SUBLETHAL EFFECTS OF LOW PERMETHRIN EXPOSURE ON THE DEMOGRAPHY PARAMETERS OF *LUCILIA CUPRINA* (WIEDEMANN) (DIPTERA: CALLIPHORIDAE).

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INTRODUCTION

The blow fly *Lucilia cuprina* is a major ectoparasite of sheep *Ovis aries* L. causing major economic loss to wool industry (Beck and Meppem, 1985). The life table of *L. cuprina* population under favorable conditions was studied by Abou Zied *et al*. (2003).

The effects of pesticides and other toxicants on the demography of different insect populations have been the subjects of a number of studies (Longstaff and Desmarchelier (1983); Karamarz and Laskowski (1997); Wennergren and Stark (2000); Walthall and Stark (1997a); Van Straalen and DeGoede (1987). Unfortunatley, work on the Diptera especially blowflies is still rare. Recent evaluations indicated that ecotoxicological analysis, based on population growth rate, results in more accurate assessments of the impacts of pesticides (Stark and Banks, 2003). So the question is what will happen to *L. cuprina* population after the treatment with a single dose (LC_{10}) of permethrin? Therefore, the aim of this paper is to evaluate the population fitness as a state of demographic toxicology using the analysis of the life history parameters and other parameters of population growth rate, the intrinsic rate of increase, the finite rate of increase and the net reproductive rate. The behavior of the population under the stress of the sub-lethal dose from one generation to the other until reaching recovery is studied and finally the change of the population strategy from one generation to the other is recorded.

MATERIAL AND METHODS

The original colony of *L. cuprina* was collected from El-Arbaeen fish market, Suez Governorate, Egypt in 1995 and was reared in the laboratory in the Department of Entomology, Cairo University following the method described by Abou Zied (2001). The lethal effect was determined by applying different concentrations of permethrin (1.86, 0.93, 0.186 0.093 0.00186%) to food material of 1-day old third larvae. The application was

carried out by adding 0.5 ml of permethrin (dissolved in acetone) on 5 g minced beef meat. For each concentration, 100 larvae were used in three replicates. Mortality was corrected according to Abbott's formula (1925). Regression curve of doses against mortality were graphed according to Finny (1971). The lethal dose that kills 10% (LD_{10}) was calculated and used to study the effect on the life table of the treated insects.

Life table study was carried out by feeding 100, 1-day old third instar larvae, on 5g minced meat mixed with 0.5 ml of 5.4 x 10^{-3}% permethrin (=LC_{10}). After 24 hrs, survived larvae were removed from this media and were fed on new fresh minced meat under observation till adult emergence. Emerging virgin males and females were isolated in pairs in a beaker (100 cm) covered with a piece of muslin and fastened with a rubber band. A piece of fresh beef meat (5 g) was offered daily for female as an oviposition site. At night, the beef meat was removed and the number of eggs was recorded. Hatching larvae of each pair were separated and reared till the adult stage. The process of rearing continued till the 2nd generation. No attempts were made to control the photoperiod; fluorescent lamps were used to illuminate the laboratory during the daytime.

Life table analysis

Raw data of *L. cuprina* were analyzed according to the theory of age stage, two-sex life table (Chi and Liu, 1985; Chi, 1988) by using TWOSEX computer program (Chi 2005). This program is available at: http://nhsbig.inhs.uiuc.edu/wes/chi.html (Illinois Natural History Survey, US). The age-stage survival rate, the distribution of mortality rate, the age-stage life expectancy and the stable age-stage distribution were calculated. Furthermore, the means and standard errors of the intrinsic rate of increase *(r),* the net reproductive rate (R_0), the mean generation time *(T)* and the finite rate of population increase (λ) were calculated by using the jackknife method (Sokal and Rohlf, 1981; Meyer *et al.,* 1986).

RESULTS AND DISCUSSION

Mortality of *L. cuprina* follows a dose dependant manner.LC_{50} and LD_{10}were 0.164% and 0.0054%, respectively (Fig. 1).

Population dynamics:

Longevity and mean generation time

Data represented in table (1) revealed that, all stages of the treated parent population lived longer as compared with the control being 8.13, 10.41, 41.5 and

50.43 days for the larva, pupa, male and the female, respectively. The mean generation time of this group reached 29.29 days against 18.8 days for the control. Statistical analysis revealed a significant increase ($P<0.01$) in the mean generation time between the control and the treated one (table2).

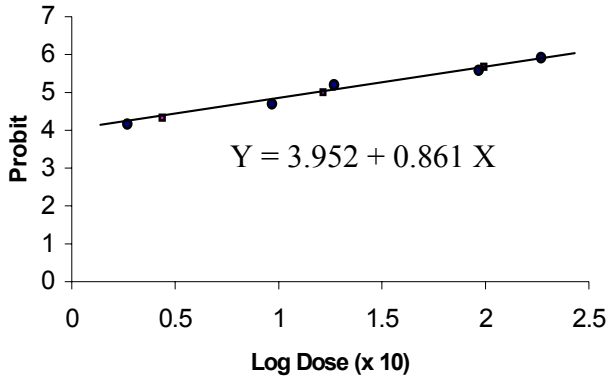

Figure 1: Regression curve representing the effect of different doses of permethrin and mortality of 3rd instar *Lucilia cuprina* larvae.

TABLE (I)

The effect of permithrine on the longevity of *L .cuprina* population

Stage	Mean longevity±SE			
	Control	Treated	1st generation	2nd generation
Larva	5.03±0.07	08.13±1.45	7.31±1.45	05.7±2.26
Pupa	5.40±0.11	10.41±2.76	6.03±1.09	7.51±0.78
Male	23.69±1.13	41.5±10.45	28.54±08.89	32.54±4.28
Female	31.91±1.29	50.43±14.98	37.88±16.45	40.85±4.19

In case of the first generation, longevity decreased to 7.31, 6.03, 28.54 and 37.88 for larva, pupa, male and the female, respectively. Also the recorded mean generation time decreased significantly ($P<0.05$) to 25.22 days as compared with the treated group and was still significantly high ($P<0.01$) when compared with the control one (table 2).

Meanwhile, in the second generation (where the longevity values reached 5.7, 7.51, 32.54 & 40.85 for the larva, pupa, male and the female, respectively) a significant decrease ($P<0.01$) in the mean generation time to 21.85 days was recorded when compared with the treated group. Such value did not increase significantly ($P>0.05$) from that value of the control (table 2). This result suggested that the population life span or generation time began to reach recovery during the second stage.

Similar observations were obtained by Robert and Olson (1989) for *Culex quinquefasciatus*. They found that the sublethal dose of malathion increased the time to pupation and also time to emergency. Reyes *et al.* (1990 and 1992) found that, *Aedes aegypti* females lived longer than the females of the control (from 26 days to 31 days) when treated during the larval stage with sublethal doses of Abates. However, Sawby *et al*. (1992) recorded decrease in female longevity of *A*. *aegypti* when treated during larval stage with sublethal dose of methoprine. Also, Vasuki (1992) recorded sharp decrease in the female longevity of *Culex quinqefasciatus***,** *Anopheles stephensi* and *A*. *aegypti* treated as larvae with sublethal dose of Hexaflumuron (IGR). Acheampong and Stark (2004) reported a shorten mean generation time from 14.83 to 12.85 and 13.14 days when adult *Diaretiella rapae* were treated with sylard309 and pymetrozine.

Fecundity and the net reproductive rate

Data displayed in figure (2) revealed that, the pattern of female egg-laying differed completely when comparing the four studied groups. Females of the control group showed only 8 peaks meanwhile 14 peaks were observed in case of the females treated during their larval stage (only 8 peaks in case of the females of the 1st generation and 6 peaks in case of the 2nd generation).

The oviposition pattern of the females of the control group showed 5 peaks of higher egg laying activity out of the 8 peaks during their early life span (excluding the last peak where only 2 females were alive). Only 2 major peaks were found in case of the second generation during the period from 9-12 days; 2 major peaks (9-11 & 11-14) in case of the treated females; one major peak (24-26 days) in case of the 1st generation and only one major peak (14- 17 days) in case of the treated females.

It was also clear that treated females showed expanded oviposition activity during their prolonged life span since 4 clear peaks of considerable values were recorded from 41- 50 days.

Data revealed a dramatic significant decrease ($P<0.01$) in the average eggs laid by females of first generation (49.41 eggs/female/life span) as compared with control (131eggs/female/life span). This yield increased to 125.25 eggs/life span in the second generation showing no significant difference from the control value ($P>0.05$), suggesting that the population recovered to the normal. All females required in average a pre-ovipositional period of 2.5 days to lay the first egg batch.

Despite the unsignificant decrease ($P>0.05$), in the gross reproductive rate of the female, from 445.69 for the control to 400 and 226 for the treated population

at the first generation, a marked insignificant (P>0.05) overlap to 380 eggs was recorded during the second generation.

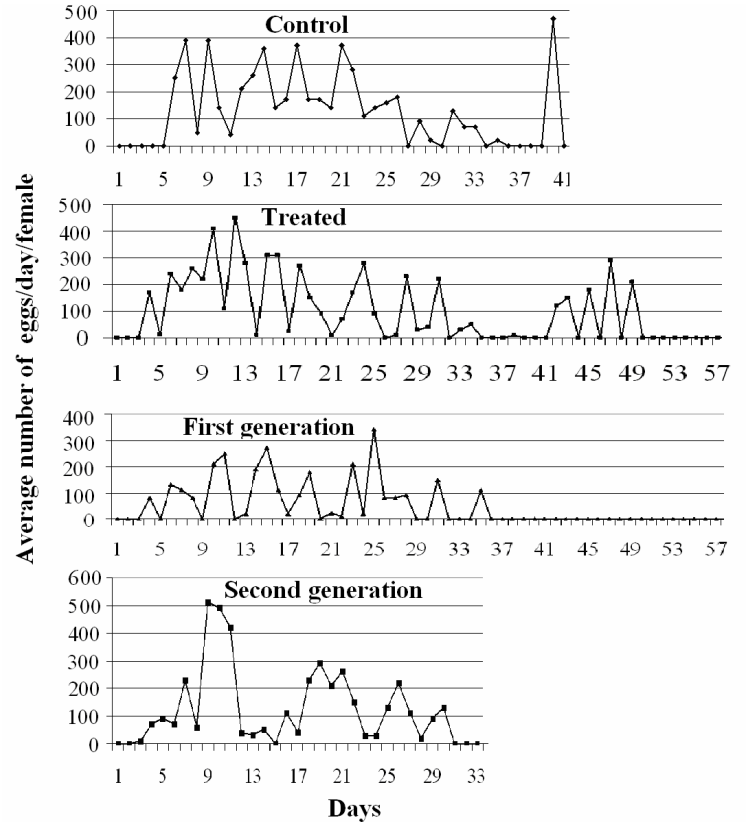

Fig. 2: Effect of permithrine on daily fecundity of *L. cuprina* population.

Similar results were reported by Reyes *et al.* (1990) for *Aedes aegypti*. They found that when the sublethal concentrations of Abate (temephos) were applied to the larvae, females oviposited only in the first 2 gonotrophic cycle; meanwhile control females laid a few eggs after taking the third blood meal. Dosages of 0.009, 0.013 and 0.015 mg/liter of Abate decreased the mean egg production per gonotrophic cycle to 37, 47 and 69%, respectively, in relation to the control. Robert and Olson (1989) and Aguilera *et al.* (1994) recorded a significant reduction in egg production for *Culex quinqefasciatus* females when treated, as larvae, with the sub lethal dose (0.1 LC_{50} & LC_{30}) of Malathion.

Data displayed in table (2) showed insignificant (P>0.05) decrease between the net reproductive rate of the treated females to 102 instead of 106 for the same value of the control. However, females of the first generation suffered severe

significant decrease (P<0.05) to a minimal value of 39.64. The population showed maximal insignificant increase to 192.2 during the life span of the females of the second generation. Similar findings were reported by Acheampong and Stark (2004) for *Diaeretiella rapae*. Both the control and the treated adults showed similar Ro values when the adults were treated with pymetrozine. In contrast, the authors recorded a reduction in Ro value when the adult *D. rapae* were exposed to Sylgard 309. Also, Wennergren Stark and (2000) recorded reduction in R_0 value for *Acyrthosiphon pisum* with neem.

TABLE (II)

The effect of permithrine on the life table of *L. cuprina* population.

Parameters	Control	Treated	1st generation	2nd generation
Intrinsic rate of increase (r)	0.001[a]±0.24	0.16±0.01 [b]	0.15±0.02 [b]	0.01 [a]± 0.24
Mean generation time (T)	19.8±0.4 [a]	29.29±1.22 [b]	25.22±1.28 [c]	0.28 [ac]±21.85
Net reproductive rate (R_0)	106.1±17.9	102±26.94	16.17±39.64	192.2±34.37
Finite rate of increase(£)	1.26±0.012[a]	1.17±0.01 [b]	0.02 [bc]± 1.16	0.014 [a]± 1.27
Gross reproductive rate	445.69±48.32	400±14	86 ± 226	76 [a]± 380

Survivorship curves

The data presented in Fig. (3) revealed that, the control showed a logarithmic scale which obeys type (ÍÍÍ) curve as described by Slobodkin (1962) with constant mortality rate. However, the second generation survivorship scale seems here to be more or less resembling type (Í). The mortality rate of the second generation acts most heavily on the adult individuals. In case of the survival-ship scales of the treated and the first generation, a limited mortality rates were recorded during the early days (13 up to 16 days) of the population life span, respectively. Meanwhile, during the rest of the life span, the survivorship curves obeys type (III) curve but with expanded individual life span.

The intrinsic and the finite rates of increase

The intrinsic rate of daily increase (*r*) of the treated parent population and first offspring generation decreased to 0.16 and 0.15, respectively for treated and first generation (table2). Statistical analysis revealed significant differences (P<0.01) between the intrinsic rate of increase of the treated parent and first offspring

generation in comparison with that value of the control (r 0.24). But during the second generation, this rate increased to equilibrium compared with the control (0.24). There was no significant difference between the intrinsic rate of increase of the second offspring generation and the control population (P>0.05). Similarly, the finite rate of increase (λ) was significantly decreased (P<0.01) to 1.17 and 1.16 for the treated and the first generation, respectively. During the second generation, this value increased to 1.27, which was not significantly different from the control (P<0.05), Table 2.

Similar to the present results, Acheampong and Stark (2004) reported a decrease in the r m value of *D. rapae* when treated with Sylgard 390.

In contrast, Acheampong and Stark (2004) recorded an increase in the value of r m when *D. rapae* was exposed to pymetrozine.

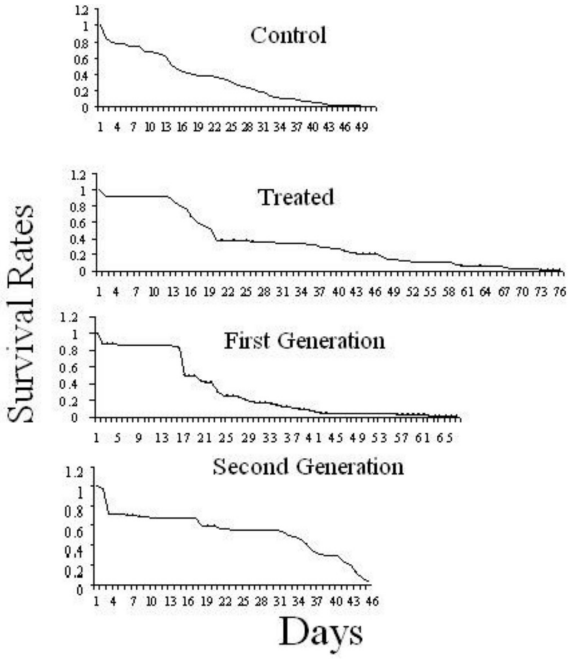

Figure 3. Effect of permithrine on survival-ship of *L. cuprina* population.

Life table analysis

The sub-lethal dose caused significant changes (P<0.01) on the intrinsic rate of increase (*r*), the mean generation time (*T*) and the finite rate of increase (*λ*) for the survived treated parent population of *L. cuprina* as well as their first progeny.

Female mean fecundity of treated parent population was not affected by the sub-lethal dose but their female progeny was significantly reduced (49.3). However, a recover to the normal level by the second generation was observed.

Data of the first generation (table 2) suggested (r-k) strategy with a low net reproductive rate (R_0 = 39.64) during a relatively significant ($P < 0.05$) longer life span (T = 25.22) with a significantly low rate of increase (r = 0.15). Treated population showed longer life span (29.29 days) compared with 19.8 days for the control, and relatively high reproductive rate (R_0=102) with a significant low rate of increase (0.16). But during the second generation, the population regained its r-strategy establishing a higher intrinsic rate of increase (0.24) with high reproductive rate (R_0 = 192.2) and short life span (T = 21.15) if only those survived individuals are used in life table study, then there should be no preadult mortality.

SUMMARY

The application of a single sublethal dose (LC_{10}) of permethrin on the early third instar larvae of *L. cuprina* caused a dramatic decrease in the net reproductive rate (R_0), the finite rate of increase and the intrinsic rate of increase. The mean generation time (T), however, was extended during the first offspring generation. The population successfully overcame such effects during the second offspring generation, and there were no significant differences between the life table parameters of the treated population and the control one. Obtained data suggested that *L. cuprina* population changed its strategy from r-strategist (control) to r-k strategist during the first generation and recovered to healthy one (r-strategist) during the second generation.

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