41 ± 0.09	130.6	1.33 ± 0.07	90.5	7.91 ± 0.09	106.9	8.05 ± 0.07	74.6
Tebufenozide-24	1.68 ± 0.06	155.6	1.07 ± 0.06	70.7	7.45 ± 0.12	100.7	8.70 ± 0.09	80.6
Control-24	1.08 ± 0.01	100	1.47 ± 0.06	100	7.40 ± 0.80	100	10.79 ±0.04	100
Tebufenozide-48	0.68 ± 0.02	20.7	1.60 ± 0.09	63.2	8.04 ± 0.04	31.1	9.81 ± 0.08	121.9
Control-48	3.29 ± 0.12	100	2.53 ± 0.04	100	25.89 ± .14	100	8.05 ± 0.09	100
Kafr El-Sheikh-Strain								
Profenofos-24	1.48 ± 0.13	104.9	3.04 ± 0.24	117.4	4.46 ± 0.07	74.5	1.97 ± 0.07	19.8
Esfenvalerate-24	1.36 ± 0.09	96.5	3.24 ± 0.11	125.1	10.14 ±0.01	169.3	8.83 ± 0.12	88.7
Tebufenozide-24	2.41 ± 0.02	170.9	1.24 ± 0.06	47.9	7.87 ± 0.06	131.4	10.36 ±0.04	104
Control-24	1.41 ± 0.05	100	2.59 ± 0.10	100	5.99 ± 0.11	100	9.96 ± 0.09	100
Tebufenozide-48	1.77 ± 0.13	553.1	5.62 ± 0.08	138.8	7.21 ± 0.09	82.4	10.26 ±0.04	72.7
Control-48	0.32 ± 0.06	100	4.05 ± 0.08	100	8.75 ± 0.11	100	14.12 ±0.14	100
Behera-Strain								
Profenofos-24	1.47 ± 0.08	79.0	0.27 ± 0.13	9.5	6.42 ± 0.09	140.2	2.36 ± 0.05	28.7
Esfenvalerate-24	3.14 ± 0.10	168.8	2.82 ± 0.11	99.3	10.39 ±0.04	226.9	10.95 ±0.05	133.2
Tebufenozide-24	0.62 ± 0.02	33.3	0.80 ± 0.05	28.2	10.89 ±0.03	237.8	9.80 ± 0.08	119.2
Control-24	1.86 ± 0.91	100	2.84 ± 0.08	100	4.58 ± 0.05	100	8.22 ± 0.11	100
Tebufenozide-48	1.65 ± 0.10	80.5	2.40 ± 0.04	81.1	13.55 ±0.05	122.9	10.44 ±0.06	107.4
Control-48	2.05 ± 0.02	100	2.96 ± 0.01	100	11.02 ±0.06	100	9.72 ± 0.04	100

Continued Table (15)

Insecticides	ChE*				AliE*			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity**	%	Activity**	%
Menia-Strain								
Profenofos-24	0.20 ± 0.09	95.2	0.32 ± 0.13	56.1	2.28 ± 0.16	23.0	3.11 ± 0.15	36.6
Esfenvalerate-24	0.55 ± 0.06	261.9	0.71 ± 0.09	124.6	8.55 ± 0.09	86.4	7.04 ± 0.06	82.8
Tebufenozide-24	2.01 ± 0.08	957.1	1.05 ± 0.18	184.2	10.15 ±0.12	102.5	8.63 ± 0.14	101.5
Control-24	0.21 ± 0.10	100	0.57 ± 0.06	100	9.90 ± 0.06	100	8.50 ± 0.04	100
Tebufenozide-48	0.98 ± 0.08	49.5	3.12 ± 0.01	130.0	10.09 ±0.07	40.2	11.11 ± .02	78.6
Control-48	1.98 ± 0.29	100	2.4 ± 0.05	100	25.09 ±0.26	100	14.13 ±0.15	100

Insecticides	ChE*				AliE*			
	Laboratory		Resistant		Laboratory		Resistant	
	Activity*	%	Activity*	%	Activity**	%	Activity**	%
Profenofos-24	6.05 ± 0.03	139.1	4.11 ± 0.05	99.0	8.91 ± 0.03	132.8	6.23 ± 0.01	71.9
Esfenvalerate-24	5.06 ± 0.07	116.3	5.68 ± 0.02	136.8	7.78 ± 0.01	115.9	10.85 ±0.09	125.3
Tebufenozide-24	2.45 ± 0.62	56.3	4.23 ± 0.03	101.9	7.61 ± 0.07	113.4	8.15 ± 0.09	94.1
Lab. -24	4.35 ± 0.05	100	4.15 ± 0.21	100	6.71 ± 0.01	100	8.66 ± 0.07	100
Tebufenozide-48	6.65 ± 0.13	136.6	5.94 ± 0.09	198.0	10.11 ± .01	122.2	12.20 ±0.07	138.9
Lab.-48	4.87 ± 0.88	100	3.00 ± 0.03	100	8.27 ± 0.03	100	8.78 ± 0.15	100

* ChE activity = µg acetylcholine bromide hydrolyzed / larvae / min.

** AliE activity = µg methyl n-butyrate hydrolyzed / larvae / min.

Tebufenozide at 48 after application which showed remarcable reduction in the enzyme activity in insects collected at the late season compared to control.

A great increase in AchE activity was shown in Menofia strain collected at early season for all the tested insecticides with exception of the IGR at 48 hours after application which recorded severe reduction in the enzyme activity. On the other hand, insects collected at the late season revealed variable decreases in their enzyme activity as a result of insecticides treatment.

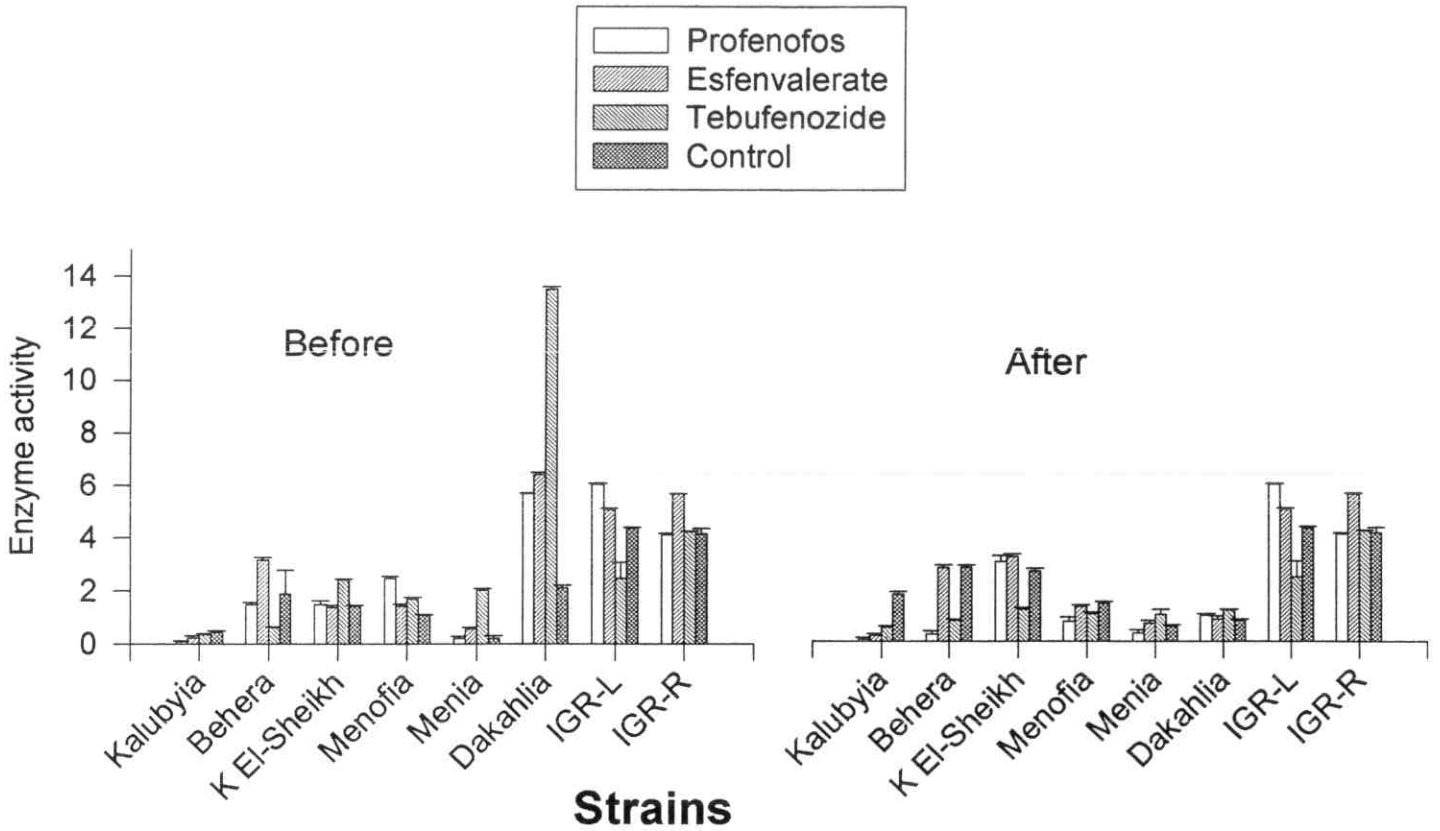


Fig.(16): Changes in ChE activity of *S.littoralis* field strains larvae representing early and late season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

The increase in AchE activity resulting after insecticides treatment was found in Kafr El-Sheikh strain collected at the early and late season with exception pyrethroid which resulted in slight decrease in the enzyme activity of larvae collected at early season, also the IGR at 24 hours after application reduced the level of AchE activity of insects collected at the late season.

In contrary, as shown in Table (15) Behera strain revealed a variable decrease in AchE activity as a result of insecticidal treatment in insects collected before and after spraying season with exception of the pyrethroid insecticide which exihibited an increase in AchE activity much higher than control in insects collected before spraying season. The maximum level of reduction was obtained from the OP insecticide.

Menia strain treated with the OP compound revealed a decrease in the level of its AchE activity of both insects collected before and after spraying compared to control, while treatment with the pyrethroid and IGR compounds caused high increases in the enzyme activity of larvae collected early and late season. On the other hand, larvae of Menia strain treated with the tested IGR recorded highly pronounced reduction in the enzyme activity at 48 hr post treatment in insects collected before spraying season and an increase in the enzyme activity much greater than control in insects collected after spraying season.

The data emerged from resistant strain revealed that the resistant strain in the normal state had a lower level of AchE activity than laboratory strain. However, treatment the two strains with the tested OP insecticide caused little decrease in AchE activity of the R-strain, while caused high increase in the enzyme activity of L-strain. The pyrethroid treatment revealed an increase in AchE activity of both

strains specially R-strain. On the other hand, the IGR treatment caused a decrease in the enzyme activity at 24 h post treatment of L-strain and gave no effect on the enzyme activity of the R-strain, while exihibited an increase in AchE activity of both strains at 48 h post treatment.

Generally, the cotton leafworm field strains were characterized by low level of AchE activity than the laboratory strain which agree with findigs of **Abdel-Hafez (1978)**, who indicated that the activity of AchE in the haemolymph of both lannate and cytrolane resistant strains was much lower than that in S-strain, On the other hand, the presnt data disagree with that found by **El-Ghareeb *et al.* (1983),** they showed high level of AchE activity in two field strains of *S. littoralis*. **Abdallah *et al.* (1973)**, found that ChE activity in the cotton leafworm, *S. littoralis* was higher in the methyl parathion resistant lab. strain than in the susceptible one. **Kim-Yong *et al.* (1998)** found that the field populations of *Spodoptera litura* showed resistance to commonly used insecticides, and they concluded that the broad spectrum of insecticide resistance observed was due to multiple resistance mechanisms, including increased detoxification of insecticides and insensitive acetylcholinesterase.

The data resulted after insecticides treatment showed that both Kalubyia and Behera strains exhibited a low level of AchE activity in larvae collected before spraying during the course of insecticides poisoning, while a high level in AchE activity was found in the other tested field strains. On the other hand, after spraying season the larvae of Menofia and Behera strains exhibited variable reductions in their AchE activity compared with the other tested strains that showed a high level of enzyme activity in relation to control. **Gunning *et al.***

(1996) found that acetylcholine esterase from the field-resistant strain of *Helicoverpa armigera* and from the thiodicarb-selected strain was less sensitive to inhibition by methomyl than that from the susceptible strain. No association between Profenofos resistance in all field strains larvae of tobacco budworm, *Heliothis virescens* and the sensitivity of acetylcholinesterase (AChE) to inhibition by chlorpyrifos oxon was observed by **Harold and Ottea (1997)**.

Two forms of AChE in field populations (BESS and BKRR) of the beet armyworm, *Spodoptera exigua* (Hubner) were identified by **Byrne *et al.* (2000)**. The BKRR AChE enzyme was ca. 30-fold and 7-fold more insensitive to methomyl and chlorpyrifos-oxon, respectively, compared with both the susceptible and BESS enzymes. This suggested that target site insensitivity is the predominant mechanism of resistance to methomyl. The lack of significant cross resistance to chlorpyrifos suggests also that the insensitive AChE in these field populations was selected by methomyl alone and not by the OP.

3.3. Aliphatic esterase (AliE):

Carboxylesterases (AliE) hydrolyze certain organophosphorus insecticides at the carboxylester linkage, resulting in the formation of the corresponding nontoxic acid (**Motoyama and Dauterman 1974**).

The data in Table (15) and Fig. (17) showed generally that, both Behera and Kafr-El-Shikh strains collected during early season had low level of AliE activity than lab strain, while the four other tested field strains had high level of AliE activity comparing to lab strain. Field population during the late season in Dakahlia and Kalubyia exihibited low level of AliE activity than lab strain, and while a high level of AliE

activity was recorded for the other field strains. The high level of AliE in *S. littoralis* resistant and field strains was recorded by **Shaaban and Sobieha (1977)** and **Abdel-Hafez (1978)**. On the other hand, **Rizkallah (1970)** and **Abdallah *et al.* (1973)** found that the resistant strain of *S. littoralis* had low level of AliE activity

The effect of the tested insecticides on AliE activity of the cotton leafworm field strains revealed that all the tested insecticides caused reduction in AliE activity at 24 h post treatment in Kalubyia strain collected before and after spraying season with exception Esfenvalerate which resulted in an increase in the enzyme activity in insect collected after spraying season compared to control. In contrary, the treatment with the tested insecticides caused great increase in AliE activity of Dakahlia strain collected before and after spraying season.

Menofia strain revealed reduction in AliE activity of the larvae collected after spraying season, while larvae collected before spraying season raveled about no change in AliE activity as a result of pyrethroid or IGR treatment. The treatment of Menofia strain with OP insecticide caused great reduction in the enzyme activity compared to control. The same trend was obtained from Kafr El-Sheikh strain, where the OP insecticide Profenofos gave reduction in AliE activity of insect collected before and after spraying season, while pyrethroid and IGR caused increases in AliE activity of the larvae collected before spraying season and caused decrease or slight increase in the enzyme activity of larval collected after spraying season. On the other hand treated larvae with IGR for 48 hrs caused decrease in AliE activity before and after spraying season.

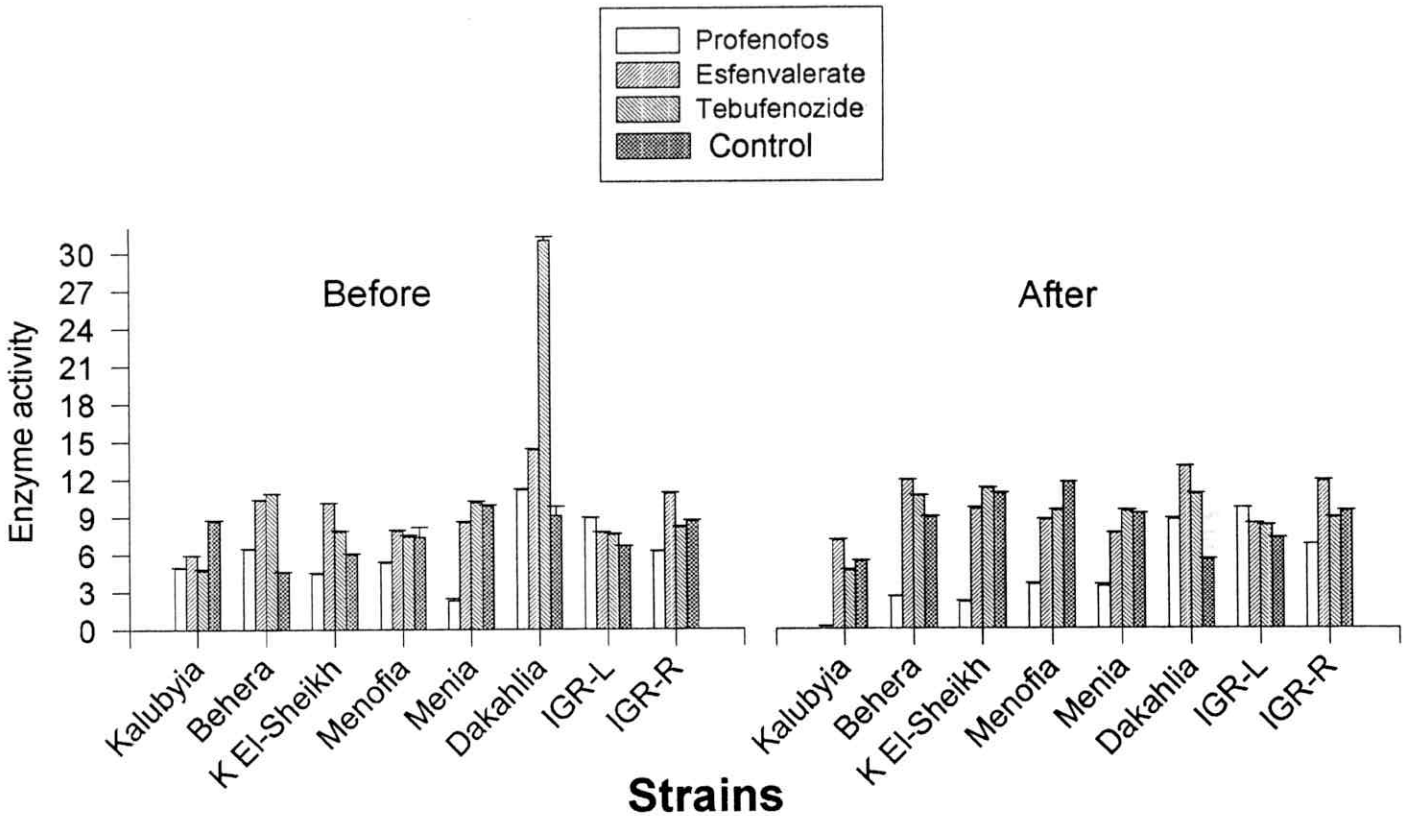


Fig.(17): Changes in AliE activity of *S.littoralis* field strains larvae collected before and after spraying season compared with IGR-L and IGR-Rstrains at 24 h posttreatment with certain insecticides.

Behera strain exhibited an increase in their AliE activity as a result of insecticides treatment with exception Profenofos treatment which recorded a decrease in AliE activity of insects collected after spraying season

Remarkable reduction in AliE activity was recorded as a result of OP and pyrethroid treatment on Menia strain collected before and after spraying season. On the other hand, slight or no increase in the enzyme activity was recorded at 24 h post treatment of the IGR, while high reduction in AliE activity was recorded at 48 h in the larvae collected before and after spraying season.

Regarding to resistant and laboratory strains, the level of AliE activity was higher in resistant strain compared with laboratory strain. The treatment with insecticides caused increases in AliE activity of L-strain for all tested insecticides, the highest level of the enzyme activity was recorded for Profenofos treatment (132.8% higher than control). While OP and IGR insecticides caused decrease in AliE activity of R-strain, the pyrethroid caused increase in AliE activity of the R-strain.

Generally, the data emerged from insecticides treatment revealed that the OP Profenofos caused variable inhibition in AliE activity of most tested field strains collected before and after spraying season. **Yu (1992)** stated that the broad spectra of insecticide resistance observed in field strains of *Spodoptera frugiperda* were due to multiple resistance mechanisms, including increased detoxification by microsomal oxidases, glutathione transferases and esterases. Also, **Li (1997)** suggested that metabolic resistance mechanisms such as carboxylesterases (CarE) and mixed function oxygenases (MFO) were

involved in parathion-methyl resistance, but not in deltamethrin resistance in *Pectinophora gossypiella* field strains. **Manikandan and Ravisankar (1998)**,reported that the field strain larvae of *Helicoverpa armigera* showed greater resistance to both monocrotophos and quinalphos (LC50 values of 0.00817 and 0.00528%, respectively) and ignificantly increased their carboxylesterase activity. **Konno (1996)** suggested that the carboxylesterase of *Chilo suppressalis* has a role in fenitrothion resistance as a sequestering protein. **Tripathy and Singh (1999)** determined the inhibition of carboxylesterase activity in larvae of *Helicoverpa armigera* field strain by quinalphos and monocrotophos. The highest I50 value (concentration that inhibited 50% of the enzyme activity) for both insecticides was obtained from a Guntur strain obtained from a laboratory reared strain. A direct positive relationship between total carboxylesterase activity and I50 values towards these insecticides were not obtained. On the other hand, no significant difference in carboxylesterase activity between resistant and susceptible strains of *Grapholita molesta.* was obtained (**Kanga *et al.*, 1997**). However, **O'Brien (1960)** suggested that the Ali-E inhibition was of little importance in OP poisoning, and attributed the case of Ali-E inhibition to the fact that 96% of the housefly Ali-E resides outside the nervous system where it was readily available, in contrast, 91% of Ch-E was found within the nervous system.

3. <u>Changes in phosphatases activities</u>:

Phosphatases are defined as enzymes hydrolyzing any phosphorus ester or anhydride bond, including P-O-C, P-S and others. One generalization can be made safely; all the OP-compounds can be

hydrolyzed, in mammals, insects and plants by phosphatases; commonly the major metabolic route (**O'Brien, 1967**).

The close relationship of phosphatases with organophosphorus resistance had long been conjectured, since **Van Asperen and Oppenoorth (1959)** observed unusually low esterase activity in resistant houseflies

Results presented in Table (16) and illustrated in Figs. (18 and 19) showed the changes in acid phosphatase (AcP) and alkaline phosphatase (AlkP) activities of the cotton leafworm field strains collected from different Governorates before and after spraying season and also of IGR-resistant and IGR-laboratory strains. The 4th instar larvae were treated with the LC_{25} of each of the organophosphates (Profenofos), pyrethroid (Esfenvalerate) and insect growth regulators (Tebufenozide) insecticides. The enzyme activity was determined at 24 and 48 h post treatment with Tebufenozide. The data obtained revealed the following:

3.1. Acid phosphatase (AcP):

Regarding to insecticides treatment as shown in Table (16) and Fig. (18), the data emerged from Kalubyia strain showed that all the tested compounds resulted in high reduction in AcP activity of insects collected before and after spraying season. The maximum level of reduction obtained from larvae treated with IGR compound at 48 hrs after application it was 7.9 and 23.4% lower than control for the larvae collected before and after spraying season, respectively.

The reduction in AcP activity as a result of insecticides treatment was also found in Dakahlia strain collected after spraying season, while

Table (16): Changes in acid (AcP) and alkaline (AlkP) phospatases activities in field strains of *S. littoralis* and IGR-R and IGR-L strains post treatment with insecticides.

Insecticides	AcP*				AlkP*			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity*	%	Activity*	%
Kalubyia-Strain								
Profenofos-24	1.82 ± 0.23	25.6	2.10 ± 0.25	75	1.04 ± 0.01	82.5	1.17 ± 0.01	43
Esfenvalerate-24	1.03 ± 0.10	14.5	1.27 ± 0.13	45.4	1.35 ± 0.03	107.1	1.44 ± 0.13	52.9
Tebufenozide-24	0.86 ± 0.11	12.1	0.70 ± 0.11	25	1.12 ± 0.09	88.9	1.26 ± 0.01	46.3
Control-24	7.10 ± 0.84	100	2.80 ± 0.33	100	1.26 ± 0.02	100	2.72 ± 0.01	100
Tebufenozide-48	0.25 ± 0.02	7.9	0.61 ± 0.08	23.4	1.33 ± 0.24	207.8	3.89 ± 0.02	222.3
Control-48	3.13 ± 0.37	100	2.61 ± 0.32	100	0.64 ± 0.01	100	1.75 ± 0.01	100
Dakahlia-Strain								
Profenofos-24	5.09 ± 0.60	129.2	0.79 ± 0.09	33.1	2.79 ± 0.01	122.4	1.75 ± 0.02	583.3
Esfenvalerate-24	7.24 ± 0.86	183.8	0.79 ± 0.10	33.1	5.15 ± 0.03	225.9	2.59 ± 0.01	863.3
Tebufenozide-24	5.77 ± 0.65	146.4	1.03 ± 0.12	43.1	13.29 ± .17	582.9	1.49 ± 0.01	496.6
Control-24	3.94 ± 0.47	100	2.39 ± 0.28	100	2.28 ± 0.01	100	0.3 ± 0.01	100
Tebufenozide-48	3.44 ± 0.54	286.7	1.14 ± 0.14	49.1	4.42 ± 0.08	107.8	1.90 ± 0.03	55.7
Control-48	1.20 ± 0.14	100	2.32 ± 0.28	100	4.10 ± 0.01	100	3.41 ± 0.01	100
Menofia-Strain								
Profenofos-24	1.28 ± 0.15	21.5	2.39 ± 0.28	129.2	1.09 ± 0.01	46.9	1.70 ± 0.01	33.9
Esfenvalerate-24	3.64 ± 0.43	61.3	2.15 ± 0.27	116.2	1.87 ± 0.03	80.6	2.25 ± 0.01	44.8
Tebufenozide-24	0.65 ± 0.08	10.9	1.09 ± 0.13	58.9	0.90 ± 0.01	38.8	1.31 ± 0.01	26.1
Control-24	5.94 ± 0.62	100	1.85 ± 0.22	100	2.32 ± 0.02	100	5.02 ± 0.01	100
Tebufenozide-48	1.18 ± 0.14	57.8	3.76 ± 0.44	134.3	1.79 ± 0.00	39.2	1.41 ± 0.00	40.3
Control-48	2.04 ± 0.25	100	2.80 ± 0.33	100	4.57 ± 0.01	100	3.50 ± 0.03	100
Kafr El Sheikh-Strain								
Profenofos-24	2.92 ± 0.35	165.9	3.89 ± 0.46	437.0	2.34 ± 0.02	93.9	2.08 ± 0.02	352.5
Esfenvalerate-24	5.42 ± 0.63	307.9	5.17 ± 0.61	580.8	2.37 ± 0.00	95.2	2.82 ± 0.02	477.9
Tebufenozide-24	1.51 ± 0.21	85.8	0.85 ± 0.10	95.5	0.86 ± 0.01	34.5	0.82 ± 0.01	138.9
Control-24	1.76 ± 0.21	100	0.89 ± 0.04	100	2.49 ± 0.01	100	0.59 ± 0.00	100
Tebufenozide-48	2.18 ± 0.26	144.4	0.69 ± 0.08	10.2	2.79 ± 0.01	123.5	1.75 ± 0.02	36.9
Control-48	1.51 ± 0.18	100	6.78 ± 0.8	100	2.26 ± 0.02	100	4.74 ± 0.02	100
Behera-Strain								
Profenofos-24	5.71 + 0.68	173.03	1.63 + 0.19	49.69	2.92 + 0.01	213.1	2.93 + 0.06	228.9
Esfenvalerate-24	4.42 ± 0.52	133.94	1.91 ± 0.23	58.23	2.70 ± 0.01	197.1	1.75 ± 0.01	136.7
Tebufenozide-24	5.05 ± 0.60	153.03	2.16 ± 0.25	65.85	2.42 ± 0.01	176.6	1.29 ± 0.02	100.8
Control-24	3.3 ± 0.04	100	3.28 ± 0.39	100	1.37 ± 0.02	100	1.28 ± 0.01	100
Tebufenozide-48	1.88 ± 0.22	221.2	1.98 ± 0.24	440	1.42 ± 0.01	60.4	1.60 ± 0.01	179.8
Control-48	0.85 ± 0.10	100	0.45 ± 0.05	100	2.35 ± 0.01	100	0.89 ± 0.01	100

Continued Table (16)

Insecticides	AcP*				AlkP*			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity*	%	Activity*	%
Menia-Strain								
Profenofos-24	3.30 ± 0.39	83.8	2.25 ± 0.26	212.3	1.73 ± 0.02	75.9	2.05 ± 0.01	75.1
Esfenvalerate-24	3.76 ± 0.46	95.4	5.32 ± 0.62	501.9	2.18 ± 0.01	95.6	3.14 ± 0.01	115
Tebufenozide-24	6.73 ± 0.80	170.8	6.48 ± 0.76	611.3	2.07 ± 0.01	90.8	3.69 ± 0.01	135.2
Control-24	3.94 ± 0.47	100	1.06 ± 0.13	100	2.28 ± 0.01	100	2.73 ± 0.01	100
Tebufenozide-48	1.76 ± 0.20	116.6	2.70 ± 0.31	28.7	2.36 ± 0.01	40.7	5.60 ± 0.01	132.4
Control-48	1.51 ± 0.21	100	9.40 ± 1.10	100	5.80 ± 0.01	100	4.23 ± 0.02	100
Insecticides	AcP*				AlkP*			
	Laboratory		Resistant		Laboratory		Resistant	
	Activity*	%	Activity*	%	Activity*	%	Activity*	%
Profenofos-24	0.93 ± 0.11	160.3	2.52 ± 0.30	600	5.25 ± 0.01	86.1	4.61 ± 0.01	268
Esfenvalerate-24	0.89 ± 0.11	153.4	1.10 ± 0.13	261.9	5.85 ± 0.54	95.9	2.68 ± 0.03	155.8
Tebufenozide-24	1.57 ± 0.19	270.7	0.91 ± 0.11	216.7	9.60 ± 0.05	157.4	1.96 ± 0.01	113.9
Lab. -24	0.58 ± 0.07	100	0.42 ± 0.06	100	6.10 ± 0.04	100	1.72 ± 0.01	100
Tebufenozide-48	1.31 ± 0.16	143.9	0.93 ± 0.11	163.2	12.34 ± .03	106.9	4.27 ± 0.01	307.2
Lab.-48	0.91 ± 0.11	100	0.57 ± 0.09	100	11.54 ±0.05	100	1.39 ± 0.01	100

* AcP & AlkP = µg phenol released / larvae /min.

that collected before spraying season revealed variable increases in their AcP activity post treatment. On the other hand, the opposite trend was found in Menofia strain, the insects collected before revealed a decrease in their enzyme activity after treatment by the tested compounds. the maximum level of reduction was obtained from insects treated with the IGR for 24 h, whereas a remarkable increase in AcP activity was recorded as a result of insecticides treatment was found in the larvae collected after spraying season.

Regarding to Kafr El-Sheikh strain all tested insecticides caused different level of increase in AcP activity in the larvae collected before and after spraying season with exception Tebufenozide gave reduction in the enzyme activity of insects collected before spraying season when

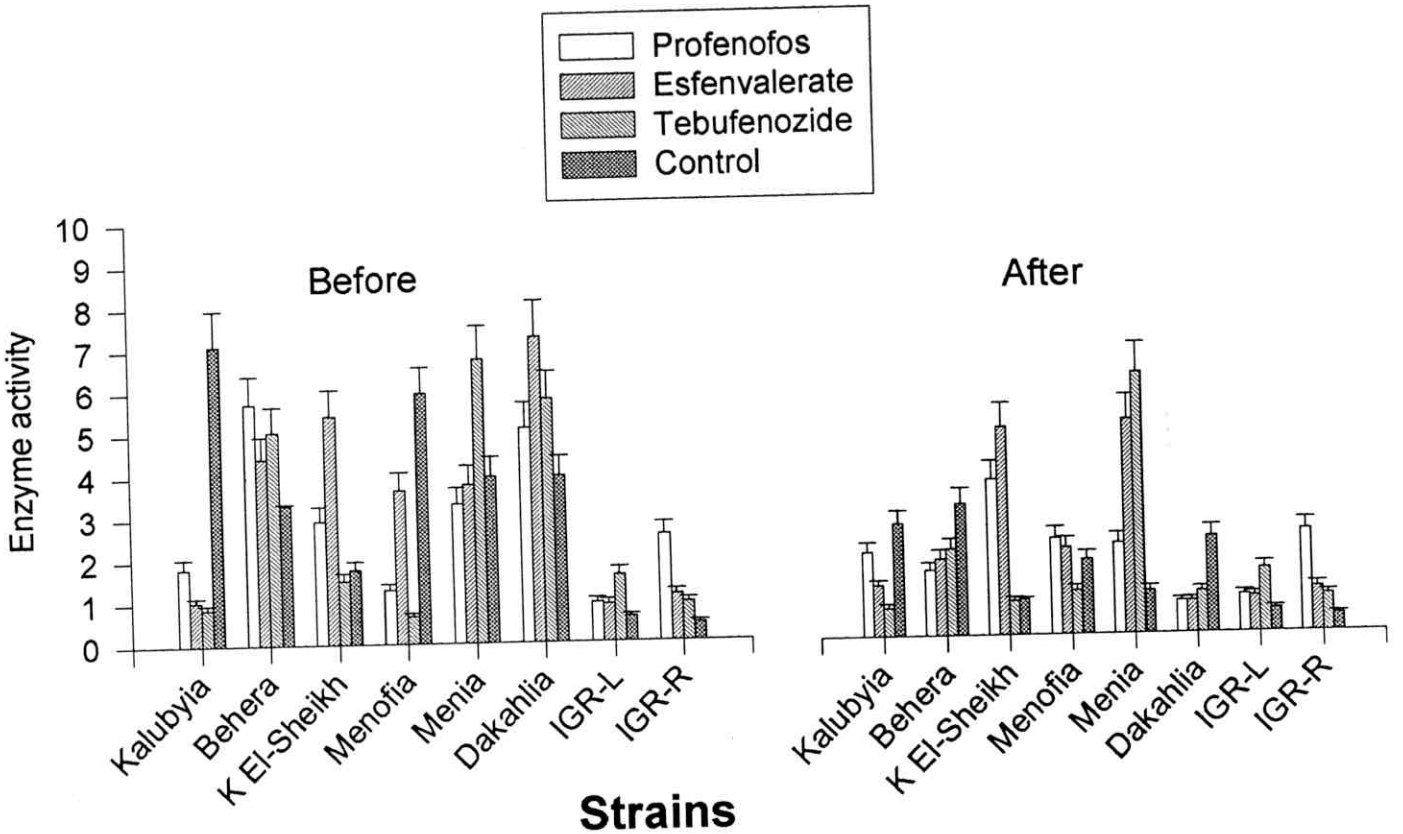


Fig.(18): Changes in AcP activity of *S.littoralis* field strain larvae representing early and late season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

assayed at 24 h and after spraying season at 48 h post treatment compared to control.

The trend that obtained from Dakahlia strain was also obtained from Behera strain. The insects collected before spraying season revealed great increase in their enzyme activity after treatment with the tested insecticides. The maximum level of 173.0% relative to Control was recorded for Profenofos compound. In contrary, the larvae collected after spraying season revealed variable decrease in their enzyme activity post insecticides treatment with exception IGR-48 recorded high increse in the enzyme activity. The maximum level of reduction was 49.7% lower than control was recorded post treatment with the OP insecticide.

Regarding the effect of tested insecticides on AcP activity of Menia strain, the data cleared that both OP and pyrethroid insecticides caused little decrease in the enzyme activity of the larvae collected before spraying, while the IGR used at 24 or 48 h post treatment caused increase in the enzyme activity. In contrary, all tested compounds gave great increase in AcP activity of insects collected after spraying season with exception the IGR at 48 h that caused great reduction in the enzyme activity. The maximum level of increase (611.3% higher than control) in AcP activity was recorded in insects treated with the IGR for 24 h.

Studying the effect of the tested insecticides on AcP activity of R- and L-strain represented in Table (19), revealed that R-strain in normal state had AcP activity less than L-strain however, the treatment with the tested insecticides caused increase in the enzyme activity of

both strains compared to control but the increase in the case of R-strain was higher than that in L-strain.

3.2. Alkaline phosphatase (AlkP):

The effect of the three tested compounds on AlkP activity of field strains was presented in Table (16) and Fig. (19). The data obtained from Kalubyia strain showed that treatment of larvae with OP and IGR compounds caused reduction in AlkP activity at 24 h post treatment in insects collected before and after spraying season while treated with pyrethroid insecticide caused little increase in AlkP activity of larvae collected before spraying season and great decrease in the enzyme activity of larvae collected after spraying season. On the other hand, larvae treated with IGR exhibited a highly increase in their AlkP activity at 48 h post treatment.

Dakahlia strain collected early season showed great increase in their AlkP activity after treatment with all tested insecticides specially for the larvae collected after spraying season.

In contrary, great reduction in AlkP activity was recorded as a result of insecticides treatment in Menofia strain collected before and after spraying season. The maximum reduction in the enzyme activity was recorded for IGR insecticides treated for 24 hours.

Treatment of Kafr El Sheikh strain with the tested insecticides caused a variable decrease in AlkP activity of insects collected at early season while exihibited an increase in the enzyme activity of the insects collected at late season. The treatment with the IGR insecticide for 24 hours resulted in reduction in AlkP activity in insects collected before

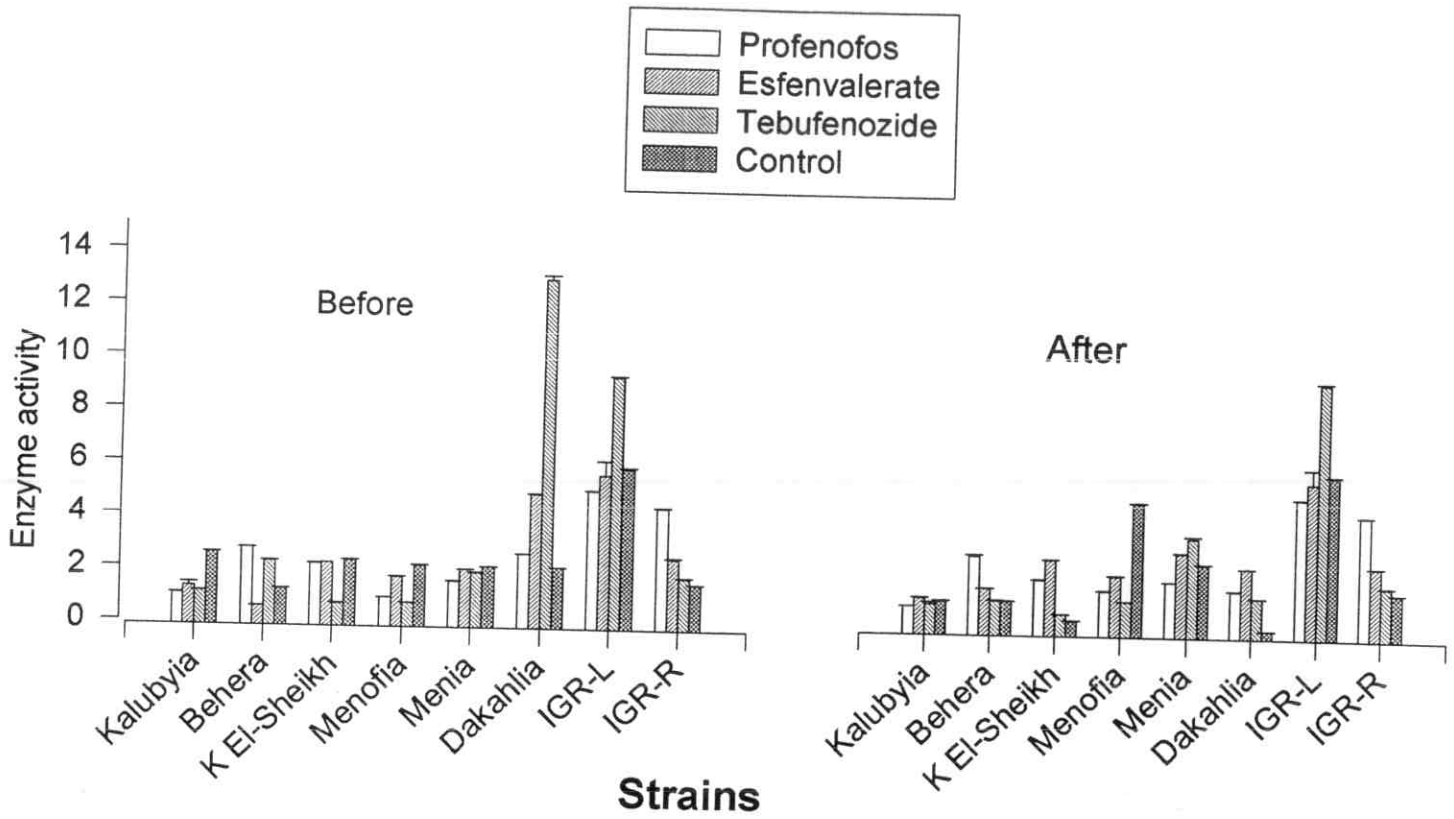


Fig.(19): Changes in AlkP activity of *S.littoralis* field strains representing early and late season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

spraying season while an increase in the enzyme activity was showed in insects collected after spraying. An opposite trend in the enzyme activity was observed when the larvae were treated with IGR for 48 h.

Regarding the Behera strain, the treatment with insecticides led to variable increases in the AlkP activity of insects collected at both intervals. The larvae collected at early season and treated with IGR for 48 h exihibited remarkable decrease in the enzyme activity.

The reduction in AlkP activity as a result of insecticides treatment was obtained in Menia strain collected before and after spraying season with exception to the tested IGR when assayed at 24 or 48 h post treatment exihibiting increase in the enzyme activity in insects collected after spraying season.

Regarding to resistant and laboratory strain, the normal laboratory strain had higher level of AlkP activity than the R-strain and other field strains. Generally, the treatment with insecticides caused mostly increases in AlkP activity of both R- and L-strain but the increase in the enzyme activity in R-strain was greater than L-strain.

All tested field strains collected before and after spraying season had phosphatases activities greater than laboratory strain. **O'Brien (1967)**, concluded that "a minor increase in phosphatase activity, like other numerous changes in hydrolases, accompanies resistance rather than cause it". **Shakoori *et al.* (1994)** showed in laboratory studies that the adults of a malathion-resistant Pakistani (PAK) strain of *Tribolium castaneum* had more active acid phosphatase as compared with those of an organophosphorus-susceptible (FSS-II) strain.

The sublethal concentration (LC_{25}) of Profenofos, Esfenvalerate and Tebufenozide caused a dramatic decrease in the level of both AcP

and AlkP activities in most tested field strains, while an increase in phosphatases activities were recorded in IGR-resistant strain. **Gao *et al.* (1996)** found that field strain of *Helicoverpa armigera* had high resistance to pyrethroid, organophosphate and carbamate insecticides. They also added that the effects of sublethal concentrations (LD_5 and LC_{50}) of parathion and methomyl on the phosphatases were related to dosage and the time after treatment. The effect on alkaline phosphatase was stronger than that on acid phosphatase. The effect of sublethal concentration of Cymbush 10EC (cypermethrin) on AcP and AlkP activity in adults of *Tribolium castaneum* was studied by **Shakoori *et al.* (1998)**, they found that the treatment increased both enzymes activities. Also the activity of acid phosphatase was significantly enhanced in the tissues (head, thorax and abdomen) of *Mythimna separata* after treatment with DDVP [dichlorvos], formothion, cypermethrin and mexacarbate, whereas alkaline phosphatase activity was significantly inhibited (**Pandey and Sharma, 1995**). The same trend was obtained by **Saleem and Shakoori (1987)**. They showed that the Sublethal concentrations of permethrin and Diflubenzuron increased acid phosphatase in 6th instar larvae of *Tribolium castaneum,* while alkaline phosphatase were not affected by either insecticide. On the other hand a sublethal dose (20 p.p.m.) of bifenthrin showed higher activities of AlkP of 6th instar larvae of *Tribolium castaneum* resistant to malathion, while AcP was not affected.

4. Carbohydrate hydrolyzing enzymes :

Carbohydrates, proteins and lipids are very efficiently utilized by insects and most species derive the main part of their nourishment from

these nutrients. The utilization of these nutrients depends on the digestive enzymes; amylase, trehalase, invertase, protease and lipase.

This work concerned with studies on the changes in trehalase and invertase activities of *S. littoralis* field strains and IGR-resistant and IGR-laboratory strains in the normal and poisoning states. The data are represented in Table (17) and illustrated in Figs. (20 and 21).

4.1. Trehalase enzyme activity:

Data in Table (17) and Fig.(20) showed in general that all field strains had trehalase enzyme much greater than laboratory strain. Menofia, Kafr El-Sheikh, Behera and Dakalia field strains collected after spraying season revealed low level of trehalase compared with that collected before spraying season, while the opposite trend was obtained from Kalubyia and Menia field strains. Also the IGR-resistant strain had trehalase activity much higher than IGR-laboratory strain.

The effect of sublethal concentrations (LC_{25}) of the tested insecticides on the activity of trehalase in field strains revealed that Kalubyia strain showed great reduction in their enzyme activity after treatment the larvae collected before spraying season with both OP and pyrethroid insecticides, while insects collected after spraying season showed an increase in the enzyme activity post treatment with the same insecticides. On the other hand, Kalubyia strain treated with the IGR Tebufenozide caused a decrease in trehalase activity at 24 h for larvae collected before and after spraying season, while the treatment with the same insecticide for 48 hours caused an increase in the enzyme activity of larvae collected at both intervals.

Table (17): Changes in Trehalase and Invertase activities in field strains of *S. littoralis* and IGR-R and IGR-L strains post treatment with insecticides.

Insecticides	Trehalase				Invertase			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity*	%	Activity*	%
Kalubyia-Strain								
Profenofos-24	13.80 ± 0.40	**49.65**	22.93 ± 0.27	**118.44**	14.91 ± 0.23	**37.43**	27.68 ± 0.20	**137.23**
Esfenvalerate-24	18.40 ± 0.50	**66.21**	24.77 ± 0.37	**127.94**	10.97 ± 0.14	**27.54**	22.81 ± 0.30	**113.08**
Tebufenozide-24	16.72 ± 0.04	**60.16**	15.64 ± 0.07	**80.78**	16.64 ± 0.10	**41.77**	23.27 ± 0.30	**115.36**
Control-24	27.79 ± 0.44	**100**	19.36 ± 0.40	**100**	39.83 ± 0.60	**100**	20.17 ± 0.43	**100**
Tebufenozide-48	26.22 ± 0.27	**140.13**	24.23 ± 0.60	**162.50**	35.81 ± 0.17	**127.93**	38.91 ± 0.38	**189.71**
Control-48	18.71 ± 0.23	**100**	14.91 ± 0.10	**100**	27.99 ± 0.27	**100**	20.51 ± 0.04	**100**
Dakahlia-Strain								
Profenofos-24	28.23 ± 0.82	**122.74**	17.67 ± 0.40	**64.02**	34.14 ± 0.32	**101.30**	21.24 ± 0.21	**86.83**
Esfenvalerate-24	36.86 ± 0.42	**160.26**	23.84 ± 0.20	**86.37**	56.93 ± 0.10	**168.93**	27.52 ± 0.20	**112.51**
Tebufenozide-24	81.75 ± 0.10	**355.43**	17.17 ± 0.60	**62.21**	93.54 ± 0.10	**277.56**	25.76 ± 0.13	**105.31**
Control-24	23.00 ± 0.20	**100**	27.60 ± 0.33	**100**	33.70 ± 0.07	**100**	24.46 ± 0.07	**100**
Tebufenozide-48	76.80 ± 0.58	**500.65**	26.18 ± 0.17	**104.80**	81.07 ± 0.51	**532.65**	32.70 ± 0.74	**125.86**
Control-48	15.34 ± 0.10	**100**	24.98 ± 0.05	**100**	15.22 ± 0.27	**100**	25.98 ± 0.64	**100**
Menofia-Strain								
Profenofos-24	11.58 ± 0.14	**125.32**	21.12 ± 0.23	**128.39**	17.00 ± 0.07	**78.34**	24.79 ± 0.21	**127.82**
Esfenvalerate-24	23.45 ± 0.45	**253.78**	21.62 ± 0.20	**131.42**	31.90 ± 0.23	**147.00**	25.61 ± 0.08	**130.99**
Tebufenozide-24	10.81 ± 0.50	**117.00**	21.85 ± 0.27	**132.82**	18.40 ± 0.20	**84.79**	29.56 ± 0.13	**151.20**
Control-24	9.24 ± 0.36	**100**	16.45 ± 0.31	**100**	21.70 ± 0.20	**100**	19.55 ± 0.07	**100**
Tebufenozide-48	14.54 ± 0.25	**29.69**	23.00 ± 0.07	**92.29**	22.99 ± 0.37	**24.60**	29.21 ± 0.47	**97.69**
Control-48	48.97 ± 0.42	**100**	24.92 ± 0.10	**100**	93.44 ± 0.66	**100**	29.90 ± 0.07	**100**
Kafr El-Sheikh-Strain								
Profenofos-24	24.19 ± 0.23	**167.40**	18.56 ± 0.47	**83.15**	35.88 ± 0.30	**157.32**	19.78 ± 1.47	**91.65**
Esfenvalerate-24	22.89 ± 0.31	**158.40**	23.16 ± 0.47	**103.80**	37.83 ± 0.24	**229.96**	14.88 ± 0.53	**68.95**
Tebufenozide-24	19.25 ± 0.04	**133.22**	24.38 ± 0.20	**109.27**	29.67 ± 0.53	**180.36**	20.36 ± 0.40	**94.34**
Control-24	14.45 ± 0.30	**100**	22.31 ± 0.07	**100**	16.45 ± 0.07	**100**	21.58 ± 0.30	**100**
Tebufenozide-48	26.07 ± 0.30	**131.60**	39.79 ± 0.07	**121.38**	35.19 ± 0.43	**195.50**	44.66 ± 0.04	**78.92**
Control-48	19.81 ± 0.24	**100**	32.78 ± 0.08	**100**	18.00 ± 0.23	**100**	56.59 ± 0.27	**100**
Behera-Strain								
Profenofos-24	32.82 ± 0.23	**209.84**	28.18 ± 0.40	**136.14**	42.78 ± 0.30	**310.90**	37.84 ± 0.50	**129.19**
Esfenvalerate-24	30.09 ± 0.17	**192.39**	25.34 ± 0.23	**122.42**	41.63 ± 0.07	**302.54**	23.88 ± 0.30	**81.52**
Tebufenozide-24	30.94 ± 0.07	**197.82**	22.08 ± 0.13	**106.66**	45.12 ± 0.20	**327.90**	21.58 ± 0.23	**73.67**
Control-24	15.64 ± 0.31	**100**	20.69 ± 0.47	**100**	13.76 ± 0.23	**100**	29.29 ± 0.23	**100**
Tebufenozide-48	28.64 ± 0.37	**157.27**	25.92 ± 0.37	**127.56**	37.95 ± 0.07	**128.90**	35.00 ± 0.47	**203.37**
Control-48	18.21 ± 0.04	**100**	20.32 ± 0.30	**100**	29.44 ± 0.13	**100**	17.21 ± 0.10	**100**

Continued Table (17)

Insecticides	Trehalase				Invertase			
	Before		After		Before		After	
	Activity*	%	Activity*	%	Activity*	%	Activity*	%
Menia-Strain								
Profenofos-24	18.75 ± 0.17	81.52	23.04 ± 0.10	114.25	31.44 ± 0.17	93.29	26.57 ± 0.24	82.31
Esfenvalerate-24	23.46 ± 0.43	102.00	21.16 ± 0.07	105.11	28.02 ± 0.17	83.14	15.26 ± 0.23	47.27
Tebufenozide-24	28.71 ± 0.30	124.82	28.33 ± 0.27	134.07	44.78 ± 0.27	132.87	24.15 ± 0.74	74.81
Control-24	23.00 ± 0.20	100	20.13 ± 0.66	100	33.70 ± 0.07	100	32.28 ± 0.27	100
Tebufenozide-48	31.68 ± 0.27	51.56	28.06 ± 0.30	94.16	46.16 ± 0.14	45.97	39.33 ± 0.00	67.67
Control-48	61.44 ± 0.11	100	29.80 ± 0.13	100	100.4 ± 0.93	100	58.12 ± 0.29	100
Insecticides	**Trehalase**				**Invertase**			
	Laboratory		Resistant		Laboratory		Resistant	
	Activity*	%	Activity*	%	Activity*	%	Activity*	%
Profenofos-24	30.17 ± 0.23	391.38	26.49 ± 0.01	141.42	40.06 ± 0.23	312.72	26.11 ± 0.13	94.60
Esfenvalerate-24	26.99 ± 0.23	350.06	35.06 ± 1.58	187.38	31.97 ± 0.13	249.57	33.73 ± 0.09	122.21
Tebufenozide-24	33.16 ± 0.04	430.09	21.20 ± 0.04	113.30	40.08 ± 0.21	312.88	27.56 ± 0.04	102.07
Lab. -24	7.71 ± 0.17	100	18.71 ± 0.30	100	12.81 ± 0.04	100	27.60 ± 0.07	100
Tebufenozide-48	39.93 ± 0.50	184.26	24.89 ± 0.27	126.53	45.04 ± 0.75	136.11	41.04 ± 0.40	143.09
Lab.-48	21.67 ± 0.23	100	19.67 ± 0.07	100	33.09 ± 0.11	100	28.68 ± 0.27	100

* Activity = µg glucose released / larvae / min.

Opposite trend was obtained in Dakahlia strain, where the treatment with the tested insecticides caused increases in trehalase activity of the larvae collected before spraying season, and caused a decrease in the enzyme activity of larvae collected after spraying season. Moreover the increase in trehalase activity was pronounced in the larvae treated with the IGR insecticide.

Regarding the Menofia strain, all tested insecticides gave variable increases in trehalase activity higher than control in both collected larvae with exception the insecticide Tebufenozide when applied for 48 hours gave a decrease in the enzyme activity lower than control in both collected larvae. The same trend was obtained in Kafr El-Sheikh strain with exception that OP compound caused little

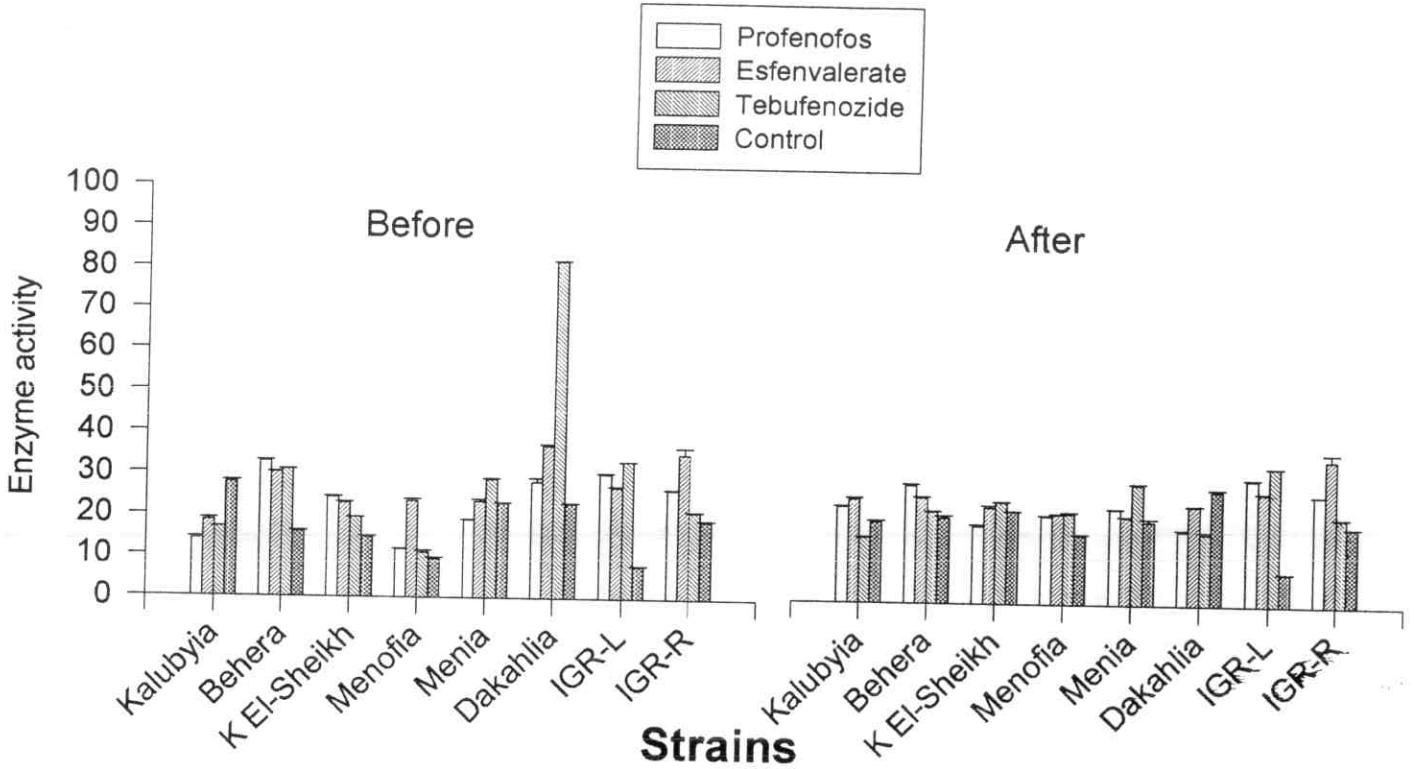


Fig.(20): Changes in Trehalase activity of *S.littoralis* field strains collected before and after spraying season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

decrease in the enzyme activity of larvae collected after spraying season and also the IGR applied for 48 hours gave an increase in the enzyme activity of both collected larvae.

The increase in trehalase activity as a result of insecticides treatment was recorded in Behera and Menia strains for all the tested compounds with the exception OP insecticide that gave reduction in the enzyme activity of Menia strain collected before spraying season. However, the IGR when assayed at 48 hours in Menia strain exihibited a decrease in trehalase activity of both collected larvae. The effect of tested insecticides on trehalase activity of the IGR-resistant and IGR-laboratory strains revealed that there were variable increases in the activity after treatment specially in the larvae collected before spraying season.

Generally, the data obtained for trehalase enzyme showed an elevation in the enzyme activity of most tested field strains during the course of insecticides poisoning, also the IGR-resistant and IGR-laboratory strains revealed an increase in their trehalase activity after insecticides treatment.

4.2- Invertase enzyme activity:

Data in Table (17) and Fig.(21) showed in general that all field strain in normal state showed invertase activity much greater than laboratory strain. Menofia, Menia, Kalubyia and Dakahlia field strains collected after spraying season had low levels of invertase activity compared with that collected before spraying season, while the opposite trend was obtained from Behera and Kafr El-Sheikh field strains.

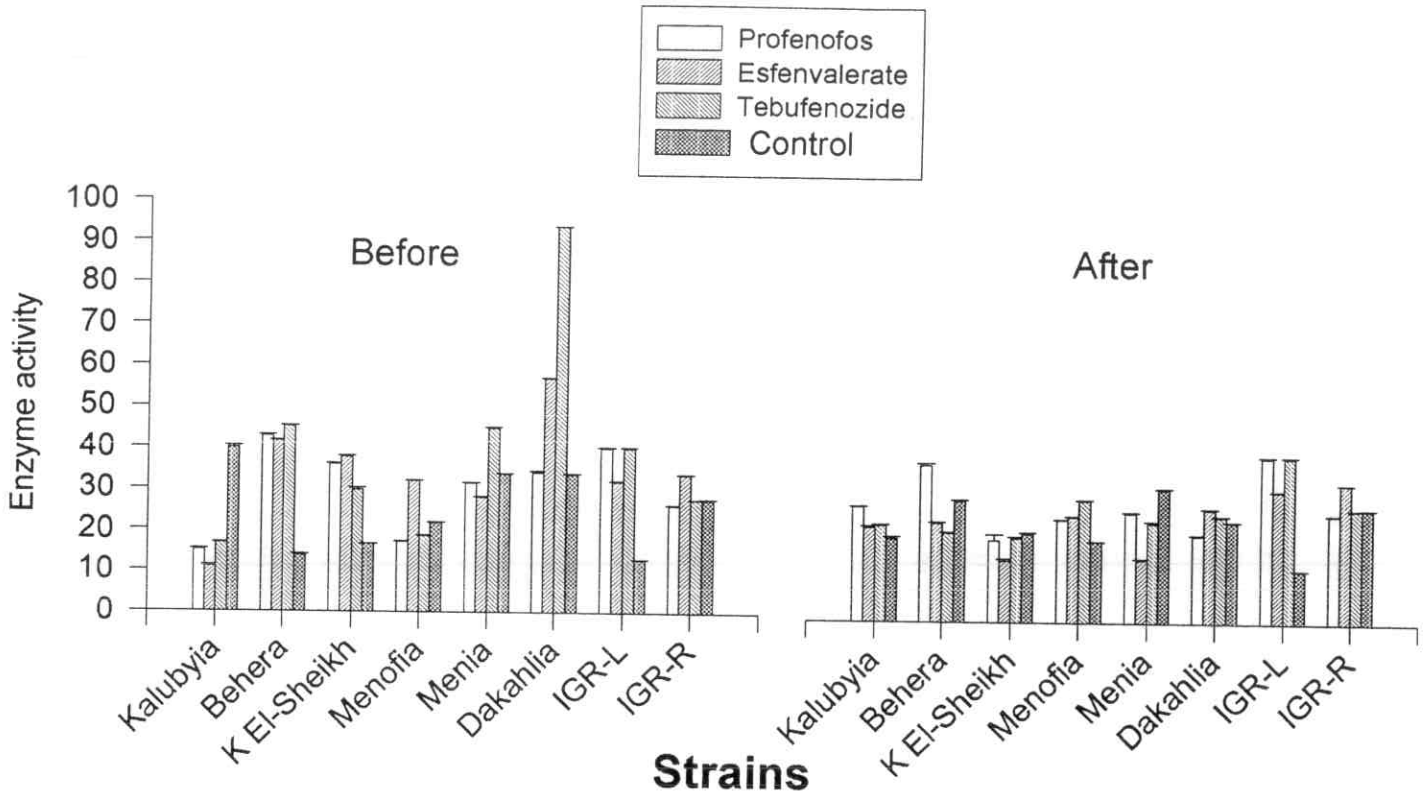


Fig.(21): Changes in Invertase activity of *S.littoralis* field strains larvae collected before and after spraying season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

Changes in invertase activity of *S. littoralis* as a result of insecticidal treatment revealed generally that a great reduction in the enzyme activity was obtained from Kalubyia strain collected during early season with exception to IGR insecticide when assayed at 48 hours exihibited increase in the enzyme activity. Larvae collected after spraying season and treated with the sublethal concentrations of the tested insecticides revealed an increase in their invertase activity.

In the case of Dakahlia strain the data revealed that variable increases in invertase activity higher than control was shown in the insects collected before and after spraying for all tested compounds with exception to the OP which gave little decrease in the enzyme activity of larvae collected after spraying season. In Menofia strain both OP and IGR caused a decrease in invertase activity of larvae collected before spraying while the pyrethroid insecticide caused great increase in the enzyme activity. On the other hand, all tested compounds caused a variable increase in the enzyme activity of larvae collected after spraying season.

Kafr El-Sheikh strain during insecticides poisoning showed great increases in invertase activity of larvae collected before spraying season, while a decrease in the enzyme activity was found in larvae collected after spraying season. The same trend was obtained from Behera strain, all tested insecticides gave much increase in the level of invertase activity of larvae collected before spraying season, while larvae collected after spraying season, revealed a decrease in the enzyme activity for all tested insecticides with exception of OP and IGR at 48 h caused increase in the enzyme activity.

The data resulted in Menia strain revealed that treating the larvae with sublethal concentrations of tested insecticides caused reduction in invertase activity of both collected insects with exception Tebufenozide at 24 hour after application causing an increase in the enzyme activity of larvae collected before spraying season.

Regarding to the IGR-resistant and IGR-laboratory strains, the data showed that IGR-resistant strain - in normal state - had higher level of invertase activity than L-strain. However, insecticidal treatments generally, caused increases in the enzyme activity of L-strain much higher than R-strain.

The data resulted from carbohydrate hydrolyzing enzymes (trehalase and invertase) revealed that, a pronounced increase in both enzymes was observed as a result of treating the cotton leafworm field strains with the sublethal concentrations of each of Profenofos, Esfenvalerate and Tebufenozide insecticides specially trehalase enzyme activity.

It is well known that in insects, trehalase degrades the disaccharide trehalose to glucose for internal energy supply and generates, (during moulting) glucose needed for chitin build-up. So the inhibition of trehalase observed in the present work might affect this process. Study the mode of action of Dimilin revealed that this compound alter the cuticle composition of insect, specially that of chitin **(Ishaaya and Casida, 1974).** Also **Post and Vincent (1973)** found that the reduced level of chitin in the cuticle is due to the inhibition of biochemical processes leading to chitin formation. In addition trehalase played a significant role in the supply of energy to the insect and the activity of trehalase might serve as an indicator of

energy reserves resulting from availability of carbohydrate nutrients **(Wyatt 1967)**. During moulting cycles, the trehalose-trehalase system is activated to generate glucose needed, probably, for chitin build-up in the newly synthesized cuticle **(Candy and Kilby, 1962)**. The increase in enzymes involved with carbohydrate metabolism was found by **Shakoori *et al.* (1998)** on adults of *Tribolium castaneum* after treated with sublethal concentration (20 ppm) of Cymbush 10EC (cypermethrin). The data suggested the utilization of reserve carbohydrates, a finding which was supported by depleted levels of glucose (53%) and glycogen (43%) following insecticide exposure. **El-Saidy and Degheele (1990)** found that amylase activity was reduced, but neither invertase nor trehalase activity was affected after treatment with diflubenzuron.

On the other hand, the present data disagreed with that obtained by **Abdel Hafez *et al.* (1993c)** and **Radwan *et al.* (1985)**, who found that repeated selection of the cotton leafworm larvae with Deenate (Dimilin/ Nudrin mixture) and DC-702 (Dimilin/Dursban mixture) increased the invertase activity and decreased the amylase and trehalase activity. In this concern **Ishaaya and Ascher (1977)** concluded that carbohydrates might be affected due to the reduced levels of amylase, trehalase and invertase of the 4th larval instar of *T. castaneum* treated with diflubenzuron. Also **Saleem and Shakoori (1987)** recorded a reduction in trehalase and elevated amylase activity in the 6th larval instar of the same insect treated also with diflubenzuron. **Naveeda *et al.* (1994)** found a high level of invertase activity in 6th larvae of *Tribolium castaneum* resistant to malathion. The sublethal dose (20 p.p.m.) of bifenthrin caused increase in amylase, maltase,

activities of resistant larvae compared with susceptible one while invertase enzyme was not affected in both larvae. The enhanced enzyme activities after bifenthrin treatment strengthens the defense of resistant larvae against toxic effects of bifenthrin.

5. Total soluble proteins:

The data in Table (18) and Fig.(22) show that all field strains in normal state were characterized by a high level of total protein than laboratory strain with exception Menofia, Behera and Kafr El-Sheikh collected before spraying season had low level of protein content than laboratory strain.

The effect of sublethal concentrations of the tested insecticides on the level of total proteins of different field strains of the cotton leafworm collected before and after spraying season and also of the IGR-L and IGR-R strains revealed that Kalubyia strain showed a great decrease in protein concentration of larvae collected before spraying season compared to control, while that collected after spraying season revealed minor increase in their total protein. The opposite trend was obtained from Dakahlia strain, showing an increase in the level of total protein of the larvae collected before spraying season and a decrease in protein concentration of the larvae collected after spraying season.

Regarding to Menofia strain, both OP and pyrethroid insecticides resulted in an increase in total protein higher than control in larvae collected before spraying season and a decrease in protein concentration of the larvae collected after spraying season. On the other hand, the IGR caused reduction in total protein of both collected larvae with exception that IGR at 24 hours after application gave an

increase in total protein of larvae collected after spraying season. About the same results were obtained from Kafr El-Skeikh strain,

Table (18): Changes in Total protein in field strain of *S. littoralis* and IGR-R and IGR-L strains post treatment with insecticides.

Insecticides	Total protein (mg / larvae)				Total protein (mg / larvae)			
	Before		After		Before		After	
	Concen.*	%	Concen.*	%	Concen.*	%	Concen.*	%
	Kalubyia strain				Dakahlia strain			
Profenofos-24	0.47 ± .01	117.5	0.68 ± 0.01	109.68	0.82 ± 0.0	138.98	0.54 ± 0.0	84.37
Esfenvalerate-24	0.42 ± 0.0	105.0	0.64 ± 0.0	103.22	1.11 ± 0.0	188.13	0.60 ± 0.0	93.75
Tebufenozide-24	0.52 ± 0.0	125.0	0.64 ± 0.02	103.22	2.28 ± 0.0	386.44	0.64 ± 0.0	100
Control-24	0.40 ± 0.0	100	0.62 ± .0.0	100	0.59 ± 0.0	100	0.64 ± 0.0	100
Tebufenozide-48	0.95 ± 0.0	150.79	0.98 ± 0.01	188.46	1.85 ± 0.0	194.73	0.78 ± 0.0	98.73
Control-48	0.63 ± 0.0	100	0.52 ± 0.0	100	0.95 ± 0.0	100	0.79 ± 0.0	100
	Menofia-Strain				Kafr El-Sheikh-Strain			
Profenofos-24	0.44 ± 0.0	110.0	0.55 ± 0.0	98.21	0.78 ± 0.0	173.33	0.41 ± 0.0	78.84
Esfenvalerate-24	0.60 ± 0.0	150.0	0.53 ± 0.0	94.64	0.79 ± 0.0	175.55	0.41 ± 0.0	78.84
Tebufenozide-24	0.33 ± 0.0	82.5	0.64 ± 0.0	114.28	0.66 ± 0.0	146.66	0.54 ± 0.0	103.84
Control-24	0.40 ± 0.0	100	0.56 ± 0.0	100	0.45 ± 0.0	100	0.52 ± 0.0	100
Tebufenozide-48	0.47 ± 0.02	25.68	0.58 ± 0.0	85.29	0.84 ± 0.0	175.0	1.08 ± 0.0	96.42
Control-48	1.83 ± 0.01	100	0.68 ± 0.0	100	0.48 ± 0.0	100	1.12 ± 0.0	100
	Behera-Strain				Menia-Strain			
Profenofos-24	0.98 ± 0.0	239.00	0.85 ± 0.0	113.33	0.62 ± 0.0	105.08	0.50 ± 0.0	84.75
Esfenvalerate-24	0.97 ± 0.0	236.58	0.90 ± 0.15	120.00	0.61 ± 0.0	103.39	0.47 ± 0.0	79.66
Tebufenozide-24	1.13 ± 0.0	275.61	0.52 ± 0.0	69.33	0.91 ± 0.0	154.24	0.57 ± 0.0	96.61
Control-24	0.41 ± 0.0	100	0.75 ± 0.0	100	0.59 ± 0.0	100	0.59 ± 0.0	100
Tebufenozide-48	0.79 ± 0.0	92.94	0.74 ± 0.0	134.55	0.82 ± 0.0	41.62	0.87 ± 0.0	81.31
Control-48	0.85 ±0. 13	100	0.55 ± 0.0	100	1.97 ± 0.0	100	1.07 ± 0.0	100

Insecticides	Total protein (mg / larvae)		Total protein (mg / larvae)	
	Laboratory		Resistant	
	Concentration.*	%	Concentration.*	%
Profenofos-24	0.91 ± 0.0	197.83	0.73 ± 0.0	93.59
Esfenvalerate-24	0.77 ± 0.0	167.39	0.88 ± 0.0	112.82
Tebufenozide-24	0.92 ± 0.0	200.00	0.68 ± 0.0	87.18
Lab. -24	0.46 ± 0.0	100	0.78 ± 0.0	100
Tebufenozide-48	1.24 ± 0.0	165.33	1.01 ± 0.0	162.90
Lab.-48	0.75 ± 0.0	100	0.62 ± 0.0	100

* Concentration = mg protein / larvae

increase in total protein of larvae collected after spraying season. About the same results were obtained from Kafr El-Skeikh strain,

Table (18): Changes in Total protein in field strain of *S. littoralis* and IGR-R and IGR-L strains post treatment with insecticides.

Insecticides	Total protein (mg / larvae)				Total protein (mg / larvae)			
	Before		After		Before		After	
	Concen.*	%	Concen.*	%	Concen.*	%	Concen.*	%
	Kalubyia strain				Dakahlia strain			
Profenofos-24	0.47 ± .01	117.5	0.68 ± 0.01	109.68	0.82 ± 0.0	138.98	0.54 ± 0.0	84.37
Esfenvalerate-24	0.42 ± 0.0	105.0	0.64 ± 0.0	103.22	1.11 ± 0.0	188.13	0.60 ± 0.0	93.75
Tebufenozide-24	0.52 ± 0.0	125.0	0.64 ± 0.02	103.22	2.28 ± 0.0	386.44	0.64 ± 0.0	100
Control-24	0.40 ± 0.0	100	0.62 ± .0.0	100	0.59 ± 0.0	100	0.64 ± 0.0	100
Tebufenozide-48	0.95 ± 0.0	150.79	0.98 ± 0.01	188.46	1.85 ± 0.0	194.73	0.78 ± 0.0	98.73
Control-48	0.63 ± 0.0	100	0.52 ± 0.0	100	0.95 ± 0.0	100	0.79 ± 0.0	100
	Menofia-Strain				Kafr El-Sheikh-Strain			
Profenofos-24	0.44 ± 0.0	110.0	0.55 ± 0.0	98.21	0.78 ± 0.0	173.33	0.41 ± 0.0	78.84
Esfenvalerate-24	0.60 ± 0.0	150.0	0.53 ± 0.0	94.64	0.79 ± 0.0	175.55	0.41 ± 0.0	78.84
Tebufenozide-24	0.33 ± 0.0	82.5	0.64 ± 0.0	114.28	0.66 ± 0.0	146.66	0.54 ± 0.0	103.84
Control-24	0.40 ± 0.0	100	0.56 ± 0.0	100	0.45 ± 0.0	100	0.52 ± 0.0	100
Tebufenozide-48	0.47 ± 0.02	25.68	0.58 ± 0.0	85.29	0.84 ± 0.0	175.0	1.08 ± 0.0	96.42
Control-48	1.83 ± 0.01	100	0.68 ± 0.0	100	0.48 ± 0.0	100	1.12 ± 0.0	100
	Behera-Strain				Menia-Strain			
Profenofos-24	0.98 ± 0.0	239.00	0.85 ± 0.0	113.33	0.62 ± 0.0	105.08	0.50 ± 0.0	84.75
Esfenvalerate-24	0.97 ± 0.0	236.58	0.90 ± 0.15	120.00	0.61 ± 0.0	103.39	0.47 ± 0.0	79.66
Tebufenozide-24	1.13 ± 0.0	275.61	0.52 ± 0.0	69.33	0.91 ± 0.0	154.24	0.57 ± 0.0	96.61
Control-24	0.41 ± 0.0	100	0.75 ± 0.0	100	0.59 ± 0.0	100	0.59 ± 0.0	100
Tebufenozide-48	0.79 ± 0.0	92.94	0.74 ± 0.0	134.55	0.82 ± 0.0	41.62	0.87 ± 0.0	81.31
Control-48	0.85 ±0. 13	100	0.55 ± 0.0	100	1.97 ± 0.0	100	1.07 ± 0.0	100

Insecticides	Total protein (mg / larvae)		Total protein (mg / larvae)	
	Laboratory		Resistant	
	Concentration.*	%	Concentration.*	%
Profenofos-24	0.91 ± 0.0	197.83	0.73 ± 0.0	93.59
Esfenvalerate-24	0.77 ± 0.0	167.39	0.88 ± 0.0	112.82
Tebufenozide-24	0.92 ± 0.0	200.00	0.68 ± 0.0	87.18
Lab. -24	0.46 ± 0.0	100	0.78 ± 0.0	100
Tebufenozide-48	1.24 ± 0.0	165.33	1.01 ± 0.0	162.90
Lab.-48	0.75 ± 0.0	100	0.62 ± 0.0	100

* Concentration = mg protein / larvae

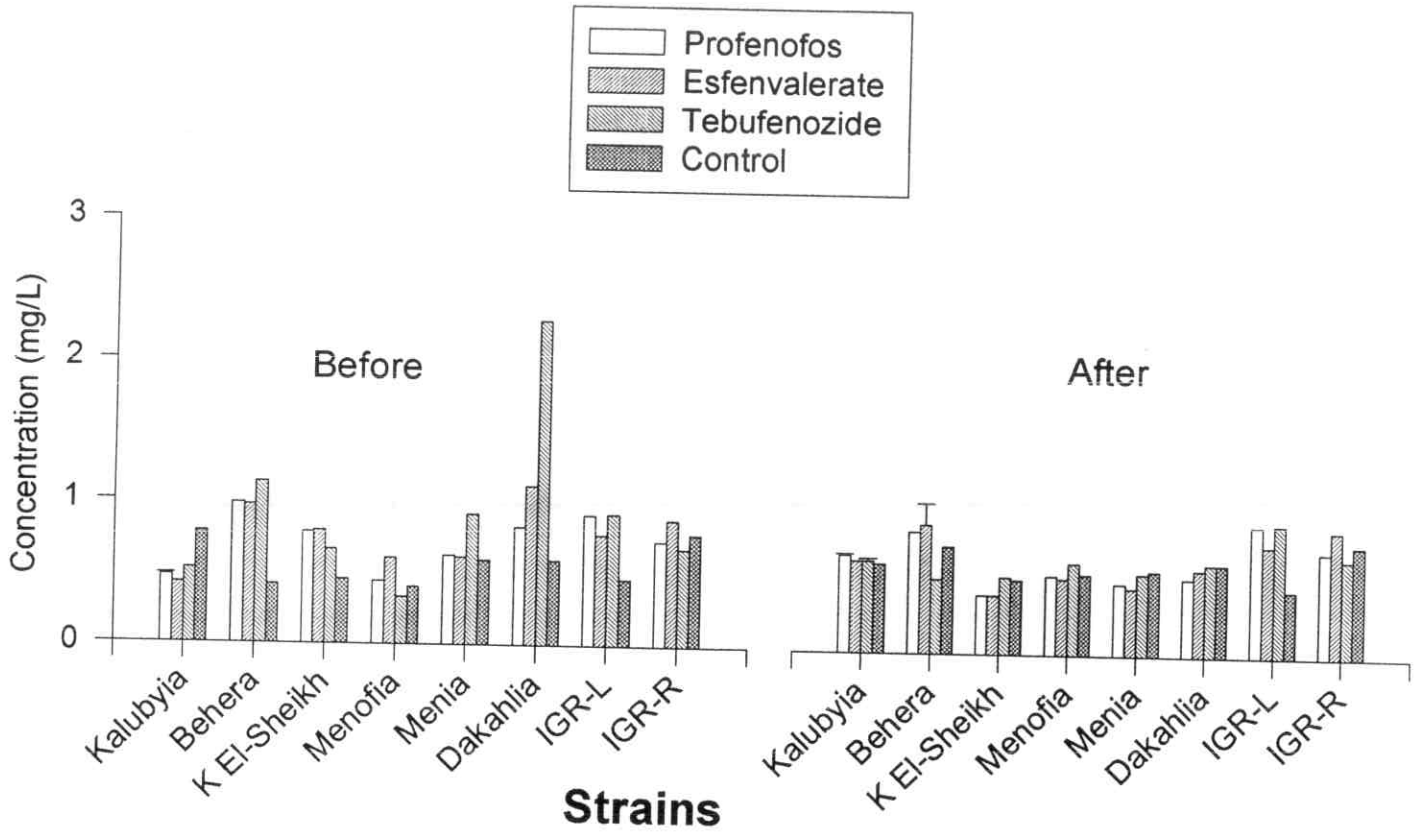


Fig. (22): Changes in total protein of *S.littoralis* field strains larvae representing early and late season compared with IGR-L and IGR-R strains at 24 h posttreatment with certain insecticides.

where the treatment with the OP and pyrethroid insecticides gave great increase in total protein of the larvae collected before spraying season and decrease in total protein of the larvae collected after spraying season. The IGR at 24 hour after application caused an increase in total protein of both collected larvae.

The effect of insecticides treatment on the protein content of Behera strain revealed that the tested OP and pyrethroid insecticides gave a variable increase in protein content of the larvae collected before and after spraying season and the increase was more pronounced in insects collected before spraying season. On the other hand, the tested IGR when applied for 24 hours caused a great increase in the protein content of the larvae of early season and great reduction in the larvae of late season. The opposite trend was obtained when the insecticide was applied for 48 hours.

Regarding Menia strain all tested insecticides caused variable increase on the total protein of the larvae collected before spraying season and gave a variable decrease on protein content of larvae collected after spraying season while the IGR compound when applied for 48 hours caused a decrease in total protein of larvae collected before and after spraying season.

The effect of the tested insecticides on the total protein of IGR-resistant and IGR-laboratory larvae revealed that all the tested compounds caused increases in the level of protein of L-larvae compared to control without any exception. While in the case of IGR-R larvae the treatment caused reduction in their protein concentration with exception to the pyrethroid which gave an increase in the protein

content, and the IGR when applied for 48 hours it caused increase in total protein.

The decrease in total protein in some tested strains specially of that collected after spraying season due to insecticides treatment was agree with that found by **Ahmed and Mostafa (1989)** when they studied the action of triflumuron and chlorfluazuron on the 4th larval instar of *S. littoralis* . They found that the haemolymph proteins and free amino acids decrease after insecticides treatment. Also, **Bakr, *et al.* (1991)** reported that the total protein of larvae and pupae of *M. domestica* treated with Dimilin and Bay SIR8514 was less than those of the normal ones allover the larval and pupal periods. The reduction in total protein as a result of insecticides poisoning was also found by **Ahmed (2001)** on the cotton leafworm.

Saleem and Shakoori (1985) studied the effects of sublethal doses of permethrin or deltamethrin on some biochemical components of 6th-instar larvae of the tenebrionid *Tribolium castaneum.* Permethrin at 20 p.p.m. led to a significant reduction in soluble proteins and free amino acids, while DNA contents were elevated significantly. Deltamethrin resulted in decreased glycogen and increased free amino acids, urea and DNA contents. Other components remained unchanged. It is concluded that deltamethrin produced more macromolecular abnormalities than did permethrin at the same dose level.

The inhibition of total proteins synthesis as a result of IGR's treatment may be due to the effect of these compounds on the enzyme of DNA synthesis (**Mitlin *et al.*, 1977** and **Deloach *et al.*, 1981**). **Ferkovich *et al.* (1981)** supported this concept in *G. mellonella*, they found that 20-hydroxyecdysone stimulated chitin production requires

the synthesis of RNA and protein. They added that there were new proteins synthesized by imaginal wing discs incubated with 20-hydroxyecdysone. The function of which is unknown but they could include cuticle structural proteins, chitin synthetase or the activator of that enzyme.

The changes in protein metabolism in the haemolymph and fat body of 5th-instar larvae of *B.mori* following exposure to sublethal concentrations of fenitrothion and ethion were studied by **Nath *et al.* (1997)**. The total protein content showed a depletion followed by an increase in free amino acids. The activity of proteinases in both tissues also increased at the same time. An increase in the activities of GPT and GOT paralleled the elevation of glutamate dehydrogenase activity in all the tissues studied. All changes clearly indicated a severe proteolysis and transamination of amino acids.