IV. RESULTS

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1- Susceptibility levels of *Culex pipiens* larvae to certain insecticides and insect growth regulators :

1.1. Insecticides .

Data of the insecticidal activities of the organophosphates sumithion, diazinon and dursban, the carbamate propoxur and the synthetic pyrethroids sumicidin and permethrin against the 3rd instar larvae of *Culex pipiens* which were collected from two geographical areas and tested under laboratory conditions are presented in the tables (Tables 1- 16) and shown graphically in the figures (Figs. 1- 13) .

1.1.1. Miet El-Attar strain :

Results of susceptibility measurements of the larvae of *Culex pipiens* of Miet El-Attar strain to certain insecticides are presented in the tables (Tables 1- 8) and shown graphically in the figures (Figs. 1 - 6) .

Data presented in table (Table 1) and the figure (Fig. 1) show that the response of larvae to sumithion is represented by a straight line indicating homogeneity of population in its response to the toxicant . The median lethal concentration (Lc_{50}) is 0.015 ppm regarding low value . Complete kill of the larvae was obtained at 0.1 ppm . The larvae of *Culex pipiens* of Miet El-Attar population proved quite susceptible to sumithion on the basis of the low value of its Lc_{50} and the slope function of the regression line .

Results presented in the table (Table 2) and the figure (Fig. 2) show that this strain of ***Culex pipiens*** larvae is relatively low susceptibility level to diazinon . This is evident from the relatively high value of its Lc_{50} (0.26 ppm) . However, the response of the larvae to diazinon concentrations is homogeneous as evident from straight regression line and the low level of the slope function (2.16) . Complete mortality of larvae was occurred at 5 ppm .

Data presented in the table (Table 3) and the figure (Fig.3) revealed that this strain of ***Culex pipiens*** larvae is highly susceptible to dursban . This is evident from the low value of the Lc_{50} (0.0016 ppm) . The population is homogeneous in its response to the toxicant on the basis of the moderately low level of slope function (2 .4) . Complete mortality was occurred at concentration of 0.007 ppm .

From the table (Table 4) and the figure (Fig.4) this strain of *Culex pipiens* larvae is relatively of lower susceptibility to baygon than other insecticides . This is evident from its Lc_{50} value (0.20 ppm) . The population is less homogeneous in its response to the toxicant on the basis of the moderately high level of the slope function (4.33) . Complete mortality was occurred at a concentration above 1.99 ppm .

Data presented in the table (Table 5) and the figure (Fig.5) show that this strain is highly susceptible to sumicidin, although the population is of lower homogeneity in its response to the toxicant than other insecticides on basis of the relatively high level of the slope function (6.33) . However, the median lethal concentration (Lc_{50}) was of low value of 0.002 ppm and complete mortality occurred at a concentration higher than 0.01 ppm

It is shown from the table (Table 6) and the figure (Fig.6) that the larval population of *Culex pipiens* of Miet El-Attar area is highly susceptible to permethrin and the response of the larvae to the action of the insecticide is rather homogeneous on basis of the low value of the Lc_{50} (0.0018 ppm) and the slope function (2.11) . Complete mortality was occurred at a concentration of 0.01 ppm .

The summerized data presented in the table (Table 7) indicate that the insecticides tested appear highly effective against this strain of ***Culex pipiens*** larvae . Their activities range between susceptible to vigour tolerance . On the basis of their Lc_{50} values, the efficiency of the tested chemical insecticides could be arranged in the following order .

dursban > permethrin > sumicidin > sumithion > bagyon > diazinon .

Further support of the previous results could be obtained from the results of superior potency which depends mainly on the insecticide activity ratios or comparative insecticidal activities . The calculated results of potency are tabulated in the table (Table 8) .

It is apparant that the potencies of the insecticides tested showed a superior efficiency of dursban on this strain of ***Culex pipiens*** larvae followed by permethrin, sumicidin, sumithion, baygon and diazinon, respectively . The results indicated a negligible development of resistance to any of the insecticides tested or the appearance of heterogeneous response of the individuals to the action of the insecticides tested .

Table (1) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to sumithion .

Concentration (ppm)	Average mortality (%) *$\overline{X}$ ± SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.0010	0.0 ± 0.0	0.015	0.07	2.59
0.0025	2.7 ± 0.33			
0.0050	10.7 ± 0.33			
0.0100	29.3 ± 0.88			
0.0200	60.0 ± 1.16			
0.0250	81.3 ± 0.67			
0.0500	86.7 ± 0.88			
0.1000	100 ± 0.0			
control	0.0			

Table (2) : Susceptibility of *Culex pipiens* larvae of Miet El- Attar population to diazinon .

Concentration (ppm)	Average mortality (%) *$\overline{X}$ ± SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.05	0.0 ± 0.0	0.26	0.96	2.16
0.10	9.3 ± 0.67			
0.25	48.0 ± 1.16			
0.50	85.3 ± 0.88			
1.00	94.7 ± 0.88			
5.00	100 ± 0.0			
control	0.0			

* Each value represents the mean of three replicates (25 larvae) ± standard error.

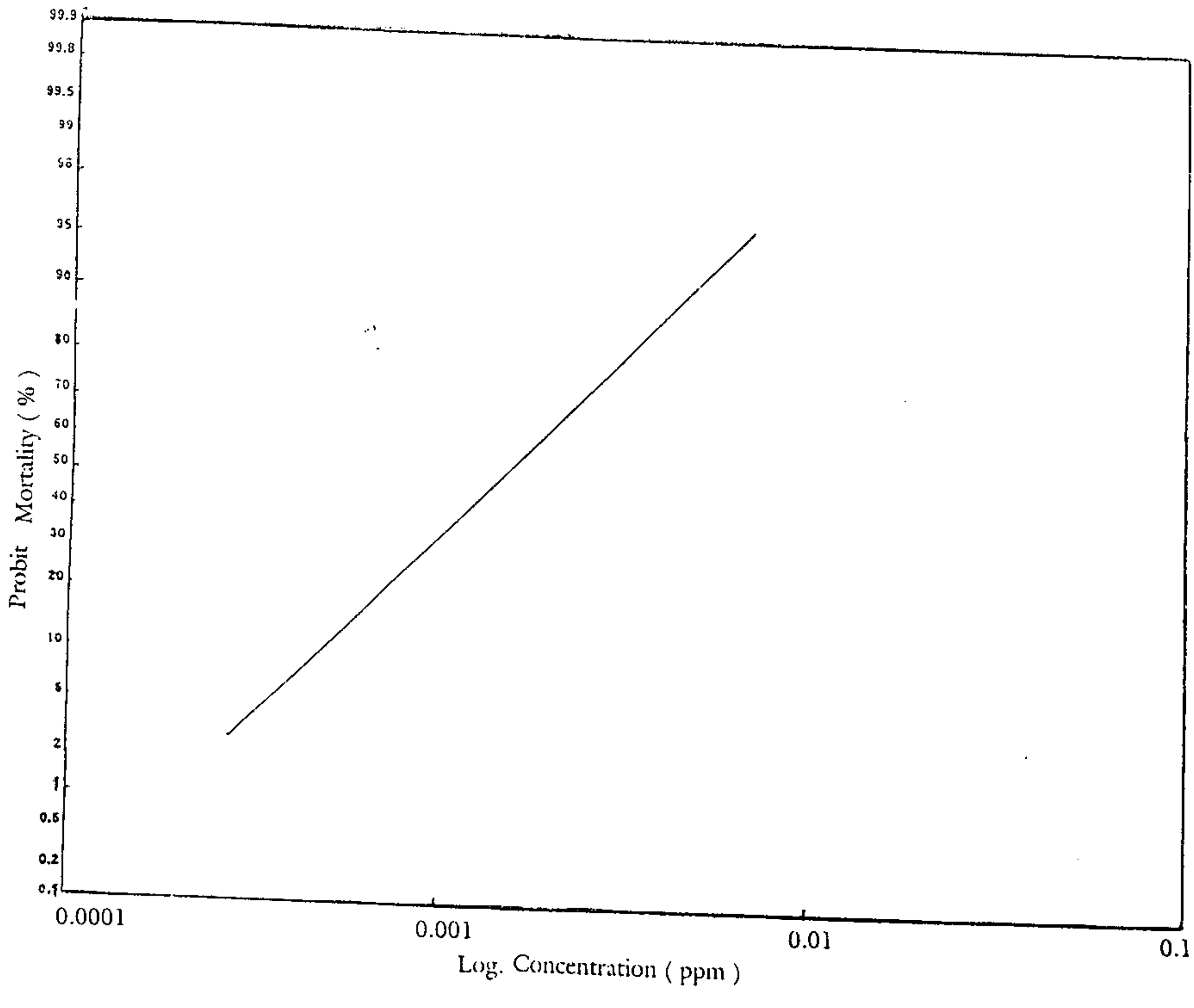

Fig. (1) : Log.– concentration probit mortality regression line of the 3rd instar larvae of ***Culex pipiens*** (Miet El-Attar strain) to sumithion .

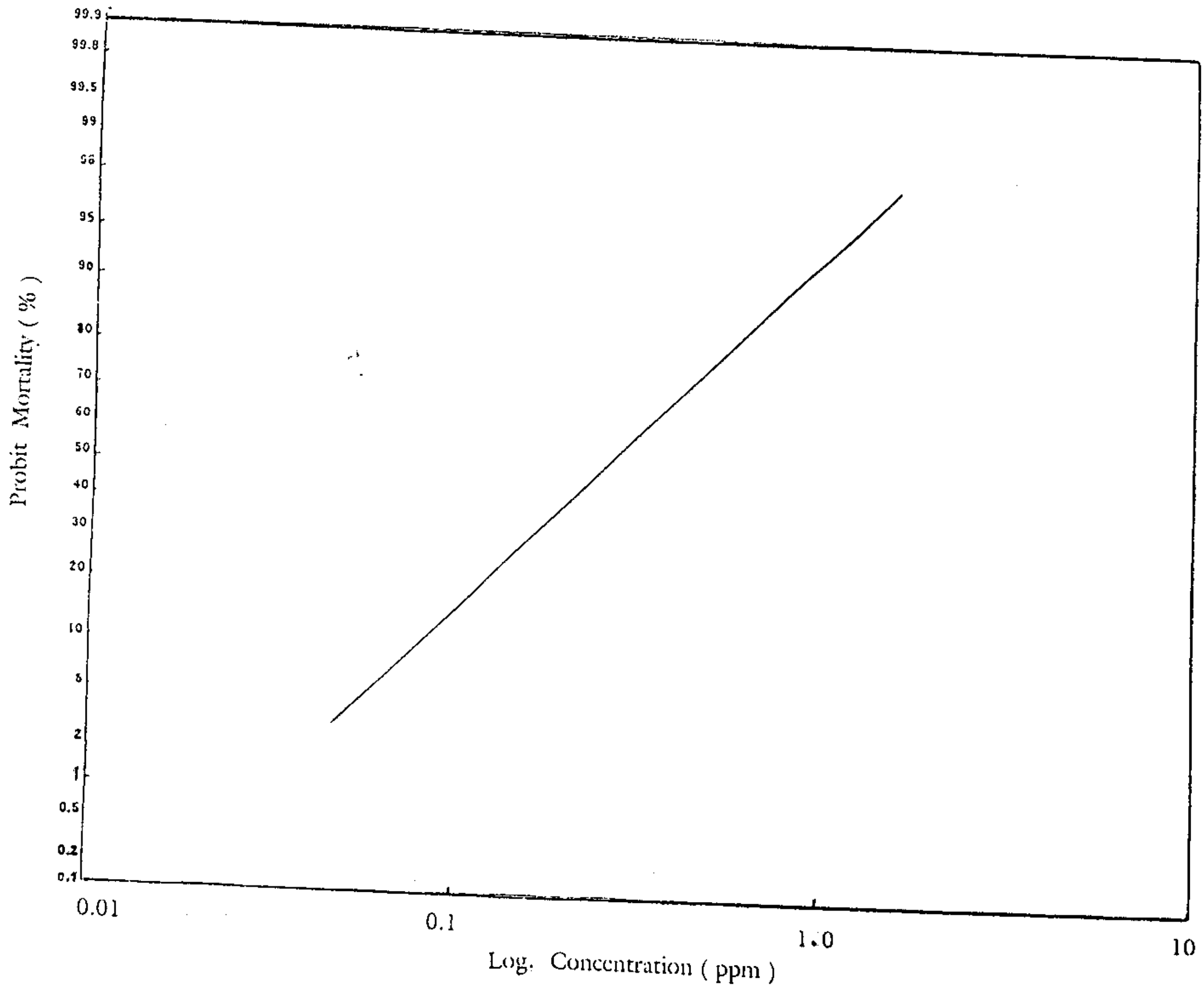

Fig. (2) : Log -concentration probit mortality regression line of the 3rd instar larvae of *Culex pipiens* (Miet El-Attar strain) to diazinon .

Table (3) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to dursban .

Concentration (ppm)	Average mortality (%) *$\overline{X} \pm SE$	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.0005	2.7 ± 0.33	0.0016	0.0095	2.4
0.0010	37.3 ± 0.88			
0.0030	70.7 ± 1.46			
0.0050	94.7 ± 0.67			
0.0070	100 ± 0.0			
control	1.3			

Table (4) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to baygon .

Concentration (ppm)	Average mortality (%) *$\overline{X} \pm SE$	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.1	30.7 ± 0.88	0.20	1.99	4.33
0.2	54.3 ± 0.88			
0.6	77.3 ± 0.67			
0.8	84.0 ± 0.85			
1.9	94.7 ± 1.34			
control	0.0			

* Each value represents the mean of three replicates (25 Larvae) ± standard error .

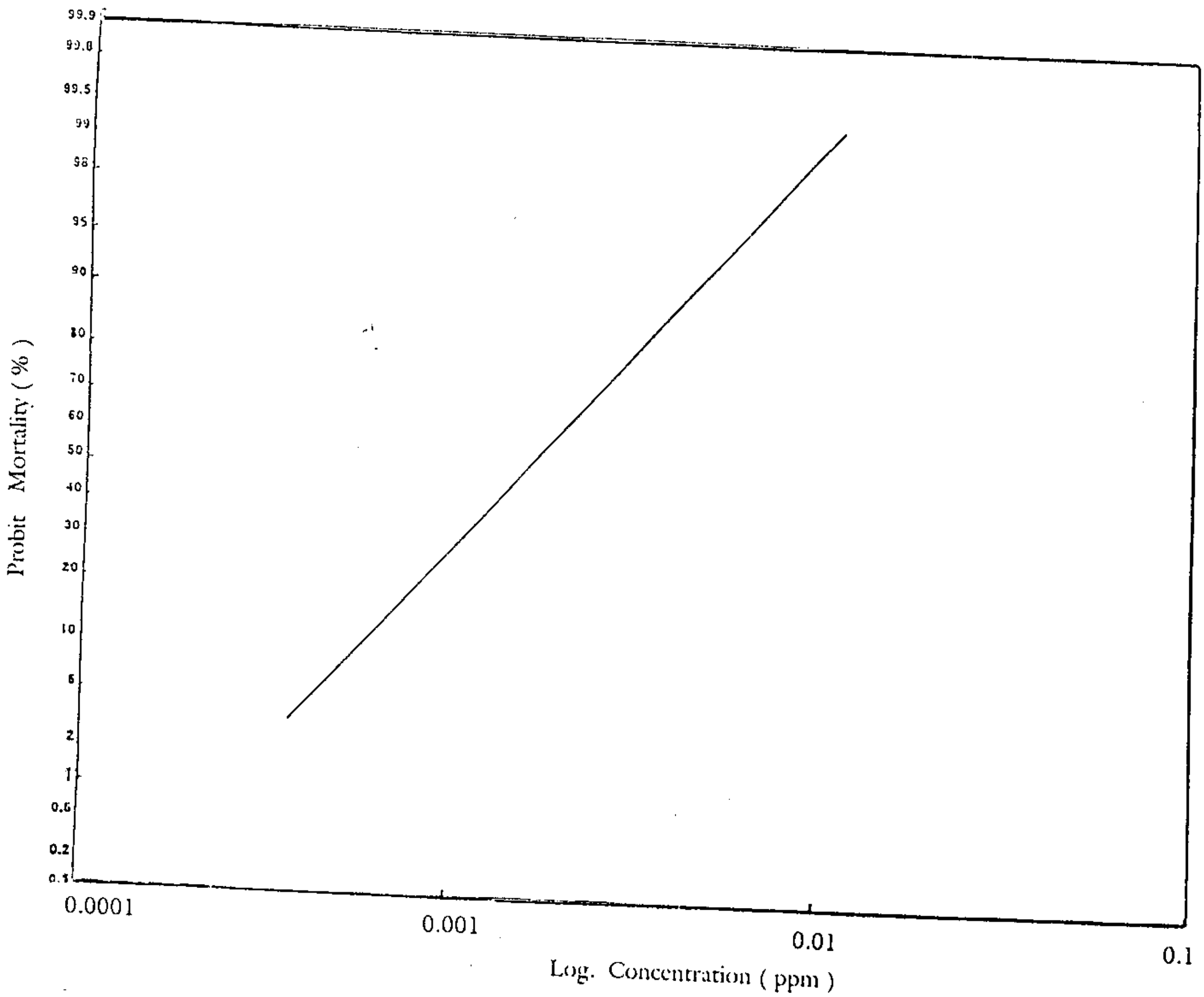

Fig. (3) : Log . concentration probit mortality regression line of the 3rd instar larvae of *Culex pipiens* (Miet El-Attar strain) to dursban .

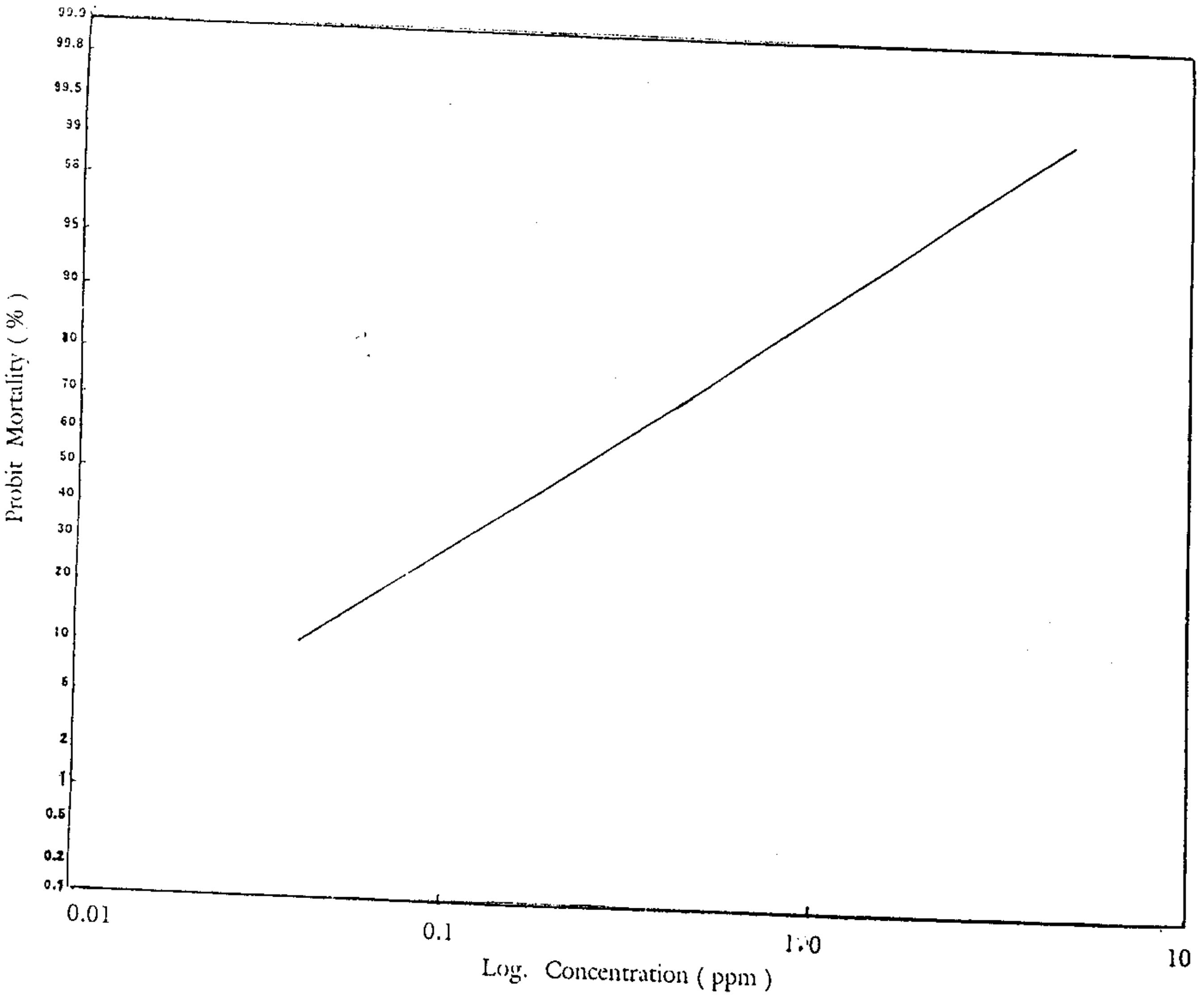

Fig. (4) : Log. concentration probit mortality regression line of the 3rd instar larvae of ***Culex pipiens*** (Miet El-Attar strain) to baygon .

Table (5) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to sumicidin.

Concentration (ppm)	Average mortality (%) *$\overline{X} \pm SE$	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.000025	1.3 ± 0.33			
0.000250	8.0 ± 0.58			
0.001000	37.3 ± 1.20	0.002	0.04	6.33
0.005000	73.3 ± 0.88			
0.010000	80.0 ± 0.16			
control	0.0			

Table (6) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to permethrin .

Concentration (ppm)	Average mortality (%) *$\overline{X} \pm SE$	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.0001	0.0 ± 0.0			
0.0005	6.7 ± 0.67			
0.0010	22.7 ± 0.88	0.0018	0.0071	2.11
0.0025	68.0 ± 1.0			
0.0050	88.0 ± 0.16			
0.0100	100 ± 0.0			
control	0.0			

* Each value represents the mean of three replicates (25 Larvae) ± standard error .

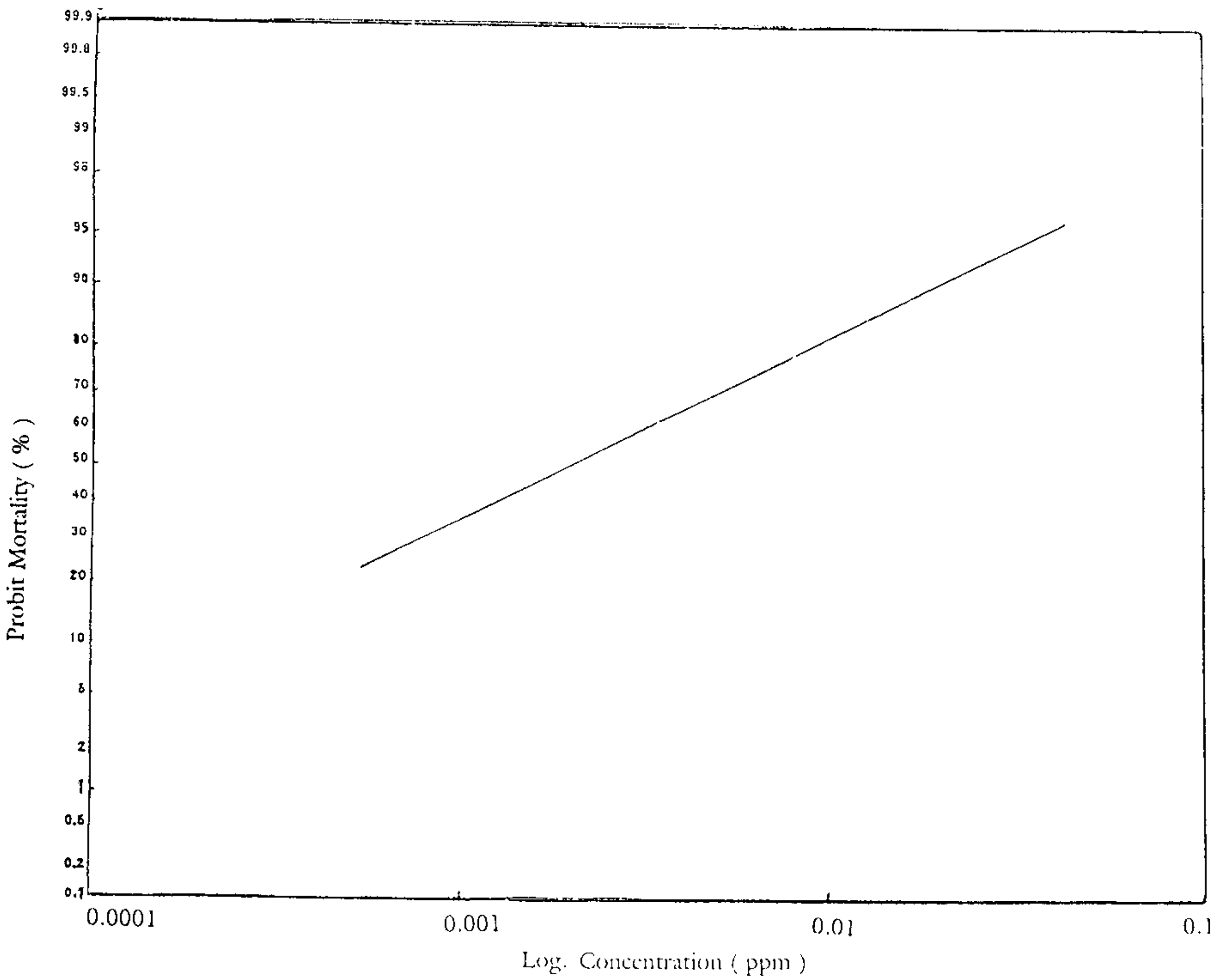

Fig. (5) : Log . concentration probit mortality regression line of the 3rd instar larvae of *Culex pipiens* (Miet El-Attar strain) to sumicidin .

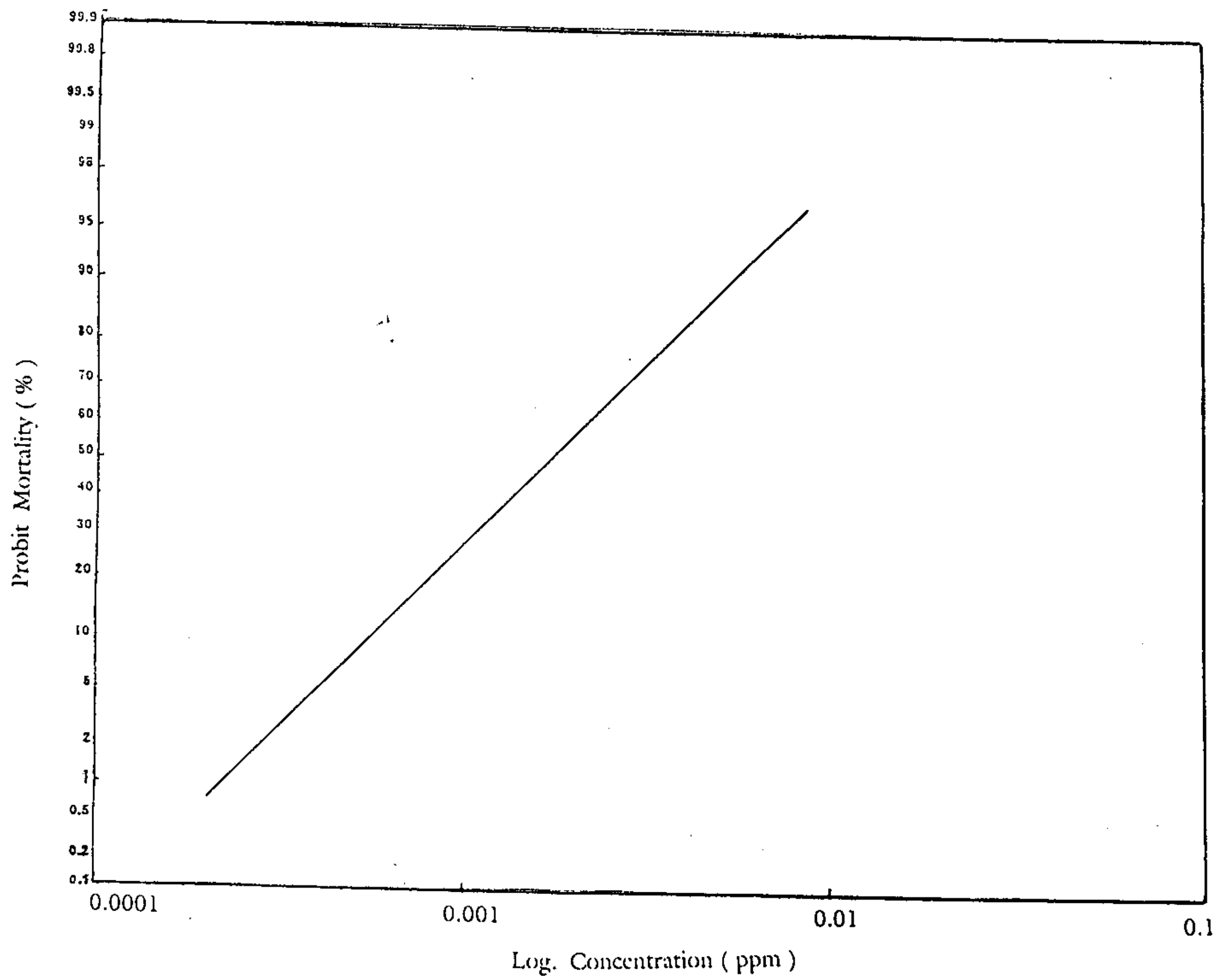

Fig. (6) : Log. concentration probit mortality regression line of the 3rd instar larvae of *Culex pipiens* (Miet El-Attar strain) to permethrin .

Table (7) : Patterns of susceptibility of ***Culex pipiens*** larvae of Miet El-Attar strain to certain chemical insecticides under laboratory conditions .

Insecticide (Group)	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
Dursban (OP.)	0.0016	0.0056	2.40
Permethrin (Pyr.)	0.0018	0.0071	2.11
Sumicidin (Pyr.)	0.0020	0.0400	6.33
Sumithion (OP.)	0.0150	0.0700	2.59
Baygon (Ca.)	0.2000	1.9900	4.33
Diazinon (OP.)	0.2600	0.9600	2.16

Table (8) : Comparative insecticidal activity of certain insecticides against *Culex pipiens* larvae (Miet El-Attar) .

Insecticide	Lc_{50} (ppm)	Relative potency based on					
		Sumithion	**Diazinon**	**Dursban**	**Baygon**	**Sumicidin**	**Permethrin**
Sumithion	0.0150	01.00	0.058	009.372	0.075	007.5	008.33
Diazinon	0.2600	17.33	1.000	162.500	1.300	130.0	144.40
Dursban	0.0016	00.11	0.006	001.000	0.008	000.8	000.88
Baygon	0.2000	13.33	0.769	125.000	1.000	100.0	111.11
Sumicidin	0.0020	00.13	0.008	001.250	0.010	001.0	001.11
Permethrin	0.0018	00.12	0.007	001.125	0.009	000.9	001.00

1.1.2. El-Saygh strain :

Series of insecticide susceptibility tests were carried out on larvae of *Culex pipiens* of field strain of El-Saygh to six insecticides from different groups .

The results of susceptibility measurements are presented in the tables (Tables 9-16) and shown graphically in the figures (Figs. 7 : 13) .

It is evident from the table (Table 9) and the figure (Fig .7) that the response of *Culex pipiens* larvae to sumithion is represented by a straight probit-regression line with a relatively low slope function indicating homogeneous response of the larvae to the concentrations tested . The median lethal concentration (Lc_{50}) was estimated 0.011 ppm. Complete kill of the tested larvae was obtained at about 0.25 ppm . This indicates that the strain is quite susceptible to sumithion insecticide .

The larvae of *Culex pipiens* were also tested for susceptibility to diazinon insecticide . The obtained data are represented in the table (Table 10) and shown graphically in the figure (Fig . 8) .

From the table and the figure it is evident that the larval population of *Culex pipiens* of El-Saygh is less susceptible to diazinon than sumithion regarding from Lc_{50} value and relatively high values of slope function . However, the response of the larvae to diazinon is represented by a straight probit-regression line indicating homogeneity . The Lc_{50} was found 0.37 ppm . Complete kill of larvae occurred at 5 ppm diazinon .

The larvae of *Culex pipiens* of El-Saygh population were tested with the dursban insecticide . The results of the susceptibility tests are presented in the table (Table 11) and shown graphically in the figure (Fig .9) .

It is evident from the table and the figure that the larval population of *Culex pipiens* in this area is highly susceptible to dursban . This may attribute to the low value of the Lc_{50} (0.0017 ppm) and the slope function (2.43) . The response of the larvae to the insecticide is representing by a straight regression line indicating homogeneity . Complete mortality may occur at a concentration less than 0.01 ppm .

The larvae of *Culex pipiens* were tested with baygon for susceptibility . The obtained data are presented in the table (Table 12) and shown graphically in the figure (Fig . 10) .

It is evident from the table and the figure that the larval population of *Culex pipiens* of El-Saygh strain is also susceptible to baygon . The response of the larvae to baygon concentrations is represented by a straight probit-regression line indicating homogeneity . The slope function is of low value being 1.38 . The Lc_{50} is 0.63 ppm and complete moraltity of larvae occurred at a concentration higher than 1ppm .

Another test was carried out on the larvae of El-Saygh strain using sumicidin insecticide . The obtained data are presented in the table (Table 13) and shown graphically in the figure (Fig. 11) .

From the presented data, it is evident that the larvae of El-Saygh strain are also susceptible to sumicidin . This is proved from the low value of the Lc_{50} (0.0006 ppm) and the response of larvae to sumicidin concentrations is represented by a straight line indicating homogeneity .

Complete mortality was occurred at a concentration higher than 0.01 ppm .

From the table (Table 14) and the figure (Fig. 12) it is evident that the response of *Culex pipiens* larvae to permethrin is represented by a straight probit-regression line with low value of slope function (2.25) indicating that this population is mostly homogeneous in its response to permethrin concentrations . The median lethal concentration (Lc_{50}) was measured 0.003 ppm and complete kill of larvae was obtained at about 0.01 ppm. This indicates that this strain is susceptible to permethrin .

On the basis of the Lc_{50} values (Table 15) sumicidin proved the most effective, followed by dursban, permethrin, sumithion, diazinon and baygon .

When the activities of these insecticides were compared (Table 16) the relative potencies of the insecticides revealed that the pyrethroid sumicidin has a superior efficiency followed by the organophosphorous durshban, the pyrethroid permethrin, the organophosphorous sumithion and diazinon and then the carbamate baygon has inferior or the lesser activity .

These findings strongly recommend these insecticides to be used as effective larvicidal agent against the larvae of ***Culex pipiens*** in El-Saygh area . No much differences in their activities are found between these insecticides .

In comparison the susceptibility levels of Miet El-Attar and El-Saygh strains of *Culex pipiens* larvae to the tested chemical insecticides, are more or less similar in their susceptibilities . Both strains are highly susceptible to the insecticides tested . No evidence of development of resistance was detected .

However, Miet El-Attar strain appeared slight more susceptible to diazinon, baygon, and permethrin than El-Saygh strain . In contrast this strain is slight less susceptible to sumithion and sumicidin than El-Saygh strain .

Both strains are almost equally susceptible to dursban insecticide (Table 17 and Fig. 13) .

Table (9) : Susceptibility of *Culex pipiens* larvae of El-Saygh population to sumithion .

Concentration (ppm)	Average mortality (%) *$\overline{X}$ ± SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.0025	08.0 ± 0.58	0.011	0.063	2.74
0.0050	29.3 ± 0.68			
0.0100	37.3 ± 1.20			
0.0250	88.0 ± 0.58			
0.0500	90.7 ± 1.34			
0.2500	100 ± 0.00			
control	0.0			

Table (10) : Susceptibility of *Culex pipiens* larvae of El-Saygh population to diazinon .

Concentration (ppm)	Average mortality (%) *$\overline{X}$ ± SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.05	00.0 ± 0.00	0.37	2.38	4.66
0.10	06.7 ± 0.68			
0.20	40.0 ± 1.16			
0.50	80.0 ± 0.58			
1.00	90.7 ± 0.88			
control	2.7			

* Each value represents the mean of three replicates (25 Larvae) ± standard error .

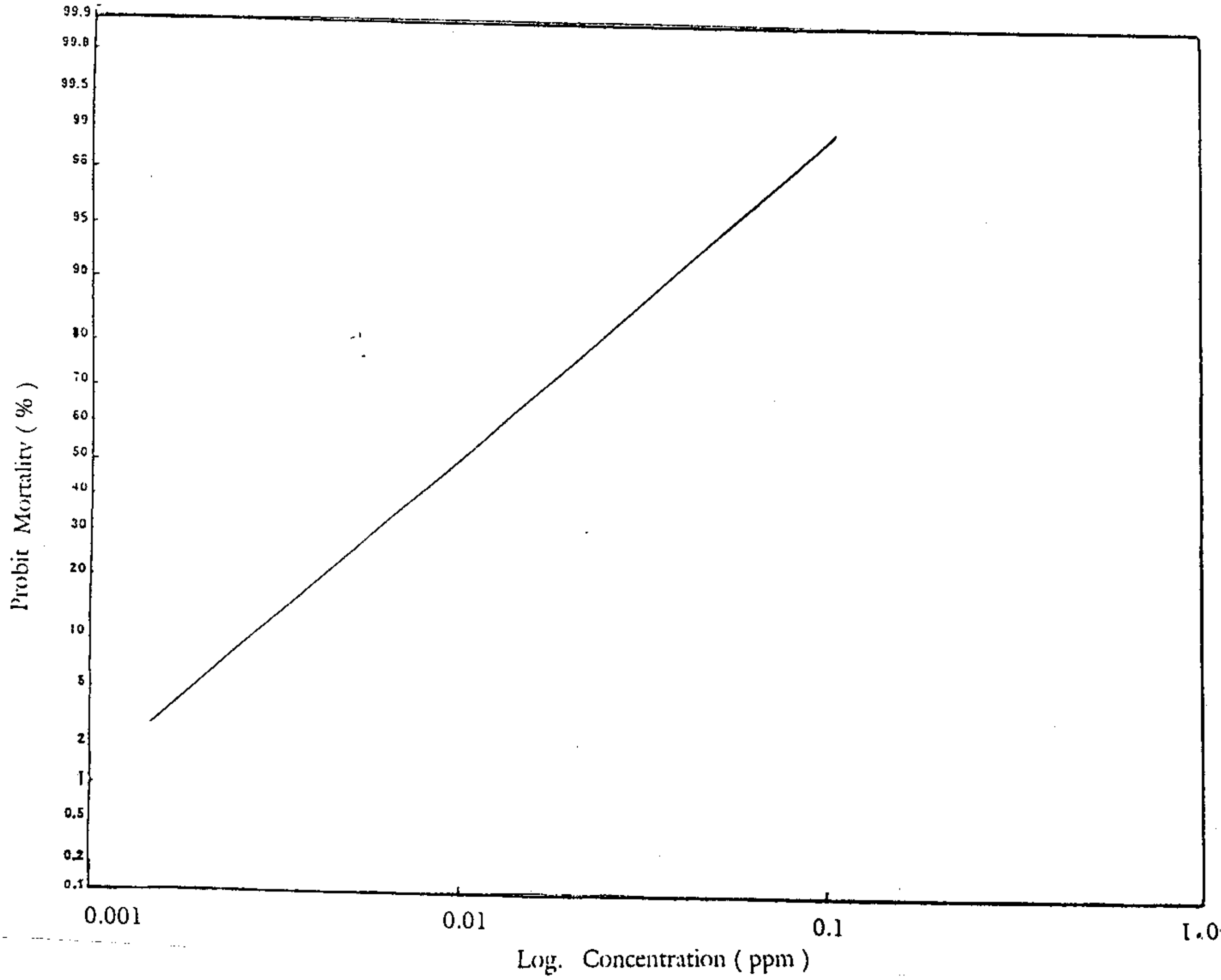

Fig. (7) : Log. concentration probit mortality regression line of the 3rd instar larvae of ***Culex pipiens*** (EL-Saygh strain) to sumithion .

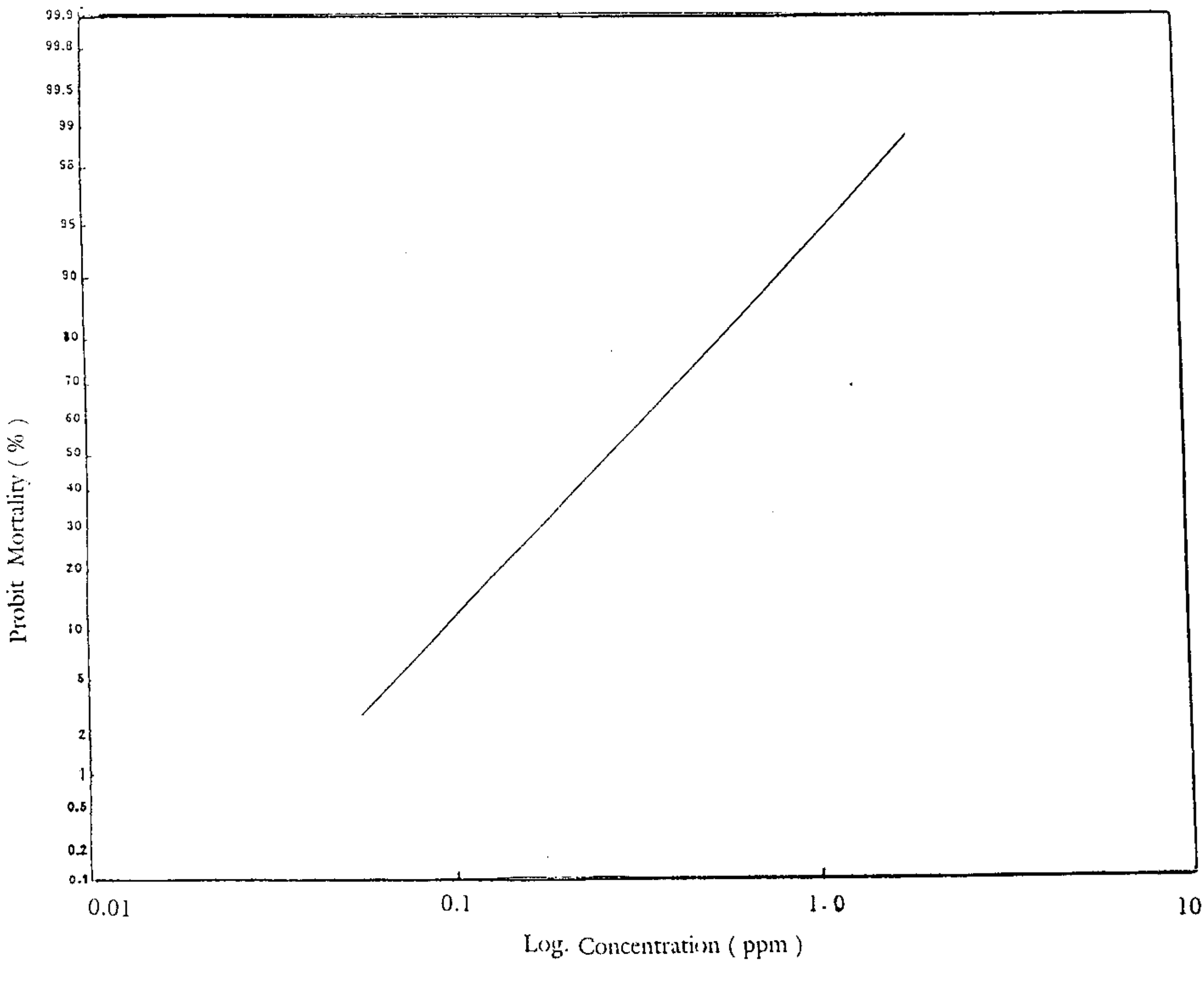

Fig. (8) : Log. concentration probit mortality regression line of the 3rd instar larvae of ***Culex pipiens*** (EL-Saygh strain) to diazinon .

Table (11) : Susceptibility of ***Culex pipiens*** larvae of El-Saygh population to dursban .

Concentration (ppm)	Average mortality (%) *$\overline{X}$ ± SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.0005	00.0 ± 0.00	0.0017	0.007	2.43
0.0007	16.0 ± 0.58			
0.0010	32.0 ± 1.16			
0.0030	64.0 ± 1.73			
0.0050	89.3 ± 1.20			
control	0.0			

Table (12) : Susceptibility of ***Culex pipiens*** larvae of El-Saygh population to baygon .

Concentration (ppm)	Average mortality (%) *$\overline{X}$ ± SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.5	22.7 ± 0.67	0.63	1.08	1.38
0.6	47.0 ± 0.88			
0.8	76.7 ± 1.20			
0.9	84.0 ± 0.58			
1.0	92.0 ± 1.53			
control	0.0			

* Each value represents the mean of three replicates (25 Larvae) ± standard error .

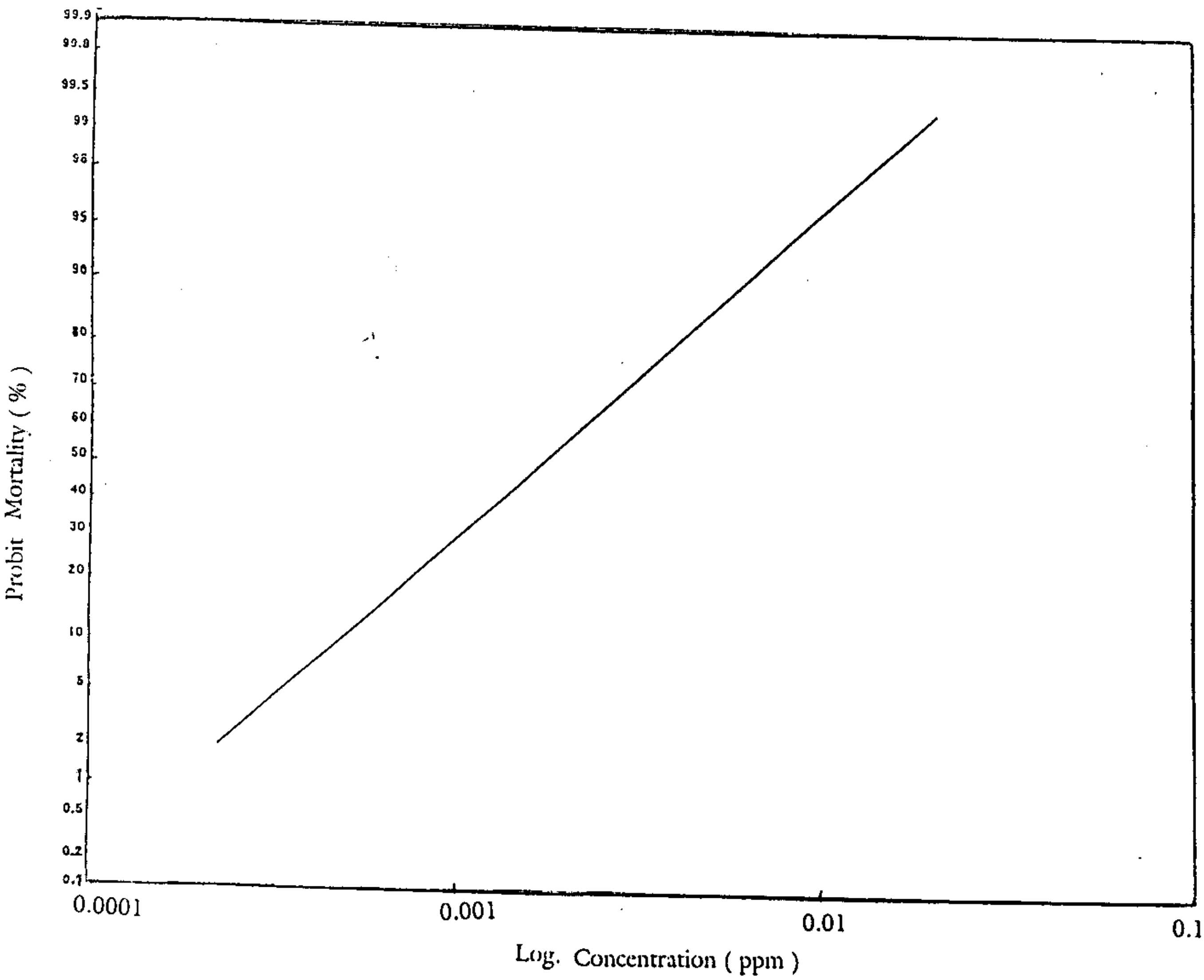

Fig. (9) : Log. concentration probit mortality regression line of the 3rd instar larvae of ***Culex pipiens*** (EL-Saygh strain) to dursban.

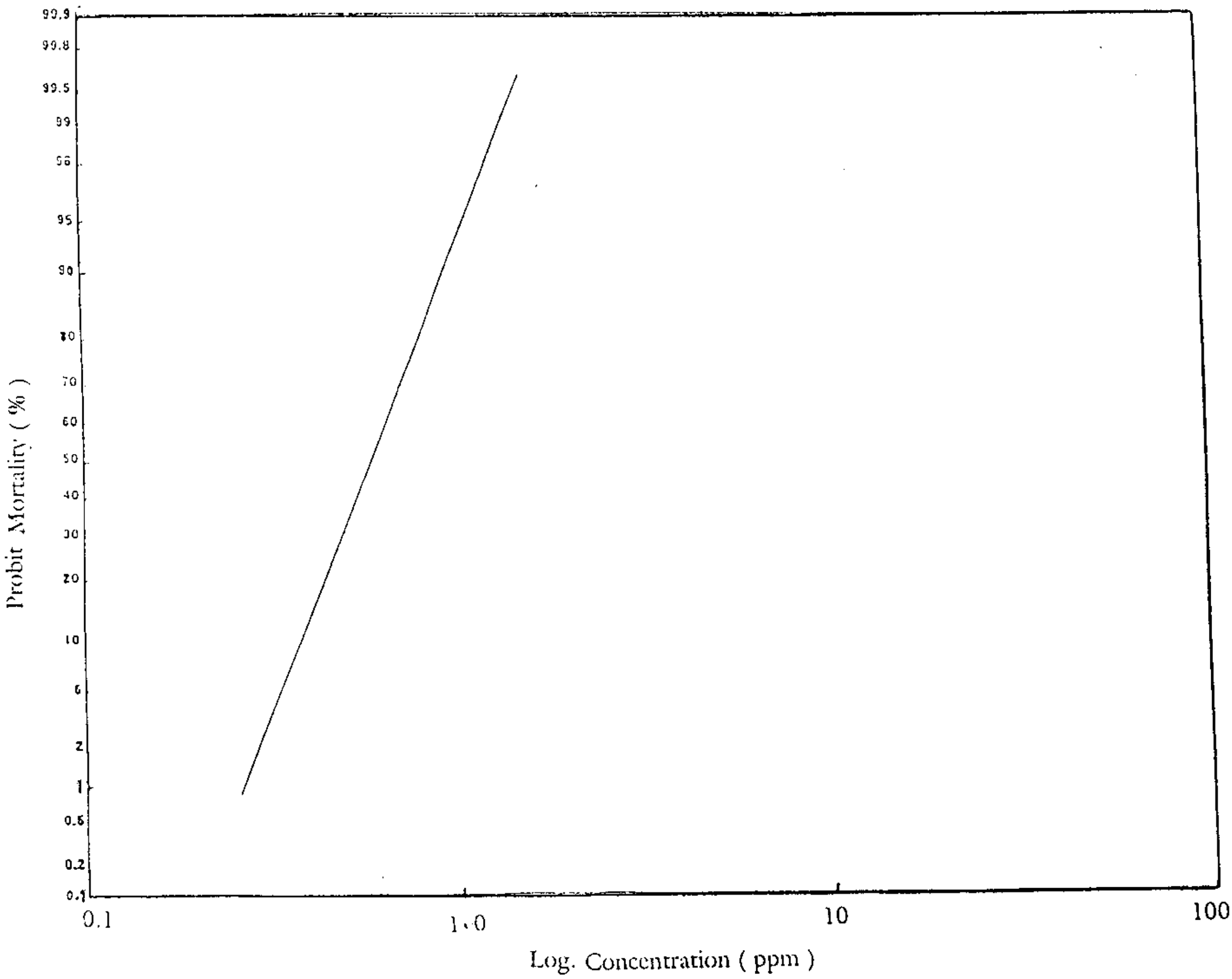

Fig. (10) : Log. concentration probit mortality regression line of the 3rd instar larvae of *Culex pipiens* (EL-Saygh strain) to baygon .

Table (13) : Susceptibility of ***Culex pipiens*** larvae of El-Saygh population to sumicidin .

Concentration (ppm)	Average mortality (%) *$\overline{X} \pm$ SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.000025	08.0 ± 0.58	0.0006	0.04	10.84
0.000250	29.3 ± 0.67			
0.001000	65.3 ± 1.46			
0.005000	80.0 ± 0.58			
0.010000	85.0 ± 0.67			
control	0.0			

* Each value represents the mean of three replicates (25 Larvae) ± standard error .

Table (14) : Susceptibility of ***Culex pipiens*** larvae of El-Saygh population to permethrin .

Concentration (ppm)	Average mortality (%) *$\overline{X} \pm$ SE	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
0.0005	02.7 ± 0.33	0.003	0.01	2.25
0.0010	17.3 ± 0.67			
0.0025	48.0 ± 1.16			
0.0050	70.7 ± 0.88			
0.0100	97.3 ± 0.67			
control	1.3			

* Each value represents the mean of three replicates (25 Larvae) ± standard error .

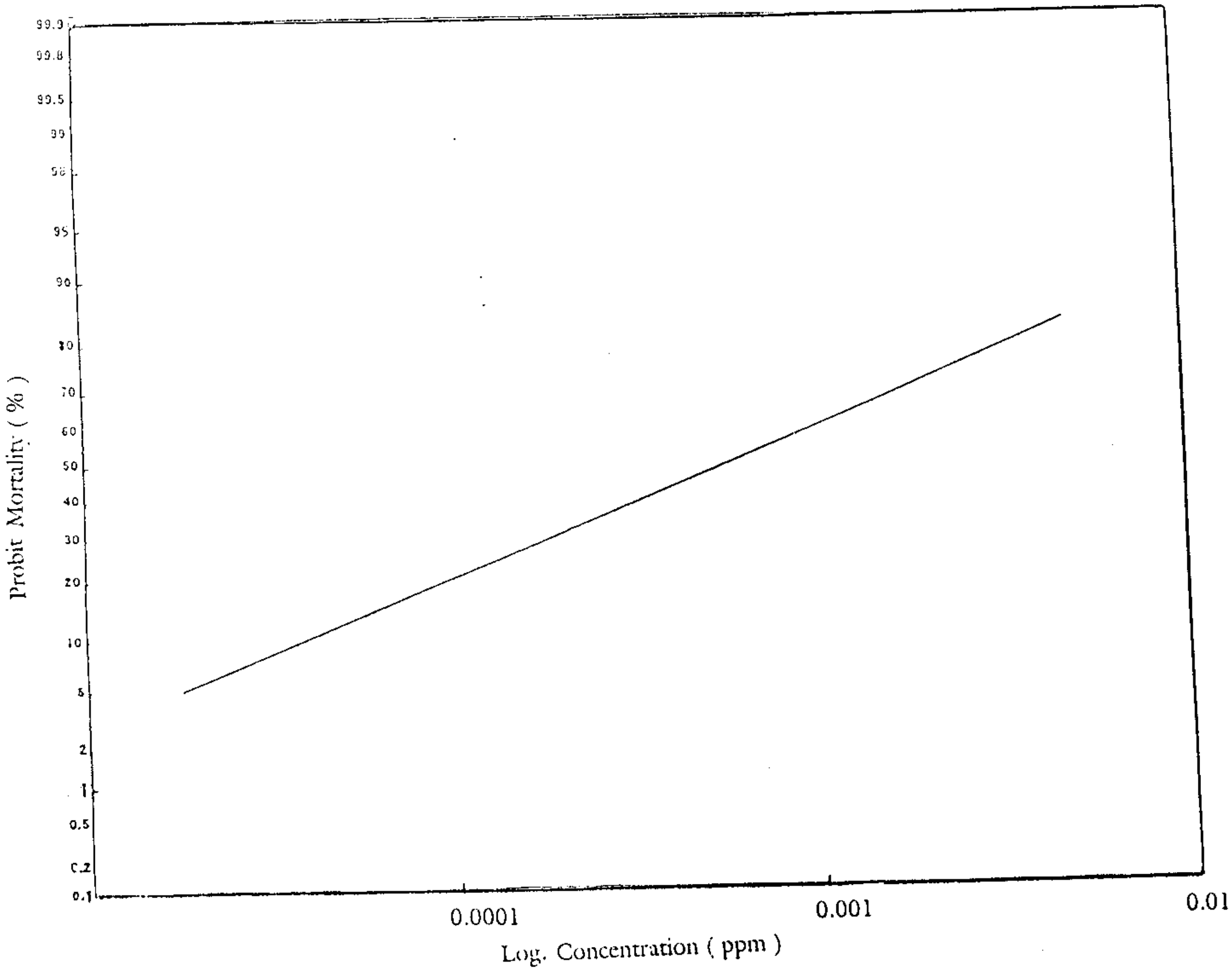

Fig. (11) : Log. concentration probit mortality regression line of the 3rd instar larvae of *Culex pipiens* (EL-Saygh strain) to sumicidin .

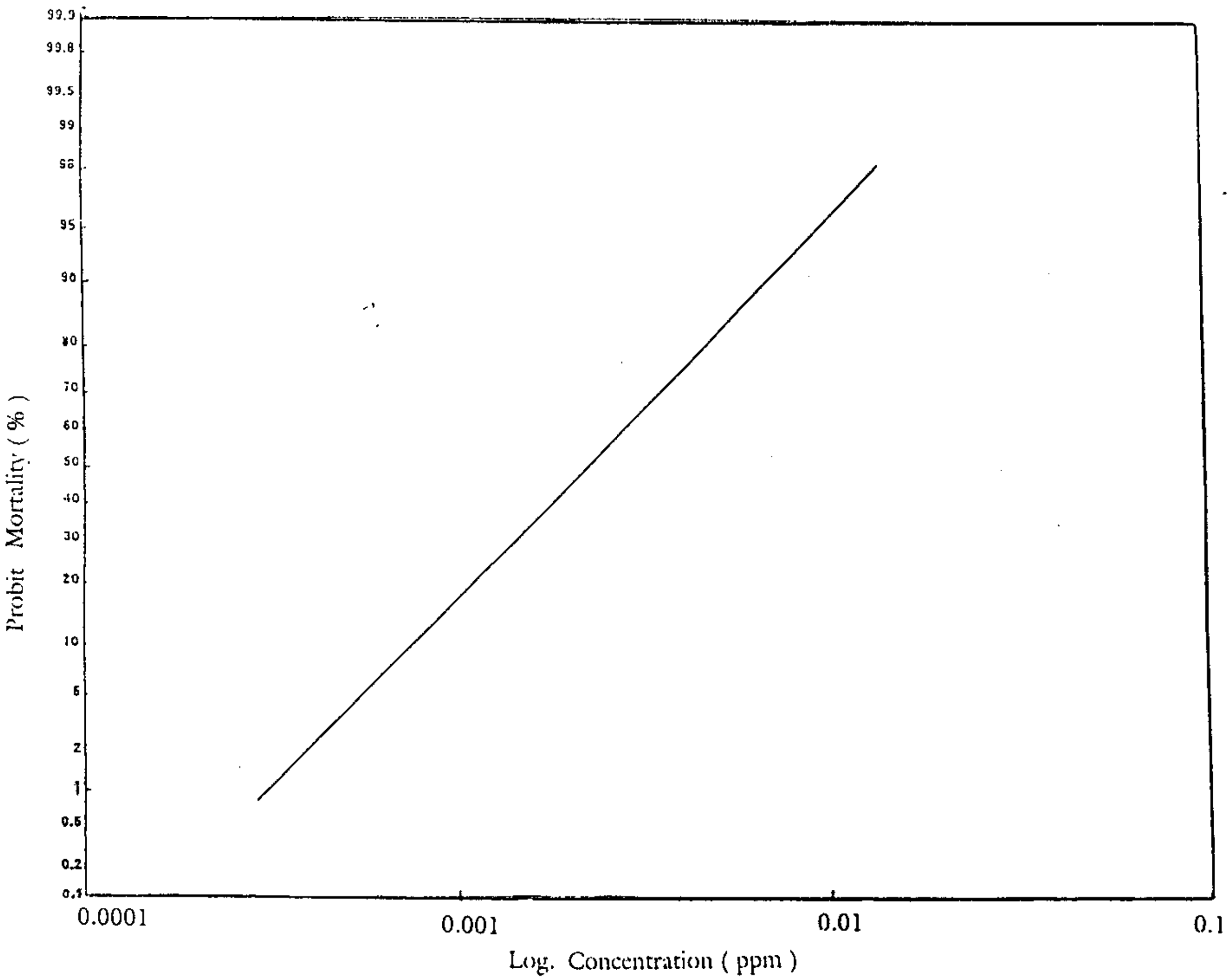

Fig. (12) : Log-concentration probit mortality regression line of the 3rd instar larvae of ***Cluex pipiens*** (El-Saygh strain) to permethrin .

Table (15) : Susceptibility of *Culex pipiens* larvae of El-Saygh population to some insecticides (summary) .

Insecticide (Group)		Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
Sumicidin	(Pyr.)	0.0006	0.040	10.84
Dursban	(OP.)	0.0017	0.007	2.43
Permethrin	(Pyr.)	0.0030	0.010	2.25
Sumithion	(OP.)	0.0110	0.063	2.74
Diazinon	(OP.)	0.3700	2.380	4.66
Baygon	(Ca.)	0.6300	1.080	1.38

Table (16) : Comparative insecticidal activity of certain insecticides against *Culex pipiens* larvae of El-Saygh population .

Insecticide	Lc_{50} (ppm)	Relative potency based on					
		Sumithion	Diazinon	Dursban	Baygon	Sumicidin	permethrin
Sumithion	0.0110	01.00	00.030	006.47	0.180	018.33	003.67
Diazinon	0.3700	33.64	01.000	217.65	0.590	616.67	123.33
Dursban	0.0017	00.16	00.005	001.00	0.003	002.83	000.57
Baygon	0.6300	57.27	00.810	370.59	1.000	1050.0	210.00
Sumicidin	0.0006	00.06	00.002	000.35	0.001	001.00	000.20
Permethrin	0.0030	00.27	08.110	001.77	0.005	005.00	001.00

Table (17) : Comparative susceptibility of Miet El-Attar and El-Saygh populations of *Culex pipiens* larvae to different chemical insecticides .

Insecticide	**Miet El-Attar strain**		**El-Saygh strain**	
	Lc_{50} (ppm)	**Slope function**	**Lc_{50} (ppm)**	**slope function**
Sumithion	0.0150	2.59	0.0110	02.740
Diazinon	0.2600	2.16	0.3700	04.660
Dursban	0.0016	2.40	0.0017	02.430
Baygon	0.2000	4.00	0.6300	01.380
Sumicidin	0.0020	6.33	0.0006	10.840
Permethrin	0.0018	2.11	0.0030	02.250

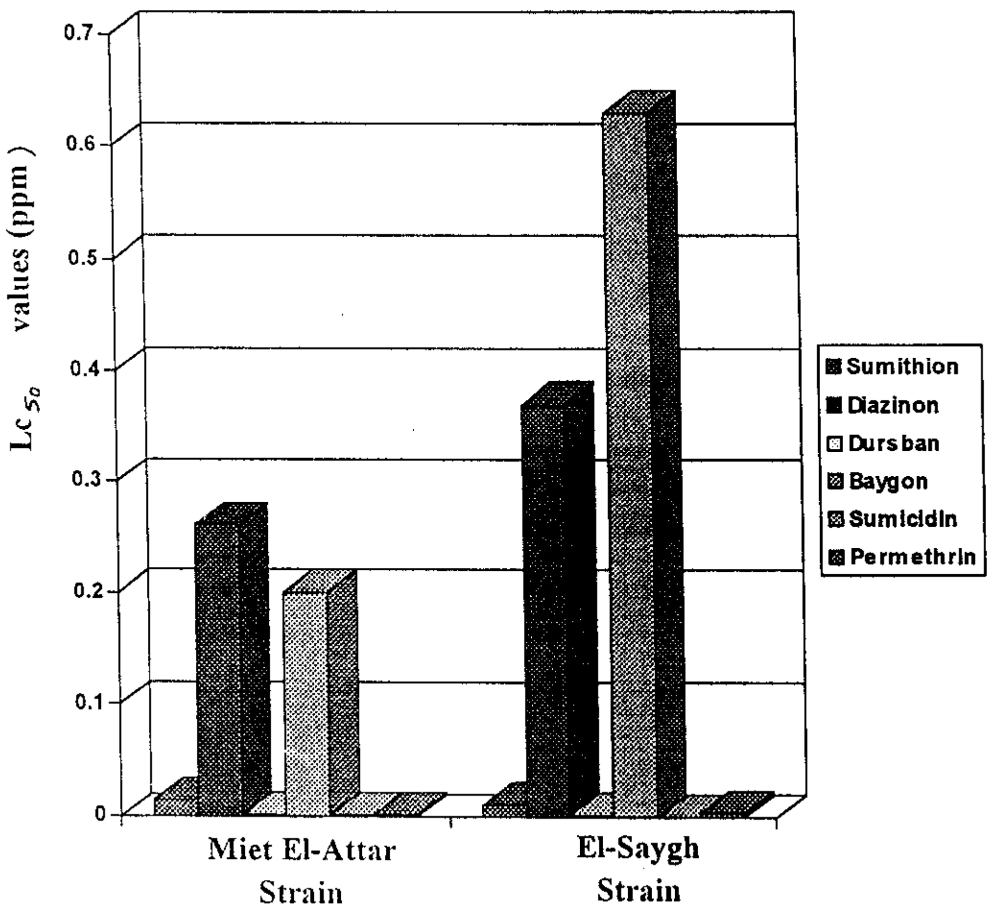

Fig. (13) : Susceptibility levels of *Culex pipiens* larvae to some insecticides of Miet El-Attar and El-Saygh populations on the basis of Lc_{50} values

1.2. Insect growth regulators (IGRs) :

1.2.1. Miet El-Attar strain :

The early third instar larvae of ***Culex pipiens*** of Miet El-Attar strain were tested with the two IGRs IKI and bay sir for their susceptibility .

Mortality resulted after 24, 48 & 72 hrs. post-treatments are presented in the tables (Tables 18 & 19) and graphically illustrated in the figures (Figs. 14 & 15) .

The obtained data showed that the two IGRs have different levels of activities against *Culex pipiens* larvae of Miet El-Attar strain . The susceptibility of the treated larvae was increased with the exposure times .

For IKI, the Lc_{50} values after 24, 48 & 72 hrs. are 1.30, 0.30 and 0.13 ppm, respectively and the slope functions are of low values of 1.85, 2.92 and 3.38 indicating high degree of homogeneity of the population tested .

Complete kill was achieved at the concentration 2.5 ppm after 48, hrs. of treatment, (Table 18) and (Fig. 14).For bay sir the Lc_{50} values are 1.79, 0.26 & 0.19 ppm and the slope functions are of relatively low values of 3.16, 3.36 & 3.63 .

Complete mortality of larvae occurred at the concentration 3.25 ppm after 72 hrs. post-treatment (Table 19) and (Fig. 15) .

Table (18) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to the insect growth regulator IKI after 24, 48, & 72 hrs. post-treatment .

Concentration (ppm)	Average mortality (%)		
	24 hr.	48 hr.	72 hr.
	$\bar{X} \pm SE$	$\bar{X} \pm SE$	$\bar{X} \pm SE$
0.01	0.0 ± 0.0	0.0 ± 0.0	10.3 ± 0.33
0.05	0.0 ± 0.0	5.7 ± 0.68	16.0 ± 0.58
0.50	5.3 ± 0.33	60.0 ± 0.58	82.0 ± 1.33
1.00	36.0 ± 1.00	84.0 ± 1.16	93.3 ± 1.53
1.50	60.0 ± 1.17	97.3 ± 0.33	98.7 ± 0.33
2.50	85.0 ± 0.88	100.0 ± 0.0	100.0 ± 0.0
control	0.0	0.0	0.0
Lc_{50} (ppm)	1.30	0.30	0.13
Lc_{95} (ppm)	3.70	1.59	1.12
Slope function	1.85	2.92	3.38

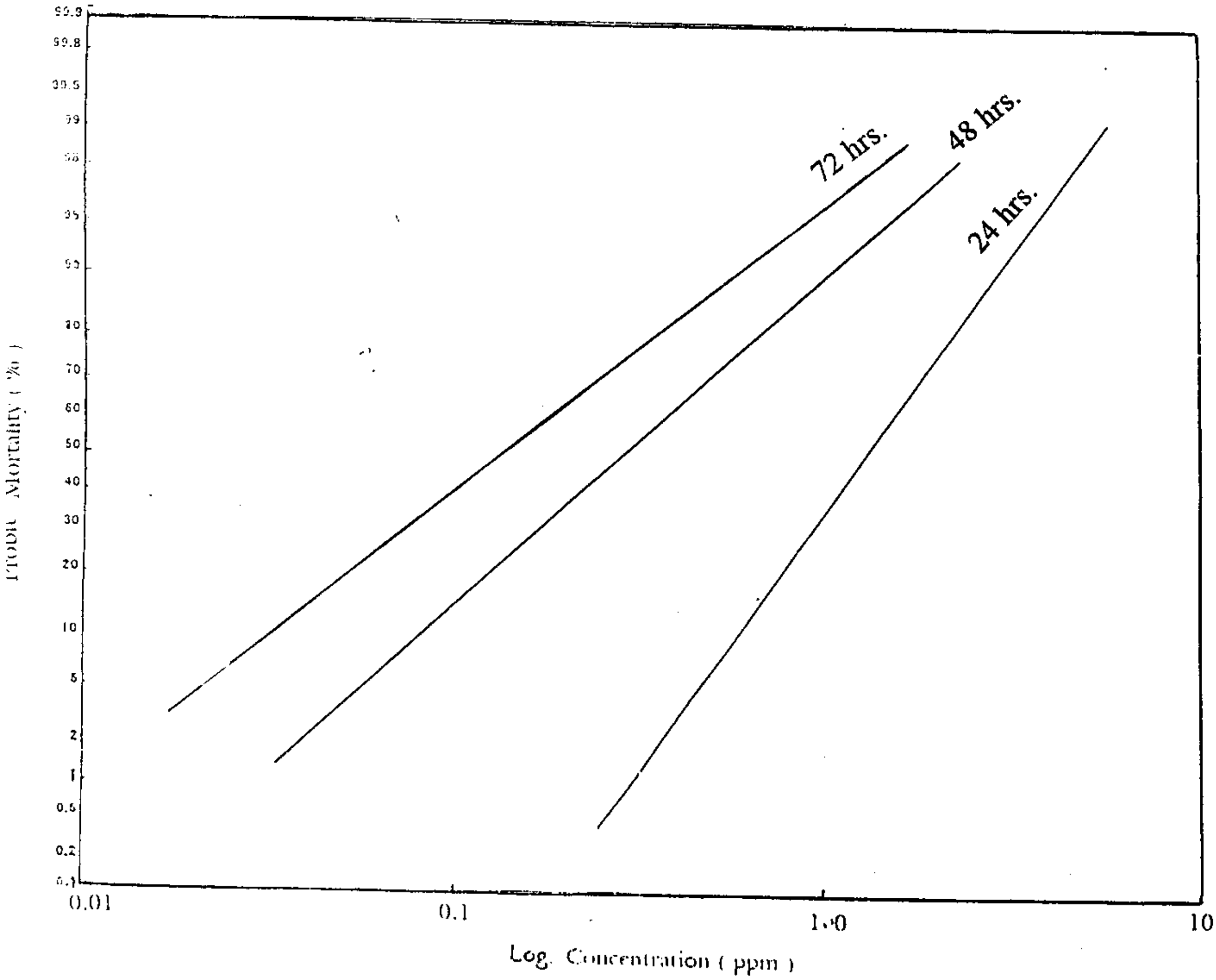

Fig. (14) : Log. concentration probit mortality regression lines of the early 3rd instar larvae of ***Culex pipiens*** (Miet El-Attar strain) after 24, 48 & 72 hrs. post-treatment with the IGR IKI .

Table (19) : Susceptibility of *Culex pipiens* larvae of Miet El-Attar population to the insect growth regulator bay sir after 24, 48, & 72 hrs. post-treatment .

Concentration (ppm)	Average mortality (%)		
	24 hr.	48 hr.	72 hr.
	$\overline{X} \pm SE$	$\overline{X} \pm SE$	$\overline{X} \pm SE$
0.03	0.0 ± 0.0	6.7 ± 0.33	10 ± 0.68
0.10	0.0 ± 0.0	10.0 ± 0.87	40 ± 0.87
0.20	5.3 ± 0.67	33.3 ± 1.20	61.3 ± 1.45
0.65	14.7 ± 0.68	81.3 ± 0.88	85.3 ± 0.94
1.30	48.0 ± 1.16	92.0 ± 1.53	96.0 ± 1.00
3.25	57.3 ± 0.88	97.3 ± 0.33	100.0 ± 0.0
5.00	85.3 ± 1.20	100.0 ± 0.0	100.0 ± 0.0
control	0.0	0.0	0.0
Lc_{50} (ppm)	1.79	0.26	0.19
Lc_{95} (ppm)	9.20	1.87	1.22
Slope function	3.63	3.36	3.63

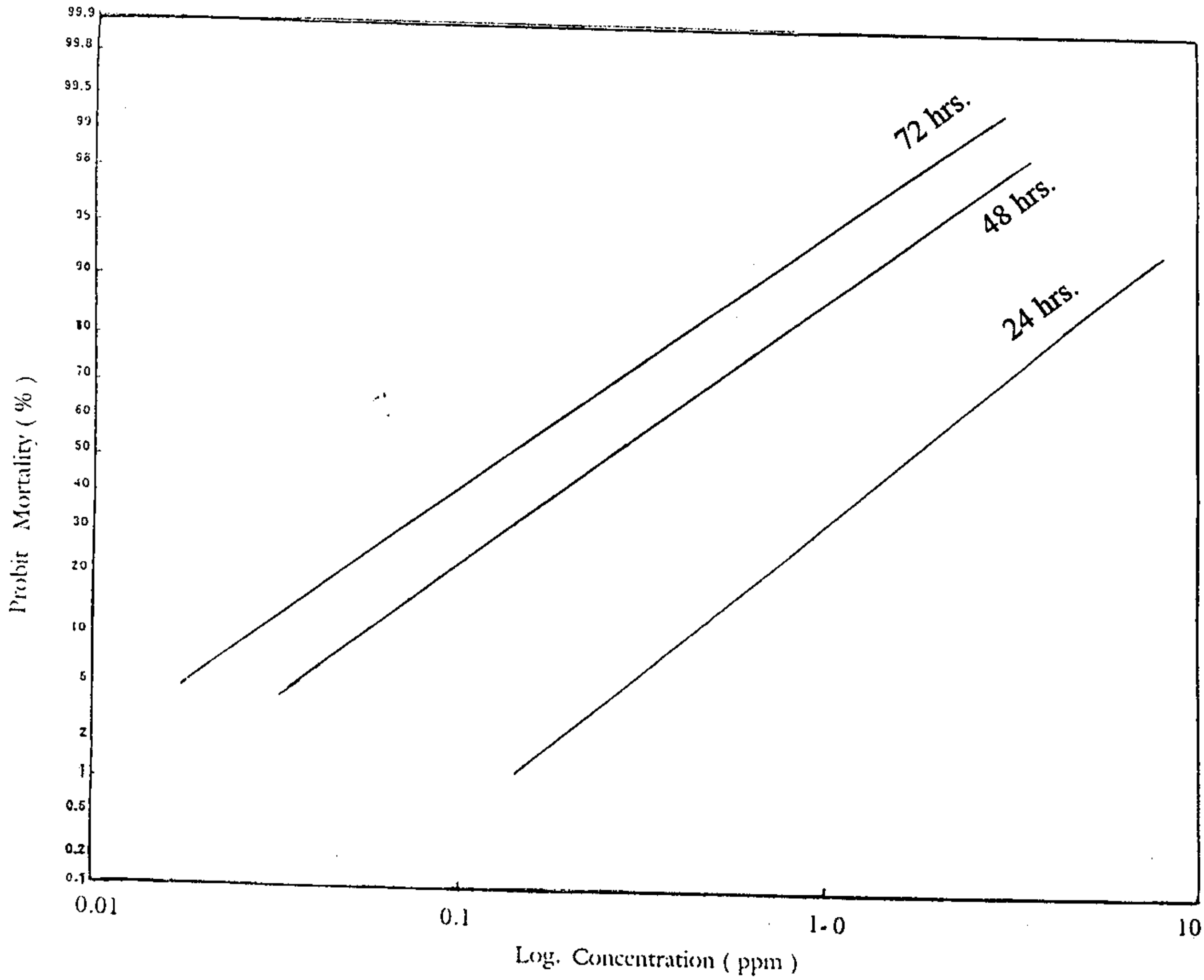

Fig. (15) : Log. concentration probit mortality regression lines of the early 3rd instar larvae of ***Culex pipiens*** (Miet El-Attar strain) after 24, 48 & 72 hrs. post-treatment with the IGR bay sir .

1.2.2. El-Saygh strain :

The same IGRs (IKI and bay sir) were also tested against the larvae of ***Culex pipiens*** collected from El-Saygh village for their susceptibilities .

Mortality resulted after 24, 48 & 72 hrs. post-treatments are presented in the tables (Tables 20 & 21) and shown graphically in the figures (Figs. 16 & 17) .

From the tables and the figures the obtained data indicated that this strain is quite susceptible to IGRs tested . IkI was more potent than bay sir against ***Culex pipiens*** larvae . Their Lc_{50} values were 1.48, 0.44 & 0.27 ppm & 1.89, 0.46 & 0.32 ppm for IKI and bay sir after 24, 48 & 72 hrs. post-treatment, respectively .

For IKI the slope functions are of low values of 1.18, 2.95 & 3.34 . Complete mortality of larvae was occurred at the concentration of 2.5 ppm after 72 hrs. post-treatment . for bay sir, the slope functions are also of relatively low values and complete kill of larvae was obtained at concentrations 3.25 & 5 ppm after 72 & 48 hrs., respectively.

The susceptibilities of the two strains of ***Culex pipiens*** larvae to the two tested IGRs (IKI and bay sir) are presented in the table (Table22) and the figure (Fig. 18) indicated that the two populations have the same susceptibility to the two IGRs tested judging from their relatively low values of Lc_{50} and slope function . However, IKI is slight more potent than bay sir compound .

Table (20) : Susceptibility of ***Culex pipiens*** larvae of El-Saygh populations to the insect growth regulator IKI after 24, 48, & 72 hrs. post-treatment.

Concentration (ppm)	Average mortality (%)		
	24 hr.	48 hr.	72 hr.
	$\bar{X} \pm SE$	$\bar{X} \pm SE$	$\bar{X} \pm SE$
0.01	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
0.05	0.0 ± 0.0	2.7 ± 0.33	8.0 ± 0.50
0.50	4.0 ± 0.58	45.3 ± 1.45	77.3 ± 0.68
1.00	33.3 ± 1.20	77.3 ± 0.88	86.7 ± 0.88
1.50	56.0 ± 1.16	90.7 ± 1.20	93.3 ± 1.20
2.50	81.3 ± 0.70	94.7 ± 0.88	100.0 ± 0.0
control	0.0	0.0	1.3
Lc_{50} (ppm)	1.48	0.44	0.27
Lc_{95} (ppm)	4.70	2.48	1.80
Slope function	1.18	2.95	3.34

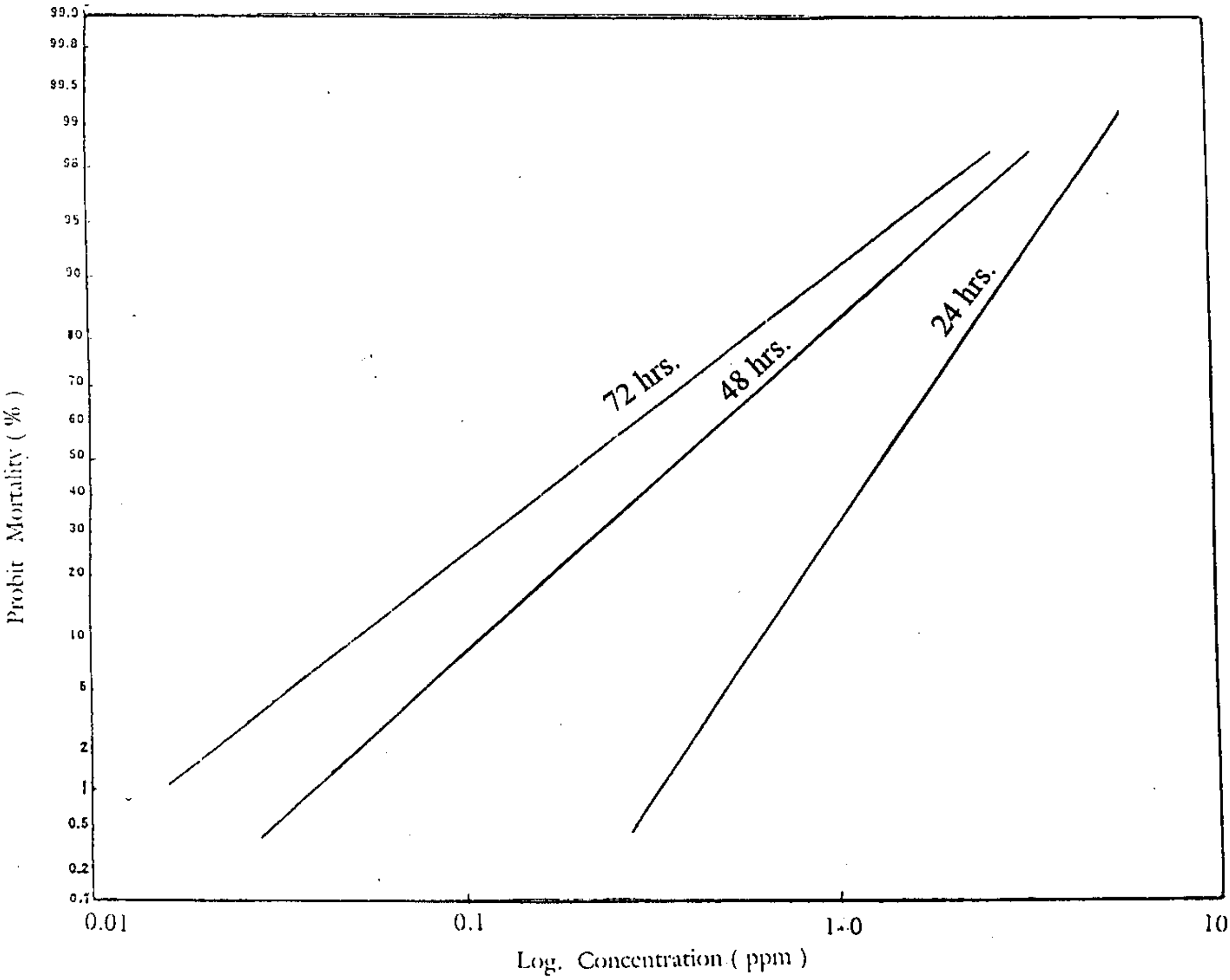

Fig. (16) : Log. concentration probit mortality regression lines of the early 3rd instar larvae of ***Culex pipiens*** (El-Saygh strain) after 24, 48 & 72 hrs. post treatment with IKI .

Table (21) : Susceptibility of *Culex pipiens* larvae of El-Saygh population to the insect growth regulator bay sir after 24, 48, & 72 hrs. post-treatment .

Concentration (ppm)	Average mortality (%)		
	24 hr.	48 hr.	72 hr.
	$\overline{X} \pm SE$	$\overline{X} \pm SE$	$\overline{X} \pm SE$
0.03	0.0 ± 0.0	0.0 ± 0.0	2.7 ± 0.67
0.10	0.0 ± 0.0	6.7 ± 0.67	12.0 ±
0.20	2.7 ± 0.33	17.3 ± 0.33	38.7 ± 0.88
0.65	10.7 ± 0.88	60.0 ± 1.16	70.7 ± 0.68
1.30	45.3 ± 1.20	86.7 ± 0.67	92.0 ± 0.58
3.25	57.3 ± 1.77	94.7 ± 0.33	100.0 ± 0.0
5.00	80.0 ± 0.58	96.0 ± 1.00	100.0 ± 0.0
control	0.0	0.0	2.7
Lc_{50} (ppm)	1.89	0.46	0.32
Lc_{95} (ppm)	7.59	3.11	1.89
Slope function	2.79	3.29	3.12

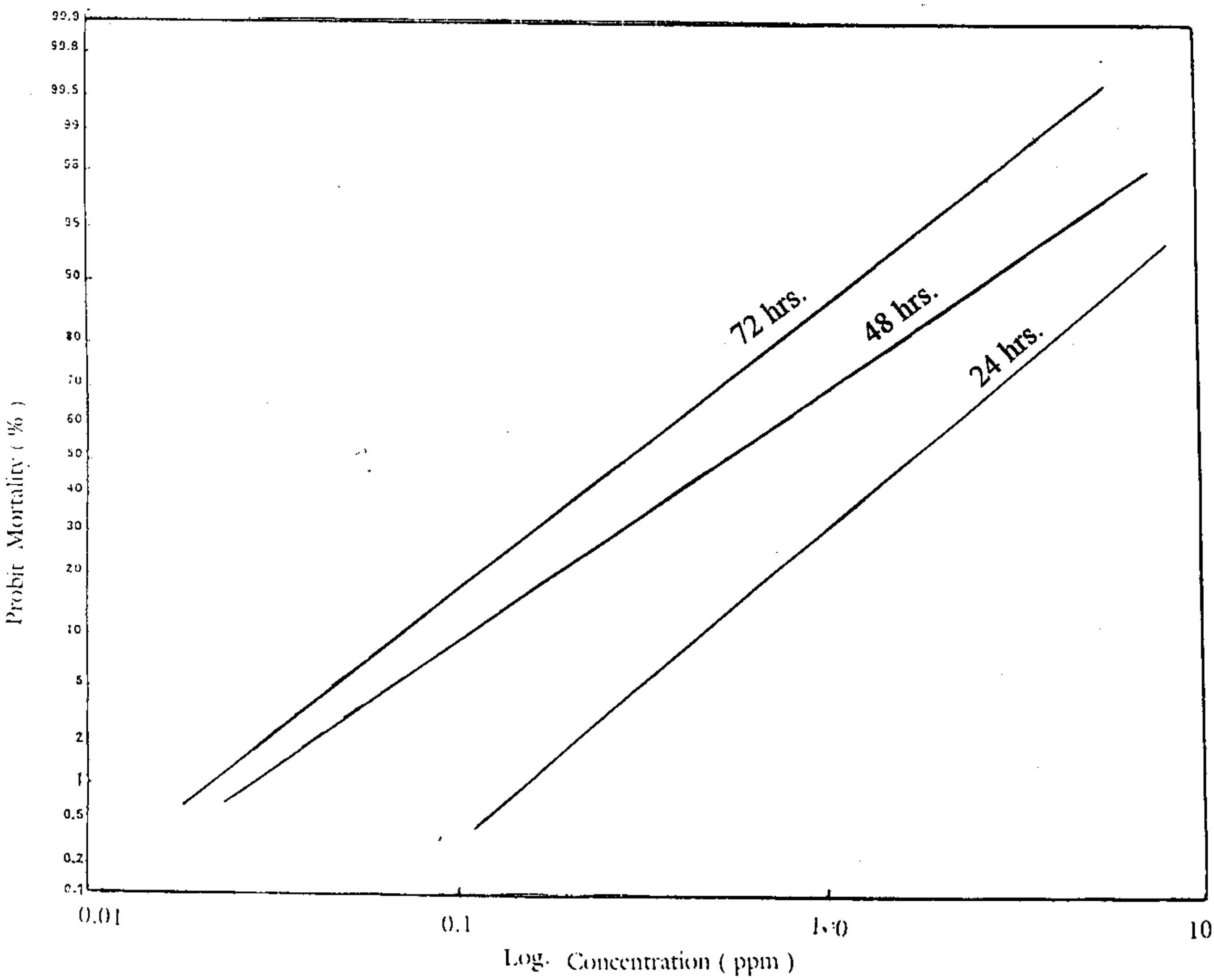

Fig. (17) : Log. concentration probit mortality regression lines of the early 3rd instar larvae of ***Culex pipiens*** (El-Saygh strain) after 24, 48 & 72 hrs. post treatment with bay sir .

Table (22) : The susceptibility of Miet El-Attar and El-Saygh strains of *Culex pipiens* larvae to IKI and Bay Sir (Summary) .

IGRs	Exposure time (hr.)	Miet El-Attar strain			El-Saygh strain		
		Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function	Lc_{50} (ppm)	Lc_{95} (ppm)	Slope function
IKI	24	1.30	3.70	1.85	1.48	4.70	1.18
	48	0.30	1.59	2.92	0.44	2.48	2.95
	72	0.13	1.12	3.38	0.27	1.80	3.34
Bay Sir	24	1.79	9.20	3.16	1.89	7.59	2.79
	48	0.26	1.87	3.36	0.46	3.11	3.29
	72	0.19	1.22	3.63	0.32	1.89	3.12

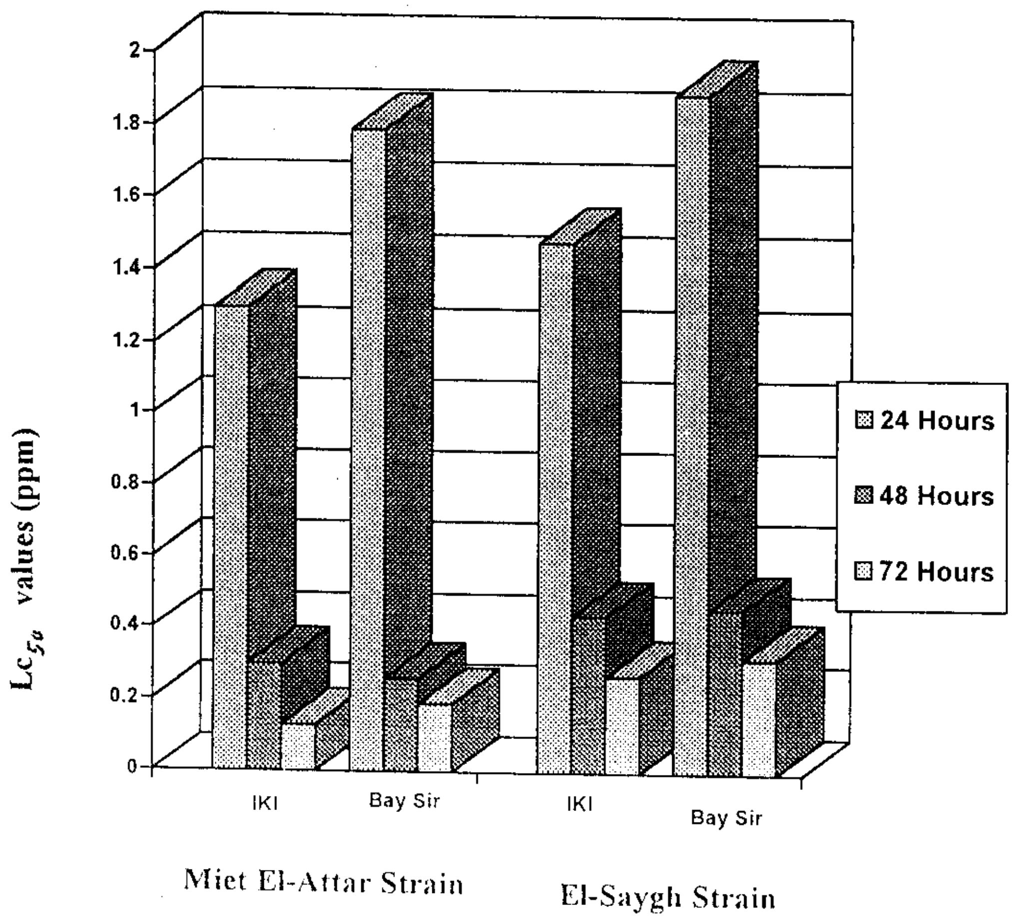

Fig. (18) : Comparative susceptibility of two populations of *Culex pipiens* larvae to IKI and bay sir on the basis of Lc_{50} values .

2. Development and reversion of baygon-resistance in *Culex pipiens* larvae .

2.1- Development of resistance :

This study was carried out on the larvae of *Culex pipiens* for 15 successive generations of selections and relaxation of insecticidal pressure .

The development of baygon-resistance was measured each three successive generations . Selection pressure was continuously performed on 15 successive generations .

The results of susceptibility level of original normal susceptible strain to baygon are presented in the table (Table 23) and graphically illustrated in the figure (Fig. 19) .

2.1.1- First selection :

Larvae of *Culex pipiens* were exposed to baygon at the higher discriminating concentrations for three successive generations .

The results of the susceptibility tests of the first selection after three generations of selection are presented in the table (Table 24) and illustrated graphically in the figure (Fig. 19) .

From the table it is clear that the Lc_{50} was increased to 0.69 ppm indicating a slight development of resistance . The level of resistance of the third generation raised to 3.5 times more than the normal strain (parent), and the slope function of the LD-p line is markedly declined after selection indicating progression of the development of resistance .

2.1.2- Second selection :

Selection was continuously performed for another three successive generations (F_4 - F_6) .

The results of the susceptibility level to ***Culex pipiens*** larvae after six successive generations of selection are presented in the table (Table 25) and graphically illustrated in the figure (Fig. 19) .

It is noticed from the table that the level of resistance of larvae is also slightly increased after 6 generations of selection regarding its Lc_{50} . value .

When the level of resistance was compared with that of the parent larvae it is calculated 4.2 times more resistant than the original strain .

2.1.3- Third Selection :

Selection was continuously performed for another three generations until the ninth generation (F_9) . The results of the susceptibility tests on F_9 larvae are presented in the table (Table 26) and graphically illustrated in the figure (Fig . 19) .

From the table and the figure it is obvious that there was another progression in the development of baygon resistance at the end of the ninth generation of selection . Their tolerance was brought up to about 8.25 times higher than the parent generation .

2.1.4- Fourth selection :

Further selection was continuously carried out for another three generations until the twelvth generation (F_{12}) .

Results of tests on F_{12} larvae are presented in the table (Table 27) and graphically illustrated in the figure (Fig. 19).

From the table and the figure it is obvious that there is a sudden increase of resistance in ***Culex pipiens*** larvae to baygon in this generation (F_{12}). The level of resistance was reached 49.5 times higher than the parent larvae.

2.1.5- Fifth selection :

This later selection was carried out on the previously selected individuals for another three successive generations until generation number fifteen (F_{15}).

Results of susceptibility measurements of ***Culex pipiens*** larvae after fifteen generations of selection are presented in the table (Table 28) and graphically illustrated in the figure (Fig. 19).

The Lc_{50} of this selected generation (F_{15}) is higher than the corresponding values of the selected larvae (F_3, F_6, F_9 and F_{12} generations) by 0.69, 0.84, 1.65, and 9.89 times, respectively. Moreover complete kill was occurred at a concentration higher than 80 ppm in this generation, indicating progression in the development of resistance to about 308.7 times higher than the original individuals. The population is considered in the state of actual resistance.

The changes in susceptibility to baygon in ***Culex pipiens*** larvae are indicated in the table (Table 29) and graphically illustrated in the figure (Fig. 20).

From the table it is clear that the Lc_{50} and the resistance level values were increased than the normal susceptible strain and the slope function value was markedly declined after selection indicating progression of the development of resistance .

Table (23) : Susceptibility level of the normal strain (parent) of *Culex pipiens* larvae to baygon .

Concentration (ppm)	Average mortality (%) $\bar{X} \pm$ S E
0.1	30.7 ± 0.88
0.2	49.3 ± 0.88
0.5	77.3 ± 0.67
0.8	84.0 ± 0.68
1.9	94.7 ± 1.34
control	0.0
Lc_{50} (ppm)	0.20
Slope function	4.33
Resistance level	0.0

Table (24) : Susceptibility level of the third generation (F_3) of *Culex pipiens* larvae to baygon .

Concentration (ppm)	Average mortality (%) $\overline{X} \pm S\,E$
0.6	23.7 ± 0.88
0.7	57.3 ± 0.46
0.8	74.7 ± 0.88
0.9	85.3 ± 0.67
control	0.0
Lc_{50}	0.69
Slope function	1.22
Resistance level	3.45

Table (25) : Susceptibility level of the sixth generation (F_6) of *Culex pipiens* larvae to baygon .

Concentration (ppm)	Average mortality (%) $\overline{X} \pm S\,E$
0.8	32.0 ± 1.00
0.9	57.3 ± 1.46
1.0	72.3 ± 0.58
2.0	82.7 ± 0.88
control	1.3
Lc_{50}	0.84
Slope function	2.46
Resistance level	4.20

Table (26) : Susceptibility level of the ninth generation (F_9) of *Culex pipiens* larvae to baygon .

Concentration (ppm)	Average mortality (%) ± S $\overline{X} \pm SE$
1.0 2.0 2.5 3.0	20.0 ± 0.58 56.3 ± 1.53 77.3 ± 0.68 84.7 ± 1.34
control	0.0
Lc_{50} (ppm)	1.65
Slope function	1.85
Resistance level	8.25

Table (27) : Susceptibility level of the twelfth generation (F_{12}) of *Culex pipiens* larvae to baygon .

Concentration (ppm)	Average mortality (%) $\overline{X} \pm SE$
2 3 4 10 15 25	0.0 ± 0.0 06.2 ± 0.67 21.3 ± 0.16 46.7 ± 0.35 64.0 ± 0.48 81.3 ± 0.61
control	0.0
Lc_{50} (ppm)	9.89
Slope function	1.62
Resistance level	49.45

Table (28) : Susceptibility level of the fifteenth generation (F_{15}) of *Culex pipiens* larvae to baygon .

Concentration (ppm)	Average mortality (%) $\overline{X} \pm SE$
20	0.0 ± 0.0
30	05.3 ± 0.88
40	24.0 ± 1.62
60	46.7 ± 0.88
80	72.7 ± 1.73
control	2.7
Lc_{50} (ppm)	61.75
Slope function	1.49
Resistance level	308.7

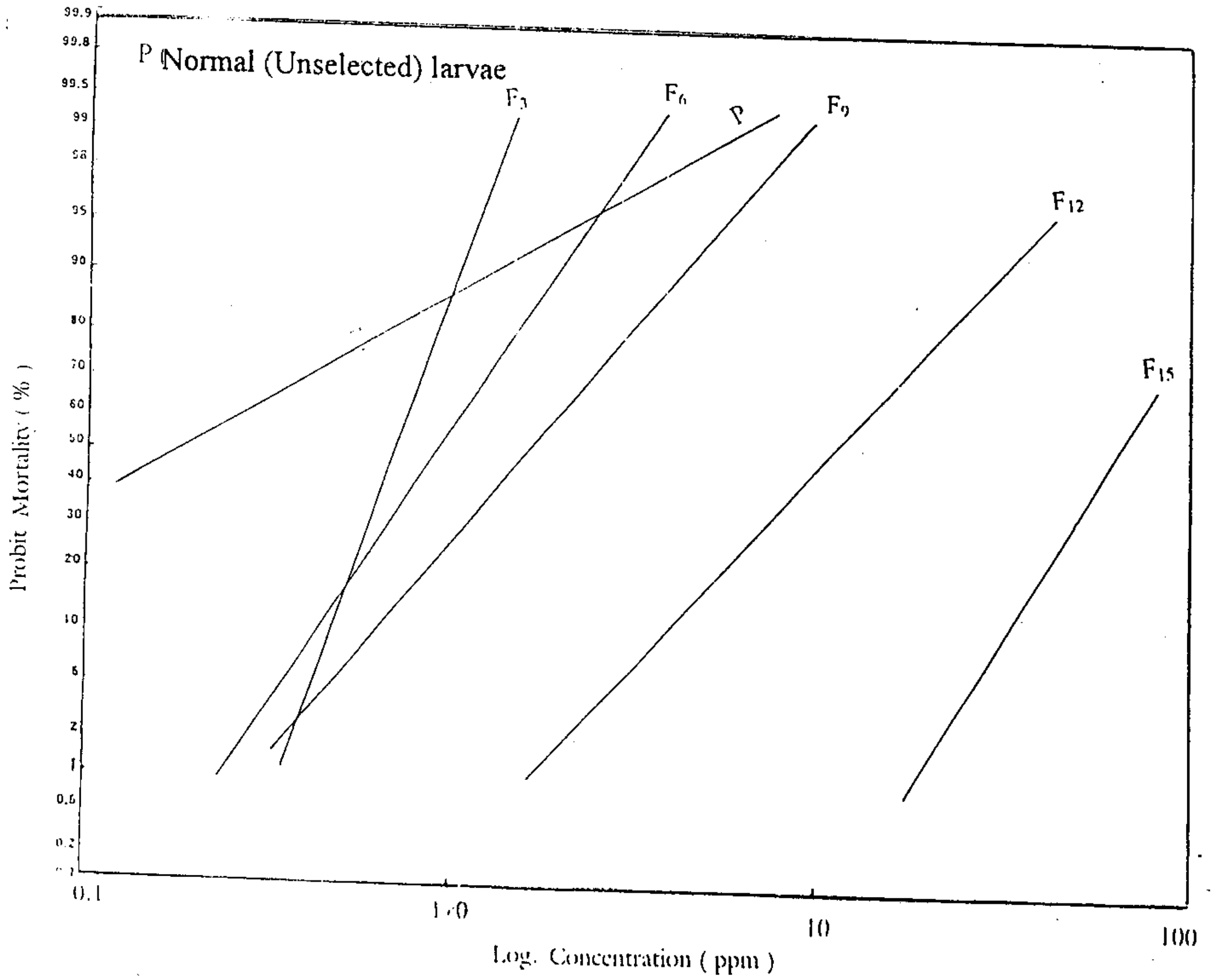

Fig. (19) : Changes in the susceptibility levels of ***Culex pipiens*** larvae to baygon after fifteen generations of selection .

Table (29) : Changes in susceptibility of ***Culex pipiens*** larvae during selection to baygon from F_1 - F_{15} .

Generation tested	Lc_{50} (ppm)	Slope function	Resistance level
N	0.20	4.33	——
F_3	0.69	1.22	3.45
F_6	0.84	2.46	4.20
F_9	1.65	1.85	8.25
F_{12}	9.89	1.62	49.45
F_{15}	61.75	1.49	308.70

N = Normal strain (Parent) .

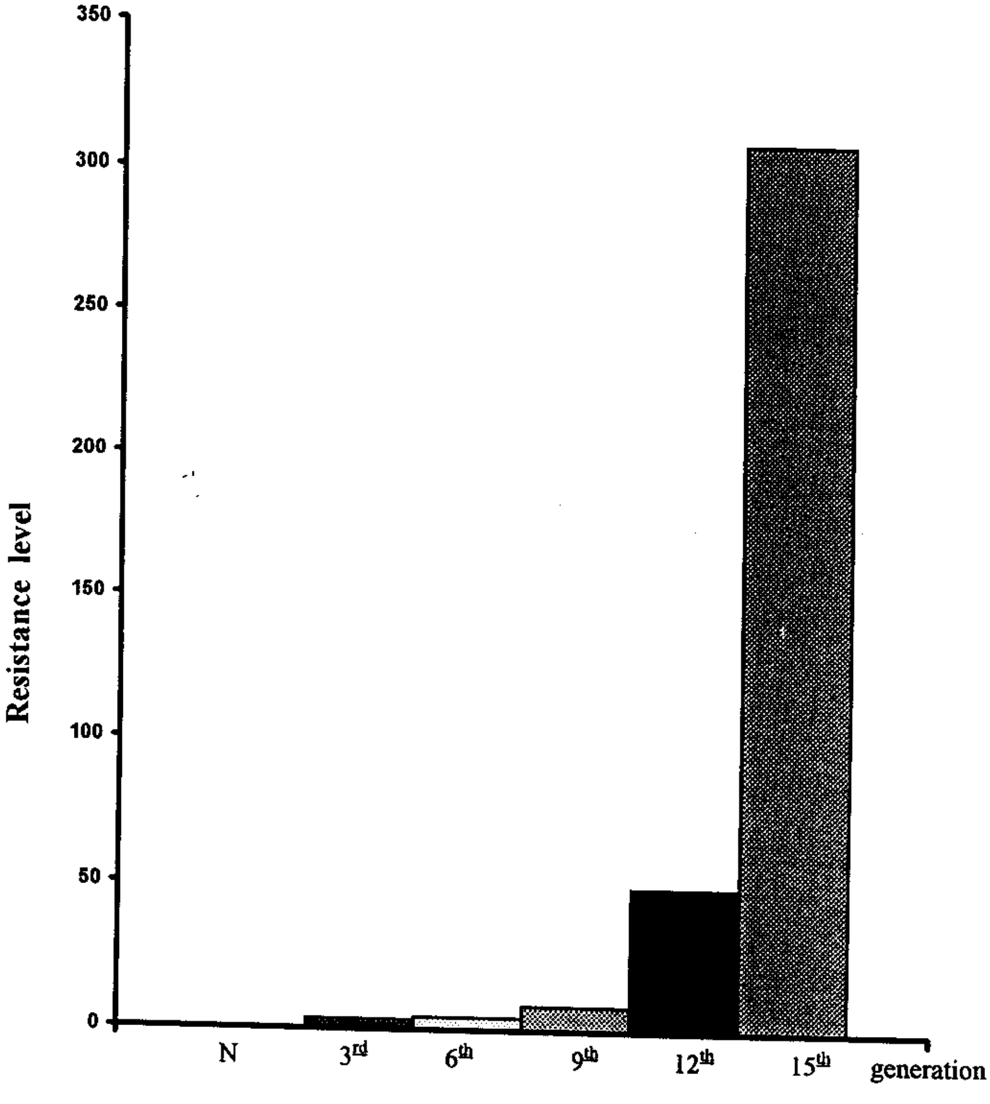

Fig. (20) : Resistance levels of ***Culex pipiens*** larvae during selection to baygon (F_1 to F_{15}) .

2.2- Reversion of resistance :

The baygon resistant strain after achieving a level of 308.7-fold resistance at generation F_{15} was left without chemical pressure for 18 generation . The levels of susceptibility were determined during relaxation generations at intervals of three generations i.e. after 3, 6, 9, 12, 15 & 18 generations of relaxation .

The rates of reversion of baygon-resistance are indicated in the tables (Tables 30-36) and the probit-regression lines are shown in the figure (Fig. 21) .

The results clearly indicated that the Lc_{50} values were decreased gradually during successive generations of relaxation . The Lc_{50} values are 60.18 , 40.7 , 30.61 , 21.18 , 16.86 & 10.96 for F_3, F_6 , F_9 , F_{12} , F_{15} and F_{18}, respectively . The resistance level of F_{18} was recorded 54.80 times more resistance than the parent larvae .

The slope function were almost of low values . In general their values are more or less similar to be 1.83 , 1.79 , 1.98 , 1.80 & 1.84 for F_3 , F_6 , F_{12} , F_{15} and F_{18} , respectively . However, the F_9 value was 2.05 although insignificant .

The patterns of reversion of baygon resistance are demonstrated in the table (Table 36) and graphically illustrated in the figure (Fig. 22) .

The rates of relaxation as expressed in relative reversibilities to baygon-resistant strain were gradually decreased during the successive relaxed generations compared to the normal strain . It reached to about one tenth after 18 relaxed generations comparing to the R-strain .

Comparison of these data revealed that high resistance to baygon occurred in the larvae of ***Culex pipiens*** is most probably cause by the interaction of several genetic factors .

Table (30) : The susceptibility level of the third relaxed generation (**F_3**) of ***Culex pipiens*** larvae to baygon insecticide .

Concentration (ppm)	Average mortality (%) $\overline{X} \pm SE$
30	16.0 ± 0.33
50	26.7 ± 1.00
60	40.0 ± 1.16
80	68.0 ± 0.88
control	0.0
Lc_{50} (ppm)	60.18
Slope function	1.83
Resistance level	300.90

Table (31) : The susceptibility level of the sixth relaxed generation (**F_6**) of ***Culex pipiens*** larvae to baygon insecticide .

Concentration (ppm)	Average mortality (%) $\overline{X} \pm SE$
20	10.7 ± 0.88
30	36.0 ± 0.58
60	74.7 ± 1.20
80	89.3 ± 0.68
control	2.7
Lc_{50} (ppm)	40.70
Slope function	1.79
Resistance level	203.50

Table (32) : The susceptibility level of the ninth relaxed generation (F_9) of *Culex pipiens* larvae to baygon insecticide .

Concentration (ppm)	Average mortality (%) $\bar{X} \pm SE$
10	6.7 ± 0.33
20	22.7 ± 0.47
30	52.0 ± 0.58
60	80.0 ± 1.16
80	92.0 ± 0.58
control	1.3
Lc_{50} (ppm)	30.61
Slope function	2.05
Resistance level	153.05

Table (33) : The susceptibility level of the twelvth relaxed generation (F_{12}) of *Culex pipiens* larvae to baygon insecticide .

Concentration (ppm)	Average mortality (%) $\bar{X} \pm SE$
6	04.0 ± 0.58
10	16.0 ± 0.73
20	44.0 ± 1.00
30	74.7 ± 0.88
50	89.3 ± 0.18
control	0.0
Lc_{50} (ppm)	21.18
Slope function	1.98
Resistance level	105.9

Table (34) : The susceptibility level of the fifteenth relaxed generation (F_{15}) of *Culex pipiens* larvae to baygon insecticide .

Concentration (ppm)	Average mortality (%) $\bar{X} \pm SE$
6	04.0 ± 0.33
10	22.7 ± 0.20
20	62.7 ± 0.33
30	85.3 ± 0.88
control	0.0
Lc_{50} (ppm)	16.86
Slope function	1.80
Resistance level	84.3

Table (35) : The susceptibility level of the eighteenth relaxed generation (F_{18}) of *Culex pipiens* larvae to baygon insecticide .

Concentration (ppm)	Average mortality (%) $\bar{X} \pm SE$
5	13.3 ± 0.68
10	37.3 ± 0.88
15	66.7 ± 0.33
20	86.7 ± 0.68
30	96.0 ± 0.82
control	2.7
Lc_{50} (ppm)	10.96
Slope function	1.84
Resistance level	54.80

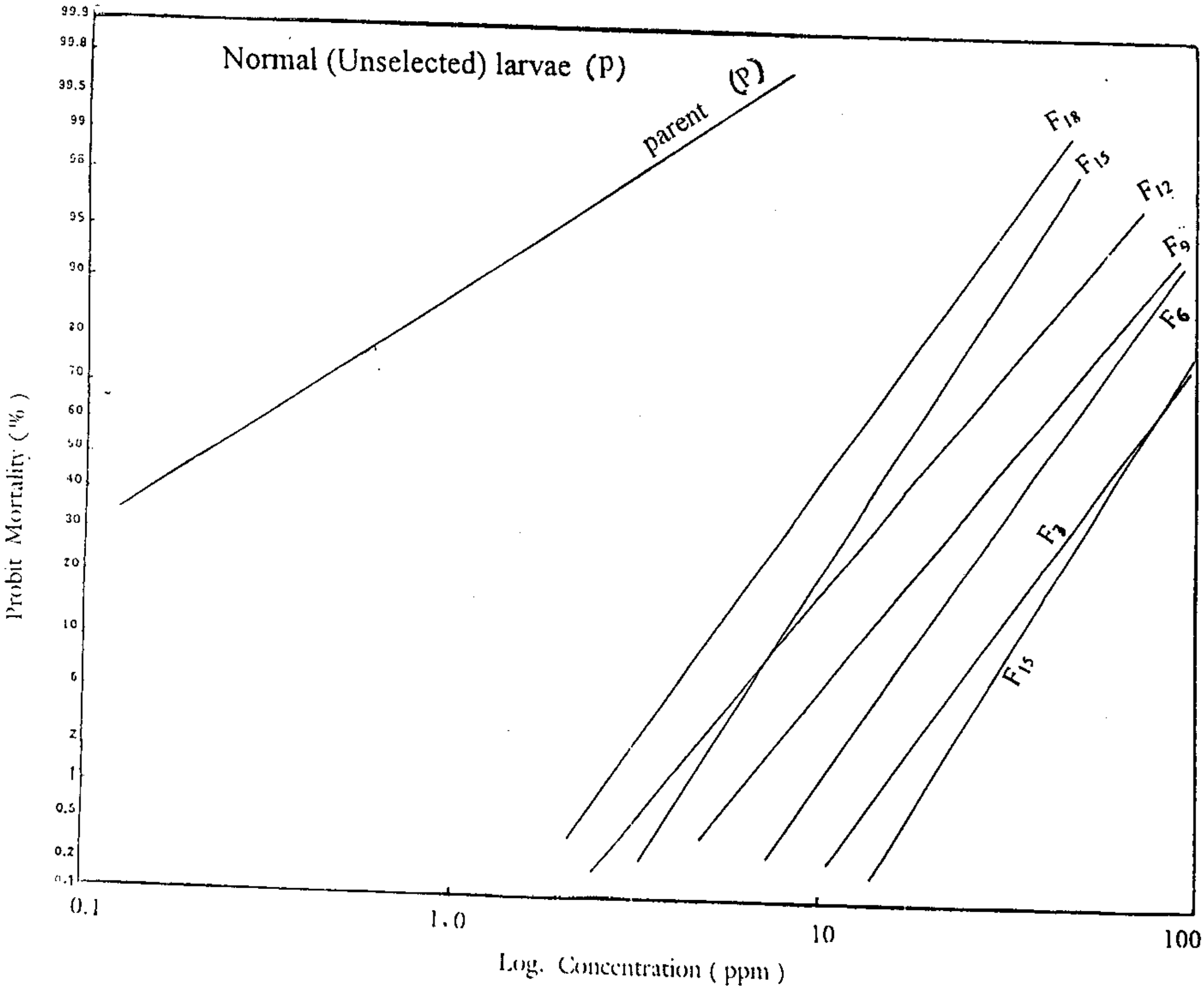

Fig. (21) : Mortality regression lines of relaxed generations of ***Culex pipiens*** larvae to baygon insecticide .

Table (36) : Relative reversibility of baygon-resistance in ***Culex pipiens*** larvae after 18 relaxed generations . (Summary)

Generation tested	Lc_{50} (ppm)	Slope function	Resistance level	Relative reversibility
R	61.75	1.49	308.70	1.00
F_3	60.18	1.83	300.90	0.97
F_6	40.70	1.79	203.50	0.66
F_9	30.61	2.05	153.05	0.50
F_{12}	21.18	1.98	105.90	0.34
F_{15}	16.86	1.80	84.30	0.27
F_{18}	10.96	1.84	54.80	0.18
N	0.20	4.33	—	—

R = Baygon - resistant strain after 15 generation of selection .

N = Normal strain (parent) .

$$\text{Relative reversibility} = \frac{Lc_{50} \text{ of the reveraed strain}}{Lc_{50} \text{ of the resistant strain}}$$

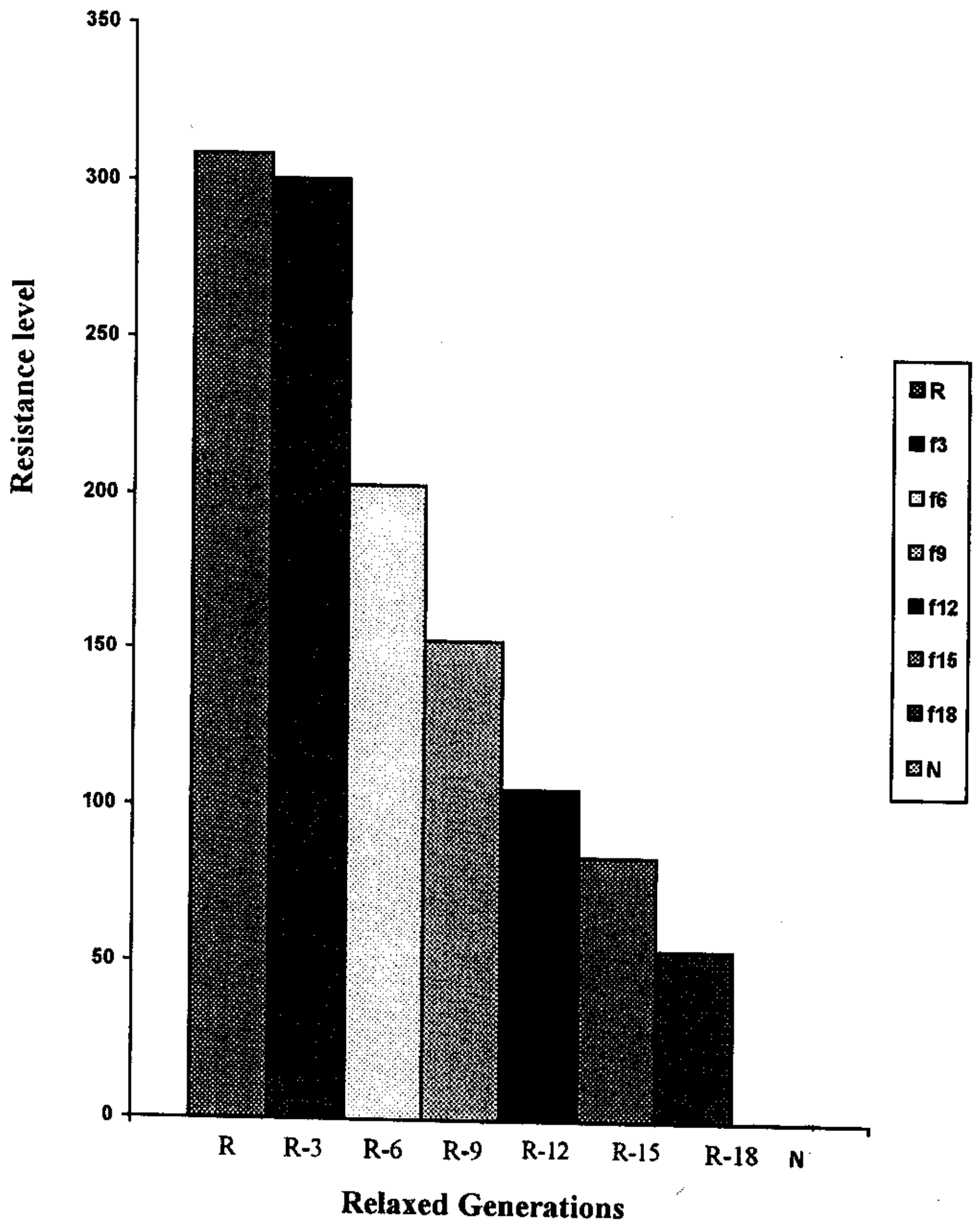

Fig. (22) : Resistance levels of ***Culex pipiens*** larvae during relaxation of baygon after 18 generations.

3- Resistance spectrum of baygon-resistant strain to various insecticides .

Cross-resistance studies were carried out after achieving high levels of resistance to baygon . The level of resistance was attained 308.7-fold . The pattern of cross-resistance to several insecticides and IGRs in the baygon resistant strain is indicated in the tables (Tables 37-43) and the figures (Figs. 23-29) .

3.1 Organophosphate group :

Results of relative susceptibility levels of the normal susceptible and baygon-selected strains of ***Culex pipiens*** larvae to sumithion, diazinon and dursban are presented in the tables (Tables 37-39) and shown graphically in the figures (Figs. 23-25) .

Data in the tables reveal that the relative resistabilities of baygon selected and normal strains (R/N) showed no correlation of baygon-R to the tested organophosphorous insecticides, hence the resistance levels were only recorded 3 times for sumithion and 1.46 times for diazinon indicating that the tolerance difference showed no correlation, whereas 4.8 times for dursban indicating a positive correlation on the basis of p values there were no significant differences in the mortality percent between the normal strain (parent) and resistant strain ($p > 0.05$), whereas there was a lower significant difference for dursban ($p < 0.05$) .

Table (37) : Relative susceptibilities of the normal and baygon selected strains of ***Culex pipiens*** larvae to sumithion .

Concentration (ppm)	Average mortality (%)	
	Normal strain (N)	Resistant strain (R)
0.01	29.7 ± 0.88	0.0 ± 0.0
0.02	60.0 ± 1.16	16.0 ± 1.16
0.05	86.7 ± 0.88	66.7 ± 0.88
0.10	100 ± 0.0	82.7 ± 0.88
control	0.0	0.0
Lc_{50} (ppm)	0.015	0.045
Slope function	2.59	2.24
Resistance level	3.0 fold	
Tolerance difference	no correlation	

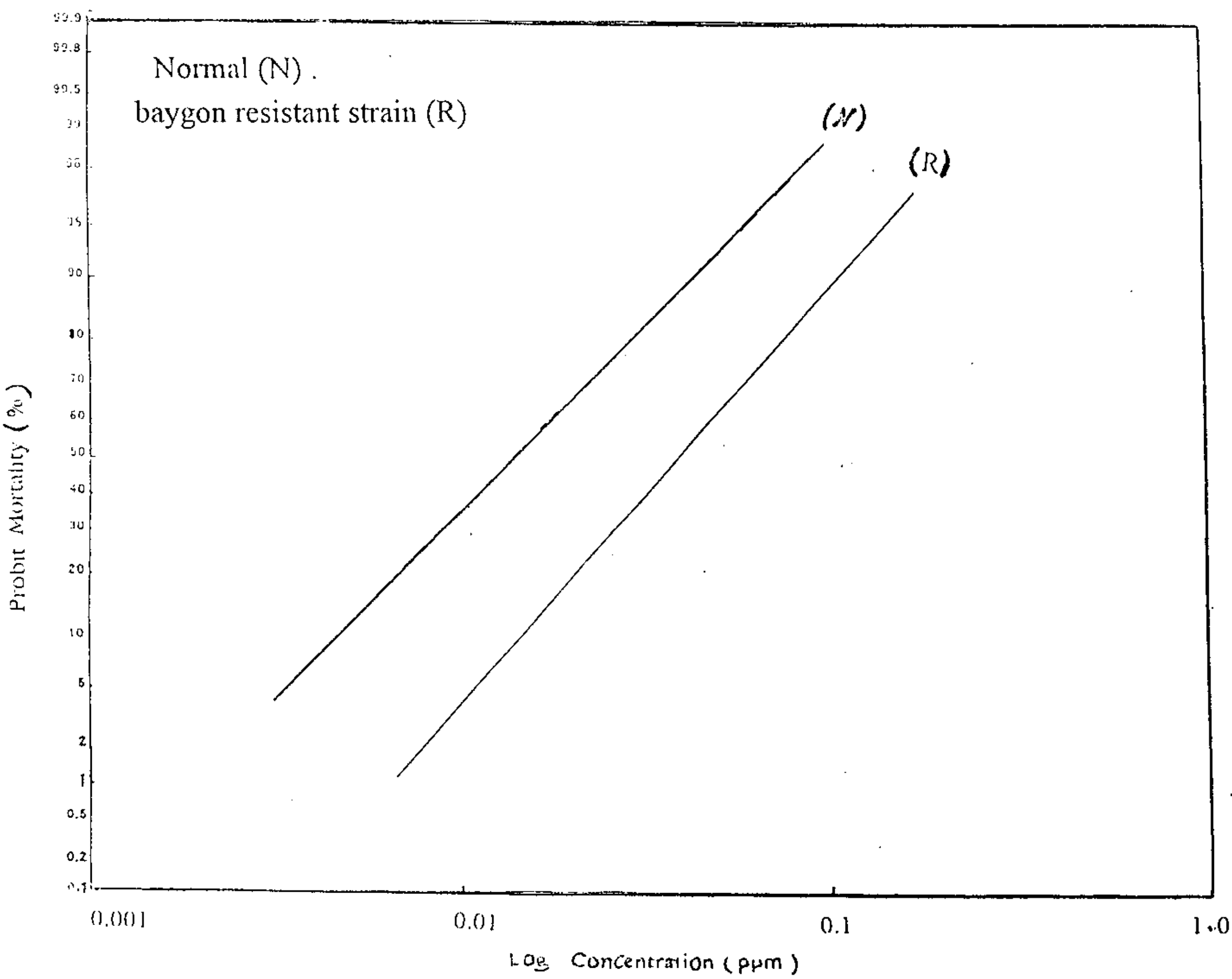

Fig. (23) : Susceptibility levels of normal and resistant strains of ***Culex pipiens*** larvae to sumithion .

Table (38) : Relative susceptibilities of the normal and baygon selected strains of ***Culex pipiens*** larvae to diazinon .

Concentration (ppm)	Average mortality (%)	
	Normal strain (N)	Resistant strain (R)
0.10	09.3 ± 0.67	04.0 ± 0.58
0.25	48.0 ± 1.16	36.0 ± 0.58
0.50	85.3 ± 0.88	74.7 ± 0.67
1.00	94.7 ± 0.88	82.7 ± 0.68
control	0.0	1.3
Lc_{50} (ppm)	0.26	0.38
Slope function	2.16	2.25
Resistance level	1.46 fold	
Tolerance difference	no correlation	

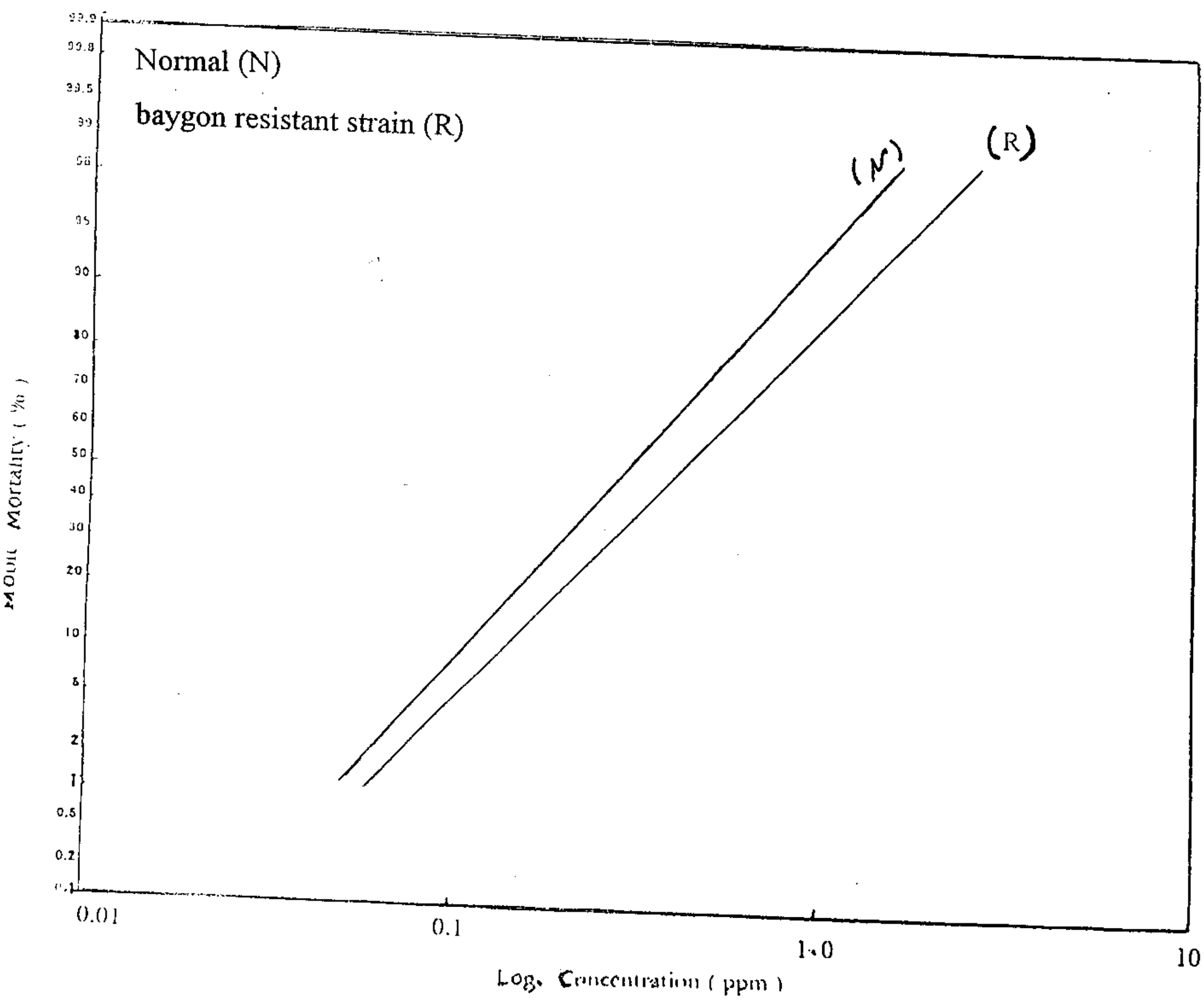

Fig. (24) : Susceptibility levels of normal and resistant strains of ***Culex pipiens*** larvae to diazinon .

Table (39) : Relative susceptibilities of the normal and baygon selected strains of *Culex pipiens* larvae to dursban .

Concentration (ppm)	Average mortality (%)	
	Normal strain (N)	Resistant strain (R)
0.0005	2.7 ± 0.33	—
0.001	37.3 ± 0.88	—
0.003	70.7 ± 1.46	—
0.005	94.7 ± 0.67	0.0 ± 0.0
0.006	—	38.0 ± 0.88
0.007	100 ± 0.0	48.0 ± 1.00
0.009	—	69.3 ± 0.68
0.01	—	82.7 ± 0.88
control	1.3	0.0
Lc_{50} (ppm)	0.0015	0.0072
Slope function	2.4	1.33
Resistance level	4.8	
Tolerance difference	positive correlation	

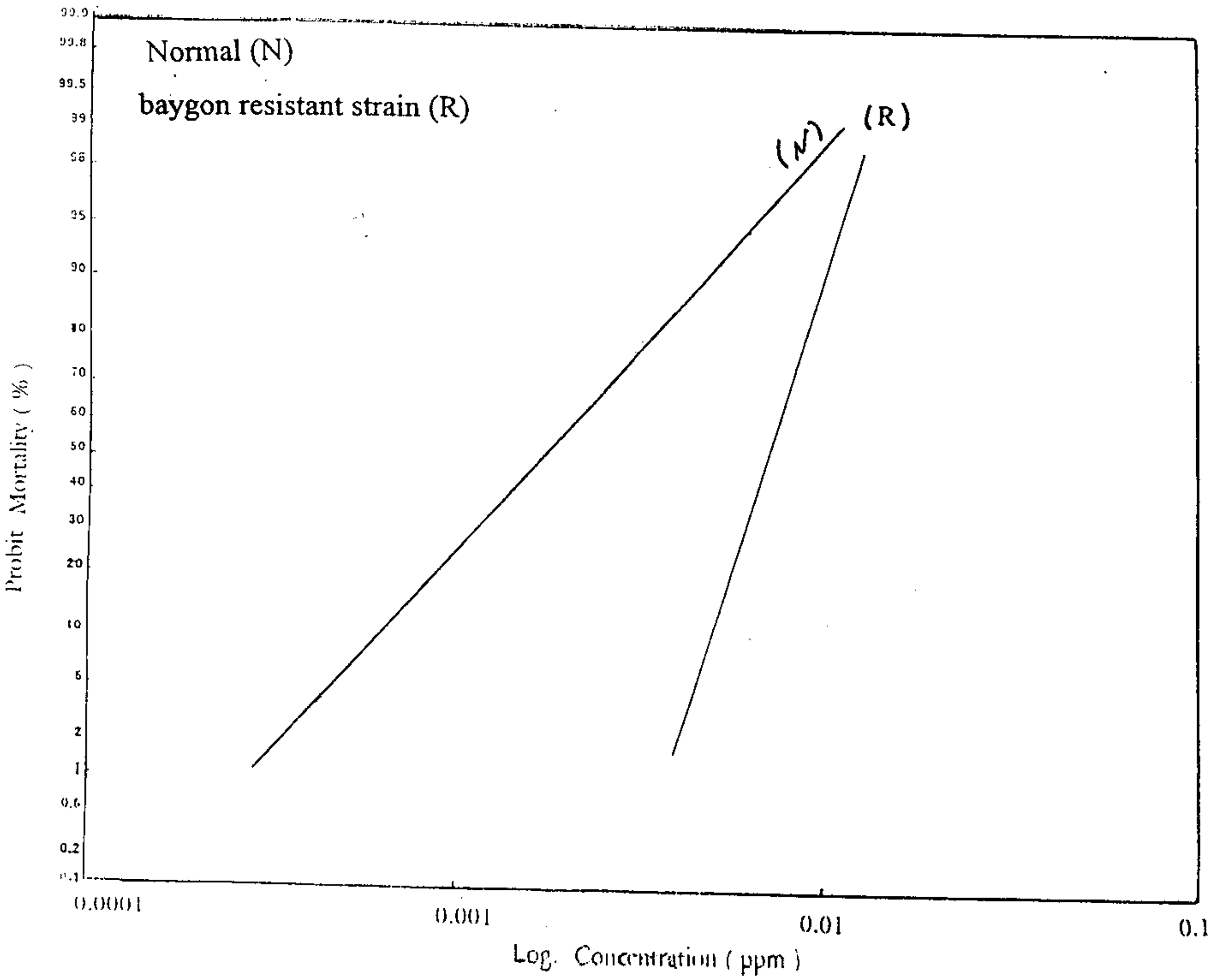

Fig. (25) : Susceptibility levels of normal and resistant strains of ***Culex pipiens*** larvae to dursban .

3.2- Pyrethroides group :

Results of relative susceptibilities of the normal and selected strains of *Culex pipiens* larvae to sumicidin and permethrin are presented in the tables (Tables 40 & 41) and graphically illustrated in the figures (Figs. 26 & 27) .

The data reveals that the baygon-resistant strain is quite susceptible to sumicidin where its level of resistance was 1.7 times indicating no correlation .

Similarly this strain was quite susceptible to permethrin hence the level of resistance is 1.22 times indicating no correlation . There were no significant differences in the mortality percents between the normal strain (parent) and resistant strain of two insecticides tested ($p > 0.05$) .

Table (40) : Relative susceptibilities of the normal and baygon selected strains of ***Culex pipiens*** larvae to sumicidin .

Concentration (ppm)	Average mortality (%)	
	Normal strain (N)	Resistant strain (R)
0.00025	8.0 ± 0.58	02.7 ± 0.33
0.001	37.3 ± 1.20	21.3 ± 0.67
0.005	73.3 ± 0.88	62.7 ± 0.88
0.01	80.0 ± 1.16	73.3 ± 0.88
control	0.0	1.3
Lc_{50} (ppm)	0.002	0.0034
Slope function	6.33	4.30
Resistance level	1.7 fold	
Tolerance difference	no correlation	

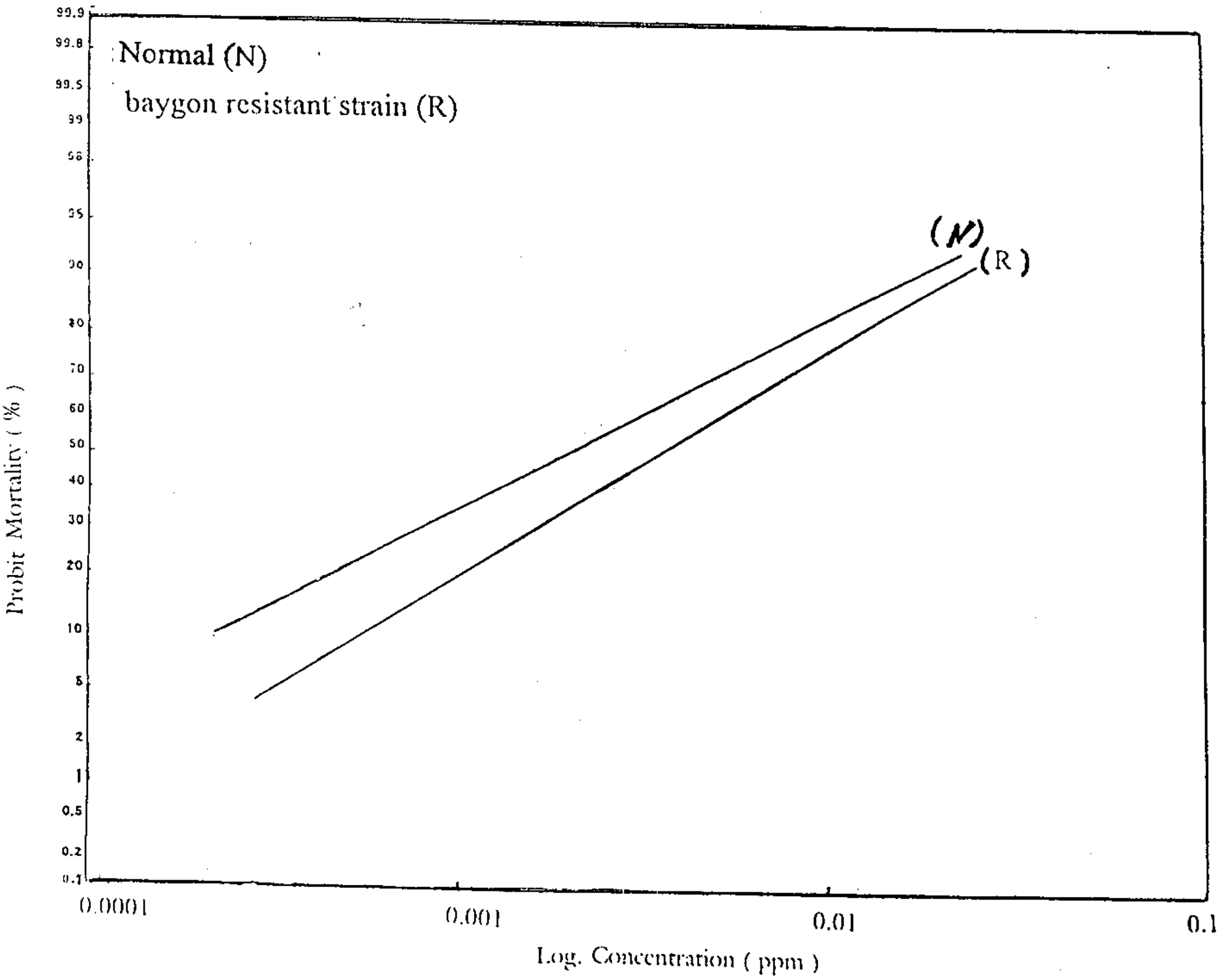

Fig. (26) : Susceptibility levels of normal and resistant strains of ***Culex pipiens*** larvae to sumicidin .

Table (41) : Relative susceptibilities of the normal and baygon selected strains of *Culex pipiens* larvae to permethrin .

Concentration (ppm)	Average mortality (%)	
	Normal strain (N)	Resistant strain (R)
0.0005	06.7 ± 0.67	04.0 ± 1.53
0.001	22.7 ± 0.88	13.3 ± 1.16
0.0025	68.0 ± 1.00	60.0 ± 0.88
0.005	88.0 ± 1.16	81.3 ± 0.58
control	0.0	0.0
Lc_{50} (ppm)	0.0018	0.0022
Slope function	2.11	2.26
Resistance level	1.22 fold	
Tolerance difference	no correlation	

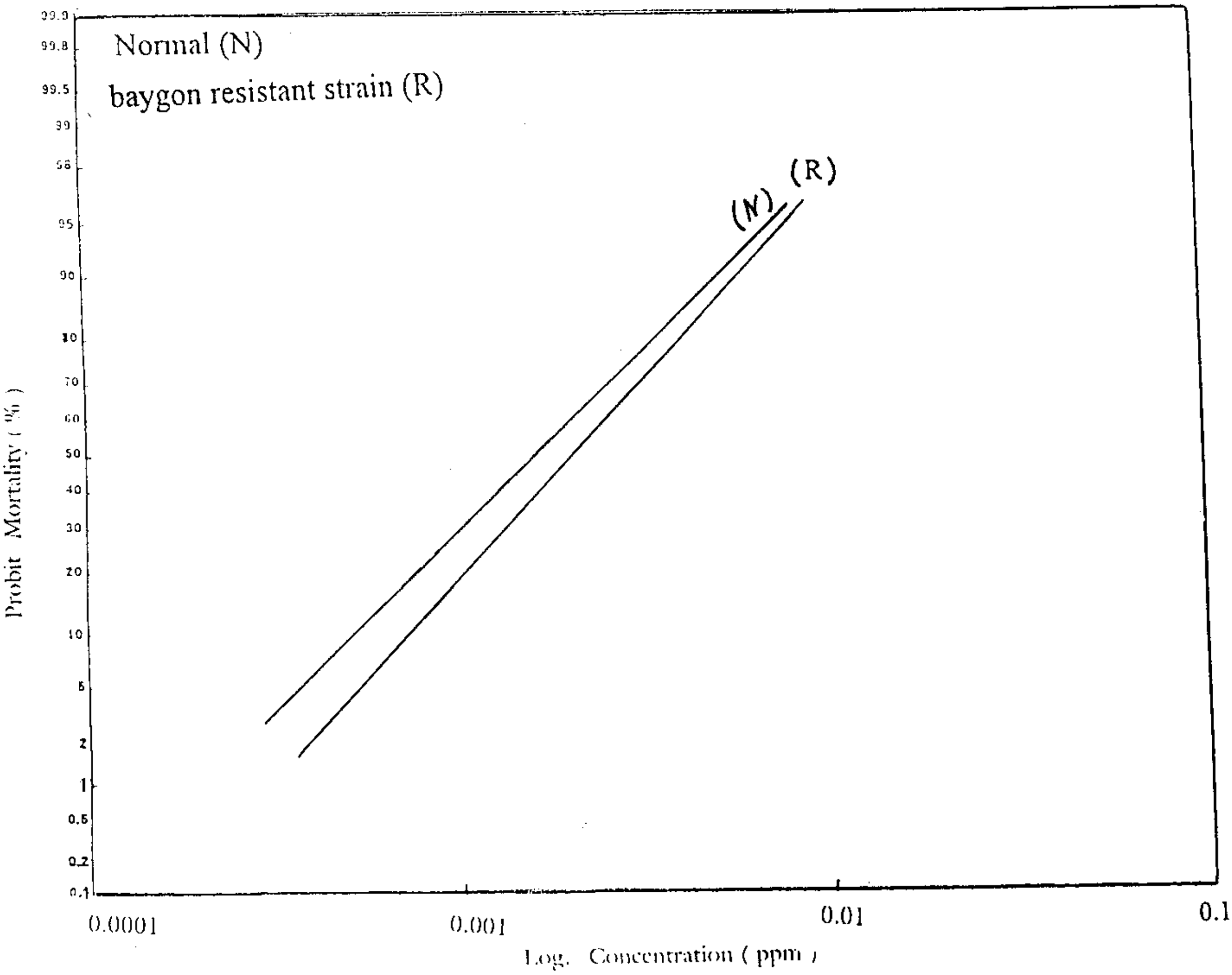

Fig. (27) : Susceptibility levels of normal and resistant strains of ***Culex pipiens*** larvae to permethrin .

3.3- IGRs group :

Results of relative susceptibilities of the normal susceptible and baygon selected strains of ***Culex pipiens*** larvae to IkI and bay sir are presented in the tables (Tables 42 & 43) and graphically illustrated in figures (Figs. 28 & 29) .

The data in the tables and the figures reveal that the baygon-resistant strain is quite susceptible to IKI and bay sir . The levels of resistance after 24 , 48 & 72 hrs. exposure periods for IKI were 1.48, 1.73 & 1.76 times & 1.56 , 1.81 & 1.32 times, for bay sir indicating no correlation . There were also no significant differences in the susceptibility levels between the normal strain (parent) and the resistant strain, based on the p values ($p > 0.05$) .

Table (42) : Relative susceptilities of the normal and baygon-selected strains of ***Culex pipiens*** larvae after 24,48 & 72 hrs. exposure periods to the insect growth regulator IKI .

Concentration (ppm)	Average mortality (%)					
	Normal strain (N)			Resistant strain (R)		
	24 hr.	48 hr.	72 hr.	24 hr.	48 hr.	72 hr.
0.05	00.0 ± 0.00	05.3 ± 0.68	16.0 ± 0.58	0.0 ± 0.00	2.7 ± 0.33	10.7 ± 0.33
0.50	05.3 ± 0.33	60.0 ± 0.58	82.7 ± 1.33	2.7 ± 0.33	57.3 ± 0.88	74.7 ± 0.73
1.00	36.0 ± 1.00	84.0 ± 1.16	94.7 ± 0.88	22.7 ± 0.67	70.7 ± 1.46	80.0 ± 0.58
1.50	60.0 ± 1.17	097.3 ± 0.33	99.0 ± 0.33	33.3 ± 0.88	80.0 ± 0.58	96.0 ± 1.00
2.50	85.3 ± 0.33	100.0 ± 0.00	100.0 ± 0.00	65.3 ± 1.46	90.7 ± 1.77	98.7 ± 0.33
control	0.0	0.0	1.3	0.0	0.0	2.7
Lc_{50} (ppm)	1.30	0.30	0.13	1.93	0.52	0.23
Slope function	1.85	2.92	3.38	2.06	3.42	3.25
Resistance level	—	—	—	1.48	1. 73	1.76
Tolerance difference	no correlation					

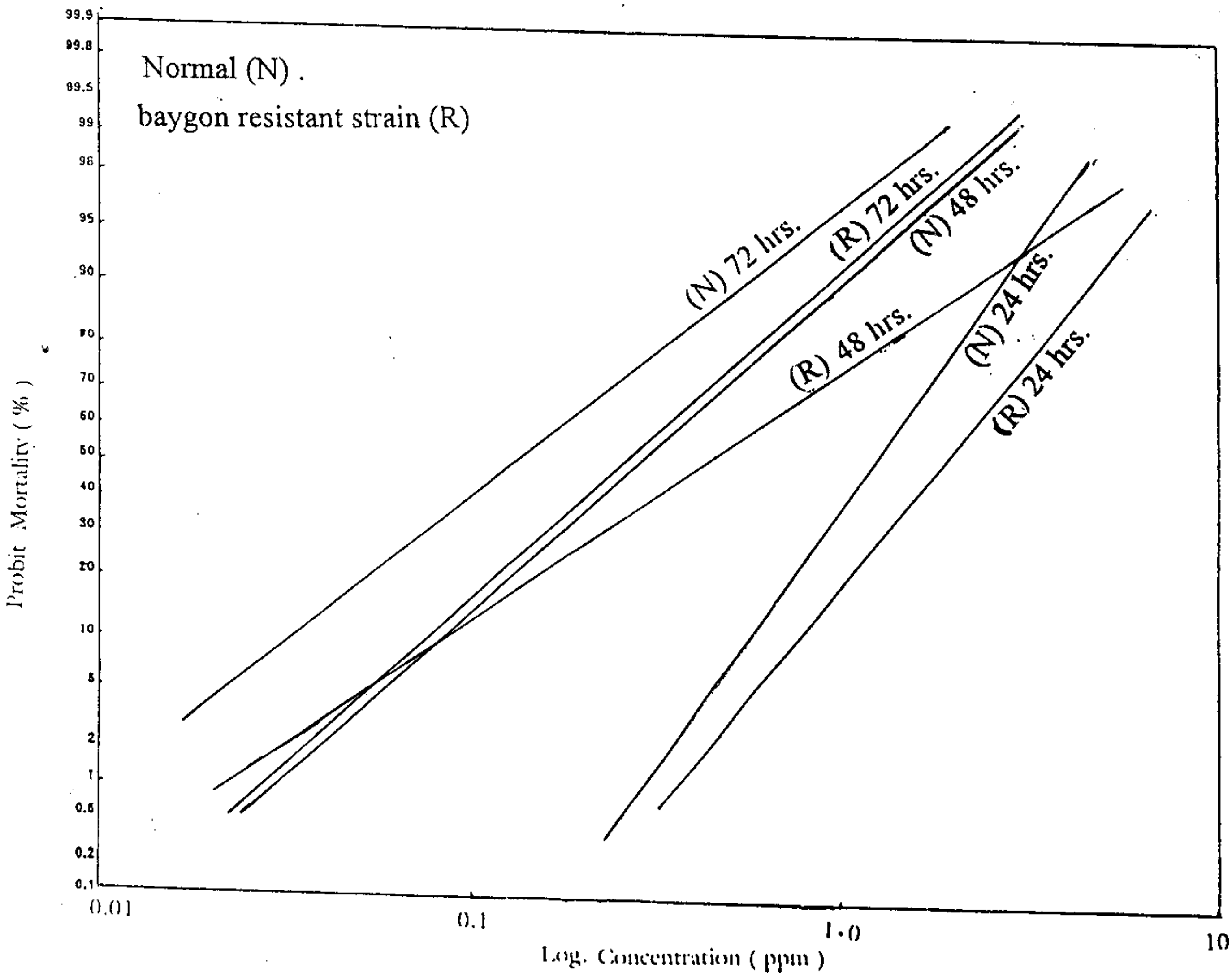

Fig. (28) : Susceptibility levels of normal and baygon-resistant strains of ***Culex pipiens*** larvae after 24, 48 & 72 hrs. exposure periods to IGR IKI .

Table (43) : Relative susceptibilities of the normal and baygon-selected strains of ***Culex pipiens*** larvae at 24, 48 & 72 hrs. exposure periods to the insect growth regulator bay sir .

Concentration (ppm)	Average mortality (%)					
	Normal strain (N)			Resistant strain (R)		
	24 hr.	48 hr.	72 hr.	24 hr.	48 hr.	72 hr.
0.03	0.0 ± 0.0	6.7 ± 0.33	10.7 ± 0.33	0.0 ± 0.0	2.7 ± 0.33	8.0 ± 0.58
0.10	0.0 ± 0.0	10.7 ± 0.67	40.0 ± 0.47	0.0 ± 0.0	13.0 ± 0.88	24.0 ±1.00
0.20	5.7 ± 0.68	33.7 ± 0.88	61.3 ± 1.73	1.3 ± 0.33	29.3 ± 1.45	57.3 ± 1.45
0.65	14.7 ± 0.33	81.3 ± 0.33	85.3 ± 1.20	6.7 ± 0.60	74.7 ± 0.88	78.7 ± 0.67
1.30	48.0 ± 1.0	92.0 ± 1.16	96.0 ± 1.0	30.7 ± 1.90	80.0 ± 0.58	84.0 ± 0.58
3.25	57.3 ± 0.88	99.0 ± 0.33	100.0 ± 0.0	45.3 ± 1.00	86.7 ± 1.20	89.3 ± 0.88
5.00	85.3 ± 0.33	100.0 ± 0.0	100.0 ± 0.0	74.7 ± 0.67	89.3 ± 1.45	96.0 ± 0.58
control	0.0	0.0	2.7	0.0	0.0	2.7
Lc_{50} (ppm)	1.79	0.26	0.19	2.80	0.47	0.25
Slope function	3.63	3.36	3.16	3.11	4.76	5.20
Resistance level	—	—	—	1.56	1.81	1.32
Tolerance difference	no correlation					

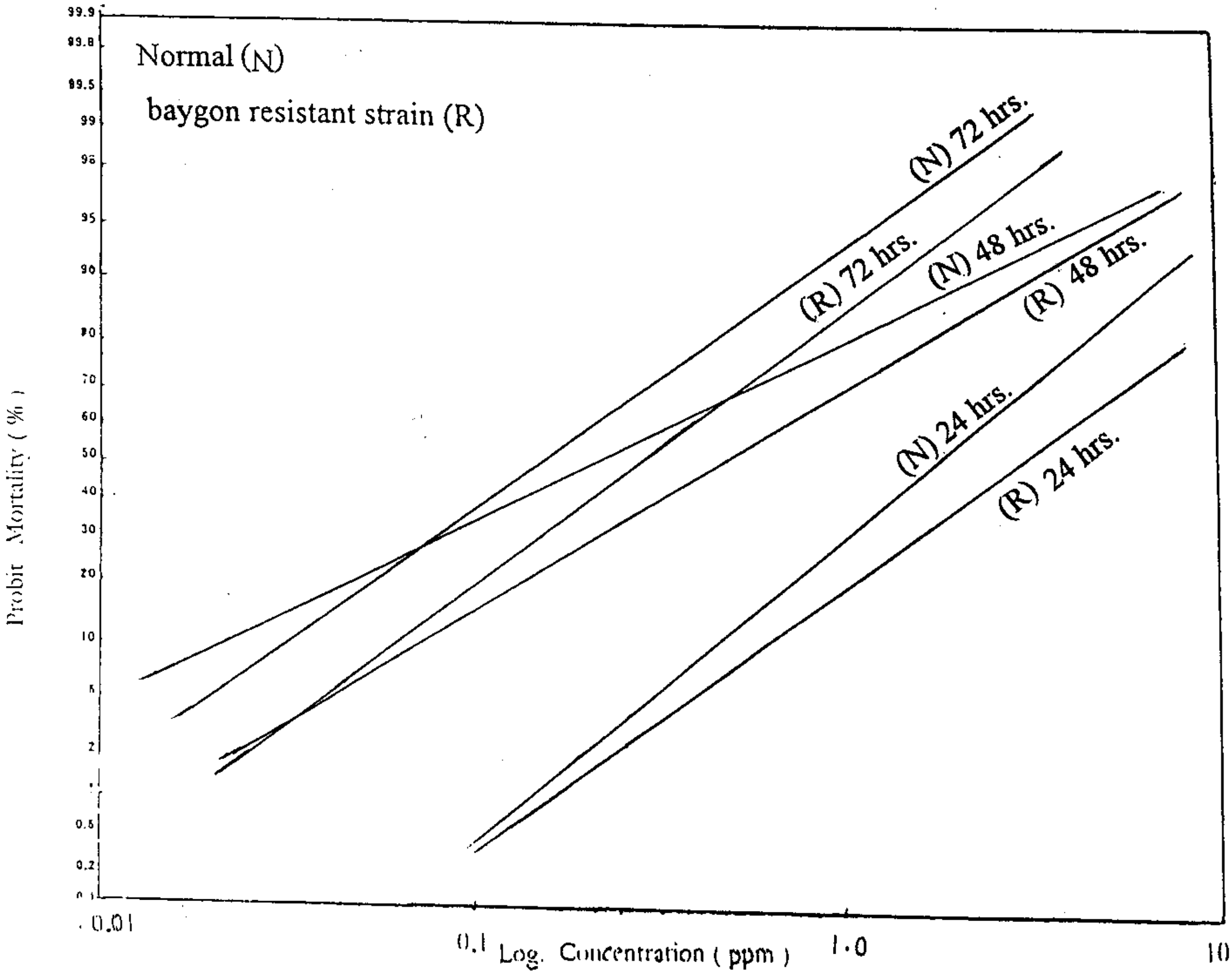

Fig. (29) : Susceptibility levels of normal and baygon-resistant strain of ***Culex pipiens*** larvae after 24, 48 & 72 hrs. exposure periods to the IGR bay sir .

4- Joint action of baygon with various insecticides and IGRs against resistant strain of *Culex pipiens* larvae :

The joint action of various insecticide mixtures was investigated by mixing insecticides and IGRs in proportion to the concentrations equivalent to half of Lc_{50} values .

The potencies of baygon and other insecticides mixtures on the larvae of the resistant strain are demonstrated in the table (Table 44) .

The results revealed that baygon produced synergistic effects (potentiation) with permethrin and diazinon . An additive effect was observed with sumicidin and sumithion . Antagonism effect was only produced with dursban .

The joint action of baygon insecticide and the IGRs (IKI and bay sir) is shown in the table (Table 45) .

Baygon produced synergistic effect (potentiation) with IKI after 24 hour exposure period . However, additive effects were produced with IKI and bay sir after 48 & 72 hrs. and 24 , 48 & 72 hrs. of treatments, respectively .

Table (44) : The joint action of baygon with various insecticides against baygon-resistant larvae of *Culex pipiens* .

Insecticide mixture	Concentrations equivalent to half the Lc_{50}'s (ppm)	Mortality (%)		Cotoxicity factor
		Expected	Observed	
Baygon (alone)	61.5 ——	50	49.3	——
+ Sumithion	61.5 + 0.045	50	48.0	- 4.0
+Diazinon	61.5 + 0.38	50	62.7	+ 25.4
+Dursban	61.5 + 0.0072	50	38.7	- 22.6
+Sumicidin	61.5 + 0.0034	50	57.3	+ 14.6
Permethrin	61.5 + 0.0022	50	65.3	+ 30.7

Table (45) : The joint action of baygon with two IGRs (IKI and bay sir) against baygon-resistant larvae of ***Culex pipiens*** .

IGRs mixture	Concentrations equivalent to half the Lc_{50}'s (ppm)	Exposure time (hr.)	Mortality (%)		Cotoxicity factor
			Expected	Observed	
Baygon + IKI	**61.5 + 1.93**	24	50	68.0	+ 36.0
		48	78.7	94.0	+ 19.44
		72	96.3	100	+ 3.84
Baygon + Bay Sir	**61.5 + 1.80**	24	50	57.3	+ 14.6
		48	77.3	81.3	+ 5.17
		72	84.0	89.3	+ 6.31

5- Synergism and antagonism of baygon against baygon-resistant strain of *Culex pipiens* larvae .

The purpose of this experiment is to investigate the synergistic effect of some synergists additive i.e. piperonyl-butoxide (p.b.), sesame oil (sesamex) and clove oil tested against baygon-resistant strain of *Culex pipiens* larvae .

The three synergists were bioassayed alone with the concentrations tested against the larvae and showed no apperciable toxicity at the highest concentration used .

A series of mixtures containing baygon and different concentrations of each synergist was tested against the resistant-strain .

The results are presented in the tables (Tables 46 - 49) and shown graphically in the figures (Figs. 30 - 33).

5.1. Effect of piperonyl-butoxide (p.b.) :

Results given in the table (Table 46) and illustrated in the figure (Fig. 30) showed the synergistic effect of p.b.when used in combination with the baygon insecticide .

The additions of 0.001 , 0.005 & 0.01% of piperonyl-butoxide to different concentrations of baygon were decreased the Lc_{50} values from 61.75 to 17.78 , 10.07 & 9.16 ppm , respectively .

In other words, the toxicities of baygon were increased by 3.47 , 6.13 & 6.74 fold when they were used in combination with the above mentioned concentrations of p.b.,respectively .

The resistance ratios of the three mixtures were declined from 308.7 fold to 88.9 , 50.35 & 45.8 fold .

The effect of synergist p.b. as represented by the mortality regression lines (Fig. 30) clearly indicated that p.b.changed the positions of the regression lines towards susceptibility .

5.2. Effect of sesame oil :

Results given in the table (Table 47) and illustrated in the figure (Fig. 31) showed the synergistic effects of sesamex when it was used in combination with baygon insecticide against baygon-resistant strain of ***Culex pipiens*** larvae . The data show that the addition of sesame oil concentrations of 1 , 2 & 4 % to baygon was decreased their Lc_{50} values to 13.04 , 7.78 & 6.20 , respectively, and hence increased its efficiency . This was noticed from the cotoxicity coefficient which increased at the concentration 4% to 9.96 times ; whereas 2 % & 1 % of sesame oil increased the toxicity of baygon by 7.94 and 4.74 times, respectively . The cotoxicity coefficients of the three mixtures indicated a clear effectiveness of sesamex on increasing the toxicity of baygon . The activity was always concentration dependent .

The resistance ratios at the above mentioned concentrations were declined from 308.7 fold to 65.2 , 38.9 & 31.0 fold, respectively . The presence of sesame oil is considerably enhanced the toxicity of baygon regarding from the mortality regression lines (Fig. 31) .

5.3. Effect of clove oil :

The data of the synergistic effect of clove oil when it was used in combination with bagyon insecticide against bagyon-resistant strain of

Culex pipiens larvae are shown in the table (Table 48) and graphically represented in the figure (Fig. 32).

The presented data show that the Lc_{50} values for baygon in combinations with concentrations of 0.25 %, 0.58 % & 1 % clove oil were 51.26, 23.70 & 18.84 ppm, respectively.

The cotoxicity coefficient of the three mixtures were 1.20, 2.61 & 3.28 times, respectively, indicating a slight increase in the toxicity of bagyon, particularly at higher concentrations of clove oil.

On other words clove oil dropped the resistance levels from 308.7 fold to 256.3, 118.5 & 94.2 fold at the concentrations of 0.25 %, 0.5 % & 1 % respectively.

The cotoxicity coefficients of different combinations of bagyon and synergists against bagyon-resistant strain of ***Culex pipiens*** larvae are summarized in the table (Table 49) and illustrated graphically in the figure (Fig. 33).

From the table and the figure the cotoxicity coefficient indicated a clear effectiveness of the synergists, sesame oil and piperonyl-butoxide on the toxicity of baygon, the activity of synergist was always concentration dependent.

The statistical analysis of the data revealed that the larval exposure to mixtures of baygon and different concentrations of the three synergists tested (p.b., sesame oil, clove oil) were induced very high significant differences in the mortality of the larvae at the highest concentrations ($p < 0.001$) and significant differences at the concentration 0.005 %, 2 % and 0.5 %, respectively ($p < 0.05$), whereas, no significant differences were observed at the lowest concentrations ($p > 0.05$).

Table (46) : Susceptibility of baygon-resistant strain of ***Culex pipiens*** larvae to baygon and its combinations with different concentrations of piperonyl-butoxide .

Synergist conc. (%) / Baygon conc. (ppm)	Average mortality (%)			
	0.0	0.001	0.005	0.01
5	—	—	5.0 ± 0.33	18.3 ± 0.67
6	—	10.0 ± 0.58	31.7 ± 0.88	35.0 ± 0.58
10	—	26.7 ± 0.88	50.0 ± 1.16	60.0 ± 1.16
20	0.0	—	—	80.0 ± 1.53
30	5.3 ± 0.88	70.0 ± 1.16	88.3 ± 1.45	95.0 ± 1.0
50	25.0 ± 1.62	90.0 ± 0.67	—	—
60	46.7 ± 0.88	—	—	—
80	72.7 ± 1.73	—	—	—
Lc_{50} (ppm)	61.75	17.78	10.07	9.16
Slope function	1.49	2.31	2.65	2.21
R.R	308.7	88.9	50.35	45.8
S.F.	0.0	3.47	6.13	6.74

R.R = Resistance ratio .
S.F. = Synergistic factor .

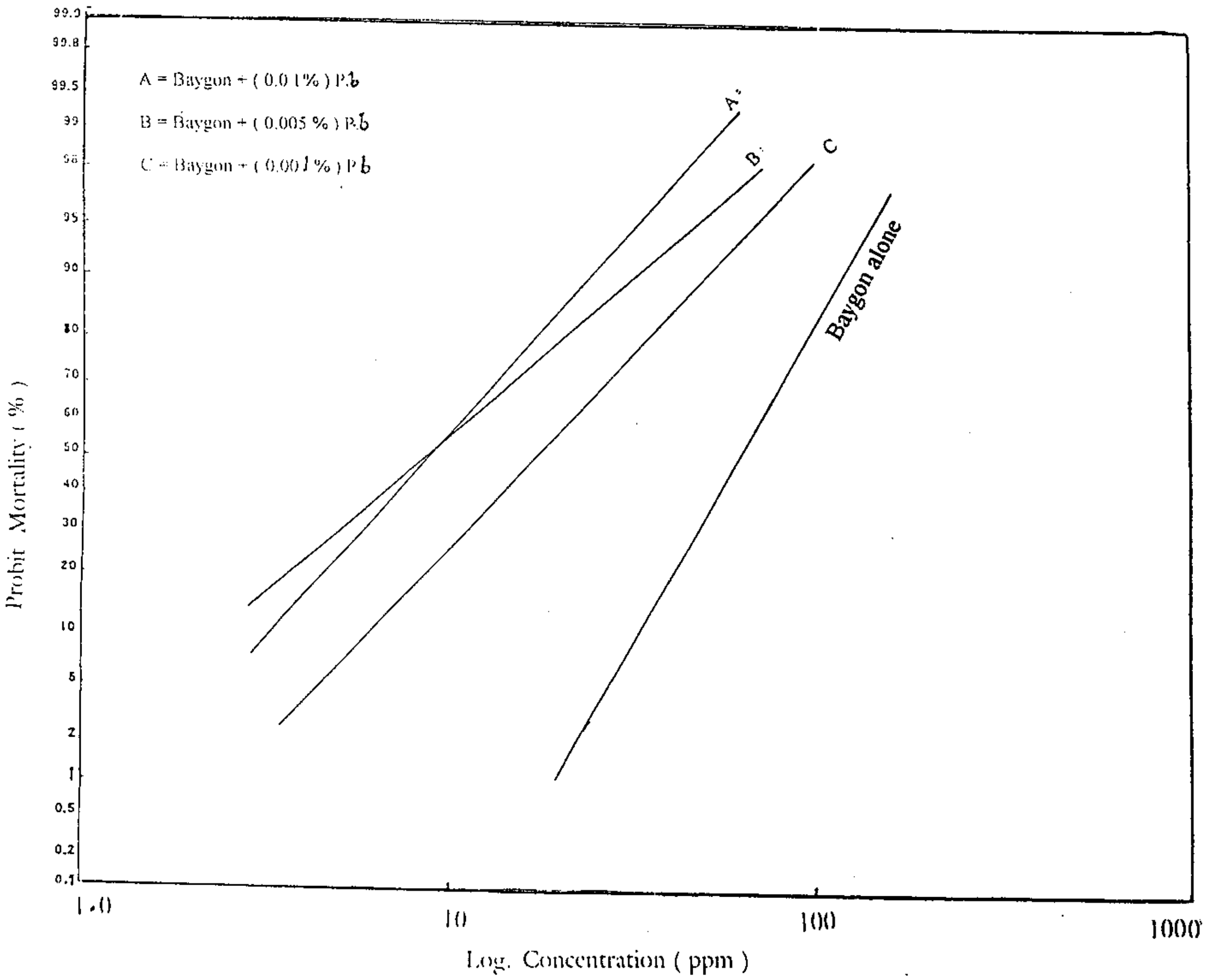

Fig. (30) : Log. Concentration probit mortality regression lines of baygon-resistant strain of *Culex pipiens* larvae exposed to a mixture of baygon and different concentrations of the synergist p.b.

Table (47) : Susceptibility of baygon-resistant strain of ***Culex pipiens*** larvae to baygon and its combinations with different concentrations of sesame oil .

Baygon conc. (ppm) \ Synergist conc. (%)	Average mortality (%)			
	0.0	1	2	4
5	—	20.0 ± 0.58	31.7 ± 1.33	36.7 ± 0.33
10	—	46.7 ± 0.33	66.7 ± 1.20	75.0 ± 1.16
20	0.0 ± 0.0	60.0 ± 1.0	82.0 ± 1.0	88.3 ± 0.88
30	5.3 ± 0.88	76.7 ± 0.88	90.0 ± 0.58	96.7 ± 0.68
50	25.0 ± 1.62	—	—	—
60	46.7 ± 0.88	—	—	—
80	72.7 ± 1.73	—	—	—
Lc_{50} (ppm)	61.75	13.04	7.78	6.20
Slope function	1.49	3.52	2.93	2.48
R.R	308.7	65.2	38.9	31.0
S.F.	0.0	4.47	7.94	9.96

R.R = Resistance ratio .
S.F. = Synergistic factor .

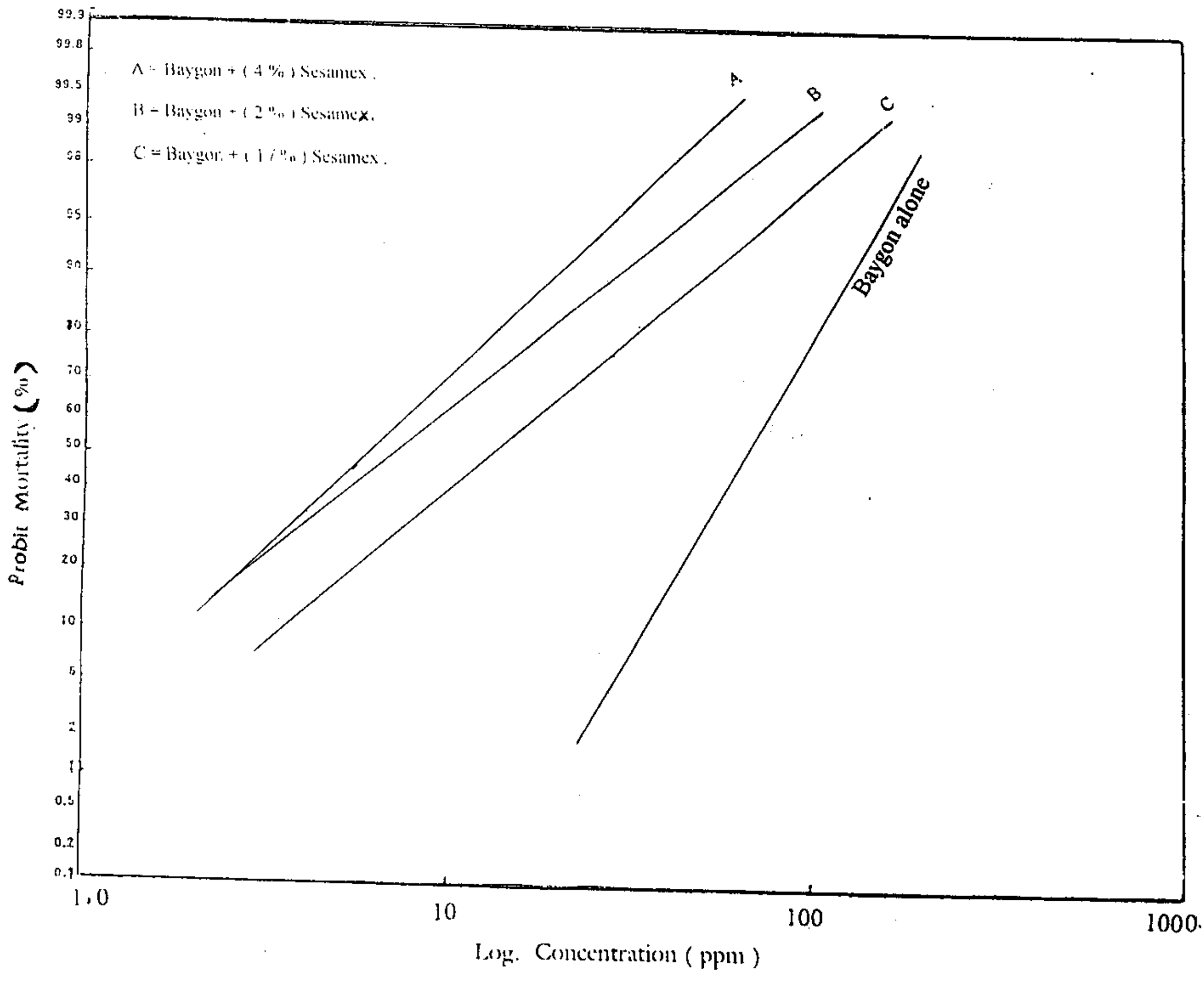

Fig. (31) : Log- concentration-probit mortality regression lines of baygon-resistant strain of ***Culex pipiens*** **larvae exposed to a mixture of** baygon and different concentrations of the synergist sesame oil .

Table (48) : Susceptibility of bagyon-resistant strain of ***Culex pipiens*** larvae to baygon and its combinations with different concentrations of clove oil .

Synergist conc. (%) / Baygon conc. (ppm)	Average mortality (%)			
	0.0	0.25	0.5	1
10	—	—	16.7 ± 0.33	28.3 ± 0.68
20	0.0 ± 0.0	8.3 ± 0.88	40.0 ± 1.0	46.7 ± 0.88
30	5.3 ± 0.88	13.7 ± 1.0	56.7 ± 0.88	71.7 ± 1.45
40	24.0 ± 0.33	31.7 ± 1.33	78.3 ± 1.16	80.0 ± 1.0
60	46.7 ± 0.88	68.3 ± 1.67	—	—
80	72.7 ± 1.73	—	—	—
Lc_{50} (ppm)	61.75	51.26	23.70	18.84
Slope function	1.49	1.81	2.25	2.60
R.R	308.7	256.3	118.5	94.2
S.F.	0.0	1.20	2.61	3.28

R.R = Resistance ratio .
S.F. = Synergistic factor .

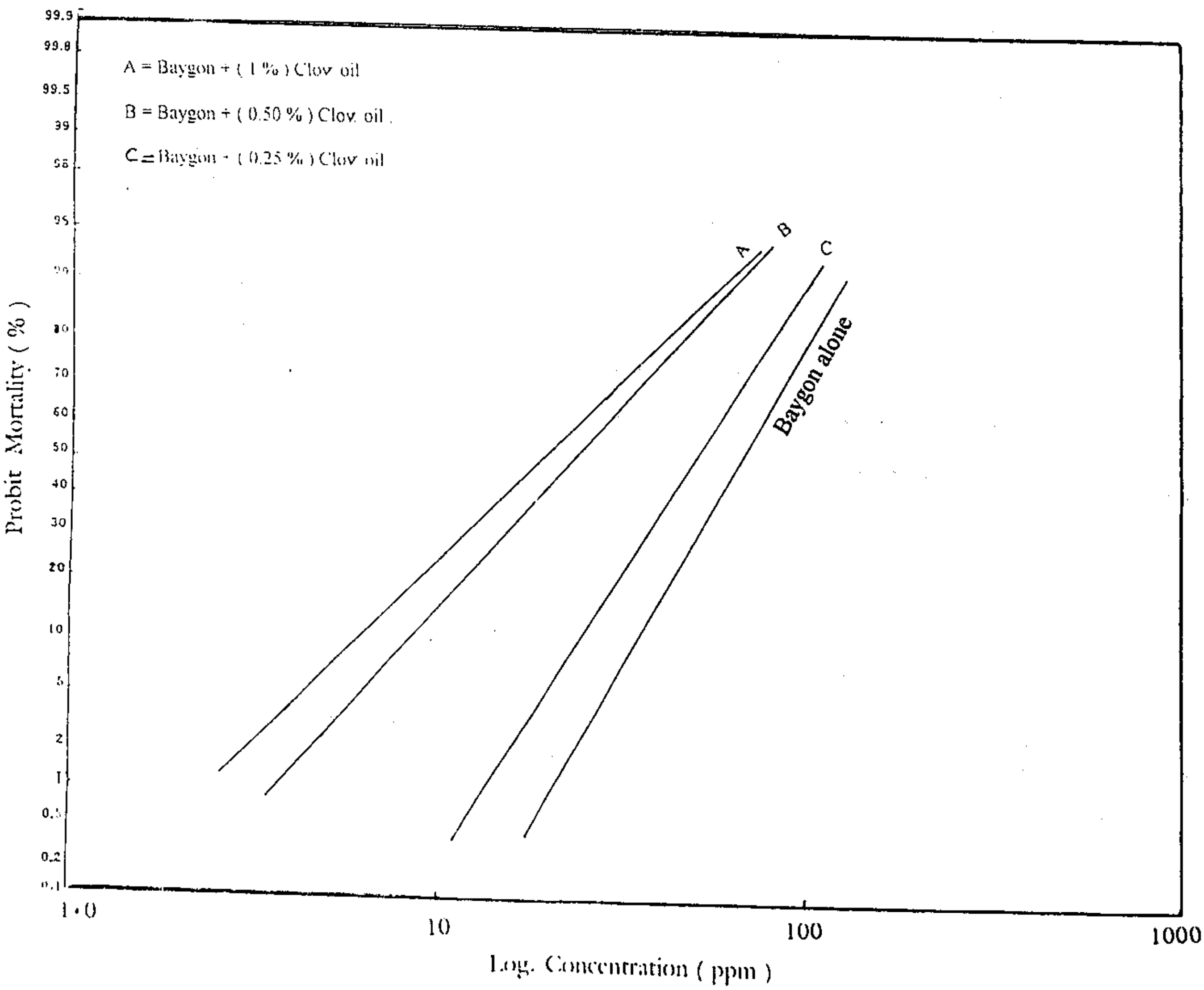

Fig. (32) : Log . concentration probit mortality regression lines of baygon-resistant strain of ***Culex pipiens*** larvae exposed to a mixture of baygon and different concentrations of clove oil .

Table (49) : Cotoxicity coefficient of different combinations of baygon insecticide and synergists tested on baygon-resistant strain of ***Culex pipiens*** larvae under laboratory conditions .

Synergist	Concentration (%)	Cotoxicity coefficient
Piperonyl-butoxide	0.001	3.47
	0.005	6.13
	0.01	6.74
Sesame oil	1	4.74
	2	7.94
	4	9.96
Clove oil	0.25	1.20
	0.5	2.61
	1.0	3.28

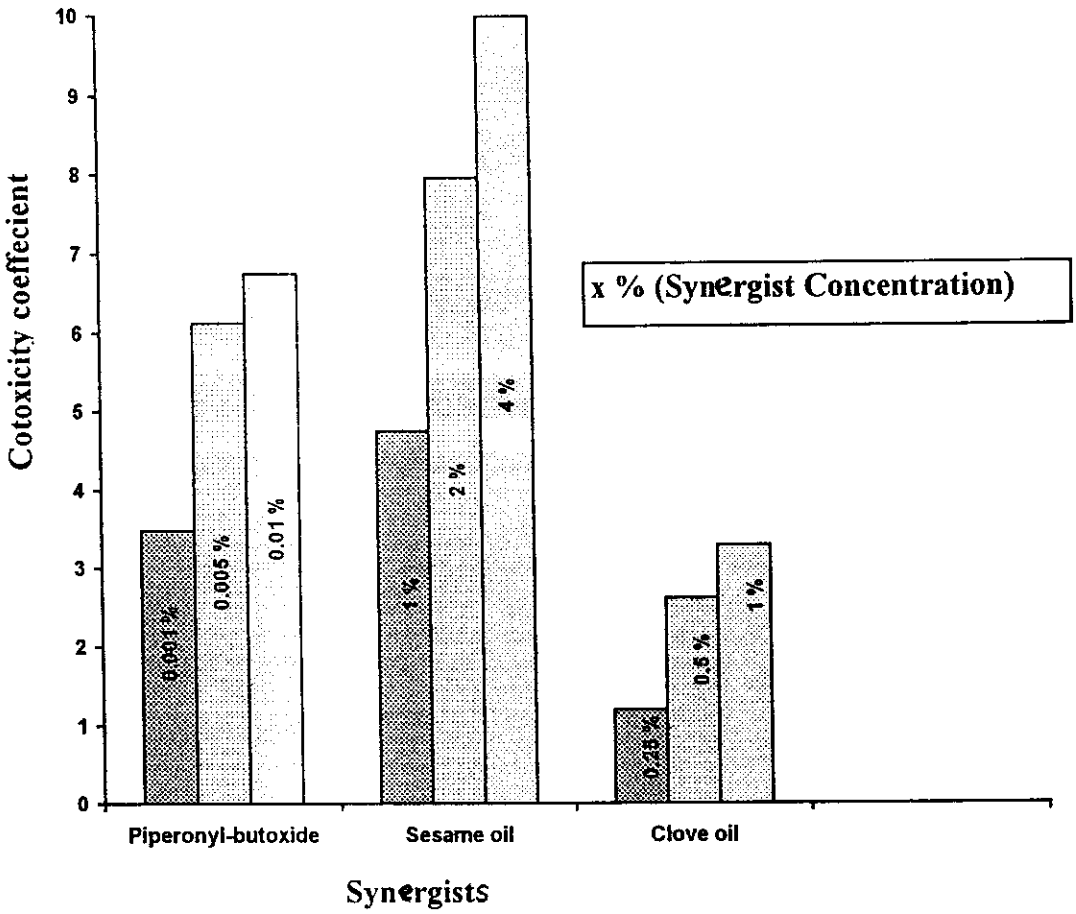

Fig. (33) : Cotoxicity coefficient of different combinations of baygon insecticide and synergists tested against baygon-resistant strain of *Culex pipiens* larvae .