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COMBINED EFFECTS OF GAMMA RADIATION AND SOME PHYSICAL FACTORS ON THE RATE OF DEVELOPMENT OF *CULEX PIPIENS COMPLEX(L.)*

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التأثير المزدوج لاشعة جاما وبعض العوامل الطبيعية على معدل النمو لبعوضة الكيولكس بيبينز

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يهتم البحث الحالي بدور بعض العوامل الطبيعية منفرده أو مقرونة بأشعة جاما على معدل النمو في الجيل الأول لبعوضة الكيولكس بيبنز والمعاملة في طور العذراء الأم . وقد بينت النتائج أنه لا يوجد تأثير محسوس على فترة حضانة البيضة . وقد زادت فترة نمو اليرقة عندما عرضت العذراء الأم للحرارة المنخفضة (١٠م) أو الرطوبة المنخفضة (٣١٪) أو عندما استخدم أي من العوامل الطبيعية مقرونة بالاشعاع (٦٠ جراي) ، وقد توقف نمو اليرقات تماما في بعض التزاوجات عندما شعت العذراء بعد تعرضها للتفريغ الجزئي (٠.١ تورشيللي) أو الرطوبة المنخفضة . وفي معظم المعاملات ازدادت فترة العذراء . أما نسبة التعذر فقد انخفضت عند جميع المعاملات وخاصة عندما اقترن التشعيع بالتفريغ الجزئي أو الحرارة المنخفضة حيث توقف التعذر تماماً . وعلى العموم فإن نسبة خروج الحشرات البالغة من الشرنقة قد قلت عند جميع المعاملات وتوقف الخروج عندما اقترنت أشعة جاما بالتفريغ الجزئي أو الحرارة المنخفضة أو الرطوبة المنخفضة .

Key Words: Gamma radiation, partial vacuum, temperature, oxygen, relative humidity, *Culex pipiens*.

ABSTRACT

The present work deals with the role of some physical factors, applied separately or combined with gamma radiation on the F_1 rate of development of *Culex pipiens* L. when treated in the pupal stage. The results showed no or slight effect of all treatments on incubation period of eggs. Larval duration was increased when parental pupae were exposed to low temperature (10°C), low humidity (31% R.H.) or when any of the factors was combined with gamma radiation (60 Gy). Larval development was stopped at some mating combinations, when gamma radiation followed exposure to partial vacuum (0.1 torr) or low humidity; Pupal duration at most of the treatments was increased. Percent pupation was significantly reduced at all treatments especially when partial vacuum or temperature was combined with gamma radiation when pupation was inhibited at all mating combinations except controls (N♂ x N♀). Generally, adult emergence was decreased at all treatments and inhibited when parental pupae were exposed to partial vacuum, low temperature, or low humidity combined with gamma radiation.

INTRODUCTION

In previous studies, the effect of each of oxygen, partial vacuum (0.1 torr), low temperature (10° C) or low humidity (31% R.H) applied to the pupal stage of *Culex pipiens* complex L. separately or combined with gamma radiation (60 Gy) on some aspects of the mosquito biology (Wakid *et al.*, 1993; Abdel-Rahman *et al.*, 1992; Hafez *et al.*, 1993) was investigated. The present work continues these investigations by studying the effects of the fore-mentioned physical factors, when parental pupae were treated, on the F_1 rate of development. the combined effects of gamma radiation applied after treatments with the other factors were also studied.

MATERIALS AND METHODS

Rearing, irradiation, statistical analysis and experimental techniques described in previous work by the authors (Wakid *et al.*, 1993 and Hafez *et al.*, 1993) were followed. According to the results presented in these two papers, effects of oxygen, partial vacuum (0.1 torr) and temperature (10° C) were detected through one and two hours, while the influence of 31% R.H. was determined after exposure for 3 hours. Exposure to these factors was separately or followed by treatments with gamma radiation (60 Gy), giving three lapses of time (1/2, 1 and 2 hours) between exposure to each factor and treatment with gamma dose, beside recording the effect of gamma radiation immediately after exposure to 31% R.H. An untreated control group and another one treated only with gamma radiation were arranged. Two hundred pupae, replicated three times were used for each treatment. The effects on the F_1 rate of development of 2 mating combinations (N♂ x T♀ and T♂ N♀) beside controls (N♂ x N♀) were studied.

RESULTS AND DISCUSSION

Tables (1-4) illustrate the effect of oxygen, partial vacuum (0.1 torr), low temperature (10±2° C) or humidity (31% R.H.), applied separately or combined with gamma radiation (60 Gy) on the rate of development of the mosquito through its different F_1 stages after treating the parental pupae.

Table 1
Combined effects of pupal irradiation (60 Gy) and exposure to oxygen on the rate of development of F_1 offspring of *Culex pipiens* L.

Treatments	Treated males X Normal females					Normal males X Treated females				
	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD
Controls	3.05 ± 0.25	12.75 ± 0.21	1.71 ± 0.51	49.91 ± 6.92	91.77 ± 3.05	3.05 ± 0.25	12.75 ± 0.21	1.71 ± 0.51	49.91 ± 6.92	91.91 ± 3.05
Gamma rays (alone)	3.27 ± 0.26	8.33 ± 7.23	0.67 ± 1.15	3.28 ± 2.97	50.00 ± 38.49	3.00 ± 0.00	-	-	-	-
Oxygen (forl hour)	3.46 ± 0.32	12.81 ± 0.20	2.16 ± 0.08	38.26 ± 0.71	64.54 ± 2.91	3.64 ± 0.61	11.69 ± 0.56	2.72 ± 0.27	27.67 ± 0.37	61.60 ± 3.09
Oxygen (for 2 hours)	3.65 ± 0.54	13.37 ± 1.79	2.52 ± 0.22	39.54 ± 0.79	60.57 ± 1.01	3.68 ± 0.58	14.42 ± 0.23	2.56 ± 0.35	27.79 ± 1.19	59.68 ± 0.96
Oxygen (1 hr) + gamma rays (after 1/2 hr.)	3.88 ± 0.19	15.00 ± 0.00	2.70 ± 0.08	16.88 ± 1.90	27.27 ± 49.32	3.44 ± 0.81	14.66 ± 0.57	2.76 ± 0.32	12.81 ± 1.16	11.11 ± 2.95
Oxygen (1 hr) + gamma rays (after 1 hr.)	4.09 ± 0.49	15.61 ± 0.57	2.71 ± 0.22	17.31 ± 1.46	12.48 ± 2.53	3.72 ± 0.27	16.94 ± 0.41	3.05 ± 0.15	13.94 ± 0.71	18.59 ± 3.10
Oxygen (1 hr.) + gamma rays (after 2 hr.)	4.08 ± 0.57	16.25 ± 1.00	3.20 ± 0.08	17.25 ± 1.15	25.23 ± 3.96	3.39 ± 0.34	16.55 ± 2.34	3.14 ± 0.11	14.91 ± 0.68	22.69 ± 1.91

SD = Standard deviation

Table 2
Combined effects of pupal irradiation (60 Gy) and exposure to partial vacuum (0.1 torr) on the rate of development of F_1 offspring of *Culex pipiens* L.

Treatments	Treated males X Normal females					Normal males X Treated females				
	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD
Controls	3.42 ± 0.25	12.81 ± 0.46	2.11 ± 0.24	54.87 ± 13.32	69.35 ± 14.88	3.42 ± 0.25	12.81 ± 0.46	2.11 ± 0.24	54.87 ± 13.82	69.35 ± 14.88
Gamma rays (alone)	3.67 ± 0.57	11.00 ± 1.73	-	10.71 ± 6.61	-	-	-	-	-	-
0.1 torr (forl hour)	3.27 ± 0.21	14.66 ± 0.57	3.72 ± 0.25	14.11 ± 4.73	13.98 ± 5.76	3.77 ± 0.21	15.66 ± 1.52	3.50 ± 0.50	15.87 ± 0.89	14.58 ± 6.09
0.1 torr (for 2 hours)	3.33 ± 0.57	17.66 ± 2.08	±	6.12 ± 2.37	±	3.67 ± 0.57	14.66 ± 1.52	8.33 ±	± 1.43	±
0.1 torr (1 hr) + gamma rays (after 1/2 hr.)	3.62 ± 0.11	-	-	-	-	-	-	-	-	-
0.1 torr (1 hr) + gamma rays (after 1 hr.)	3.00 ± 0.00	-	-	-	-	-	-	-	-	-
Oxygen (1 hr.) + gamma rays (after 2 hr.)	3.23 ± 0.40	-	-	-	-	-	-	-	-	-

SD = Standard deviation

Table 3
Combined effects of pupal irradiation (60 Gy) and exposure to low temperature (10° C) on the rate of development of F_1 offspring of *Culex pipiens* L.

Treatments	Treated males X Normal females					Normal males X Treated females				
	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD
Controls	2.72 ± 0.61	10.16 ± 0.28	1.00 ± 0.00	42.93 ± 7.87	69.73 ± 6.75	2.72 ± 0.61	10.16 ± 0.28	1.00 ± 0.00	42.93 ± 7.87	69.73 ± 6.75
Gamma rays (alone)	3.57 ± 0.69	-	-	-	-	-	-	-	-	-
10 ± 2° C (forl hour)	3.68 ± 0.73	22.00 ± 3.60	2.83 ± 0.28	24.18 ± 0.35	63.77 ± 2.24	3.87 ± 0.87	24.00 ± 2.64	2.33 ± 0.57	24.87 ± 2.13	69.70 ± 4.31

Table 3 Contd.

Treatments	Treated males X Normal females					Normal males X Treated females				
	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD
10 ± 2° C (for 2 hours)	3.67 ± 0.81	19.33 ± 1.52	2.67 ± 0.57	2.15 ± 1.37	70.00 ± 1.28	3.88 ± 0.89	22.33 ± 1.52	3.33 ± 0.57	20.70 ± 4.62	68.00 ± 3.92
10 ± 2° C (1 hr) + gamma rays (after 1/2 hr.)	3.80 ± 0.83	-	-	-	-	-	-	-	-	-
10 ± 2° C (1 hr) + gamma rays (after 1 hr.)	3.81 ± 0.83	-	-	-	-	-	-	-	-	-
10 ± 2° C (1 hr.) + gamma rays (after 2 hr.)	3.86 ± 0.88	-	-	-	-	-	-	-	-	-

SD = Standard deviation

Table 4

Combined effects of pupal irradiation (60 Gy) and exposure to low humidity (31% R.H.) on the rate of development of F_1 offspring of *Culex pipiens* L.

Treatments	Treated males X Normal females					Normal males X Treated females				
	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD	Egg duration (days) ± SD	Larval duration (days) ± SD	Pupal duration (days) ± SD	Percent pupation ± SD	Percent emergence ± SD
Controls	3.10 ± 0.34	11.91 ± 1.28	2.00 ± 0.00	44.08 ± 2.16	89.77 ± 2.13	3.10 ± 0.38	11.91 ± 1.28	2.00 ± 0.00	44.08 ± 2.16	89.77 ± 2.13
Gamma rays (alone)	2.85 ± 0.59	14.48 ± 0.56	2.67 ± 0.28	6.98 ± 2.14	83.33 ± 23.56	3.05 ± 0.48	13.00 ± 1.00	1.67 ± 1.52	6.82 ± 1.91	66.66 ± 57.73
31% R.H. (for3 hour)	3.52 ± 0.53	15.10 ± 1.36	1.36 ± 0.55	43.09 ± 1.90	65.85 ± 3.49	2.75 ± 0.58	15.92 ± 2.60	1.63 ± 0.53	40.95 ± 4.52	65.95 ± 4.77
31% R.H. (3 Hrs.) and gamma rays immediately	3.92 ± 0.14	14.83 ± 0.76	2.33 ± 0.57	2.84 ± 1.32	44.44 ± 33.33	3.83 ± 0.58	13.50 ± 0.5	1.33 ± 1.15	4.12 ± 0.91	50.00 ± 50.00
31% R.H. (3 hrs) + gamma rays (after 1/2 hr.)	3.84 ± 0.11	14.67 ± 0.15	2.17 ± 0.28	4.04 ± 2.23	50.00 ± 00.00	-	-	-	-	-
31% R.H. (3 hr) + gamma rays (after 1 hr.)	3.10 ± 0.34	14.50 ± 1.32	1.67 ± 1.52	4.98 ± 2.20	40.00 ± 38.49	-	-	-	-	-
31% R.H. (3 hr.) + gamma rays (after 2 hr.)	3.87 ± 0.41	14.61 ± 1.27	2.06 ± 0.09	5.43 ± 1.17	38.10 ± 8.93	-	-	-	-	-

SD = Standard deviation

Egg incubation period

From the presented data it is obvious that partial vacuum applied (alone for one or two hours), oxygen (alone for one or two hours or followed by gamma irradiation) and humidity (for 3 hours alone or followed by gamma radiation) had no effect on egg duration since all differences between treated populations and controls were insignificant. When parental pupae, on the other hand, were exposed to gamma radiation alone or to low temperature (for one or two hours alone or followed by gamma irradiation) the incubation period of the F_1 egg was slightly longer than that of the controls. Treatments with partial vacuum combined with gamma rays insignificantly shortened the incubation period.

Larval and pupal duration

The results indicate that, there were no effects on larval duration in both mating combinations when oxygen or partial vacuum were applied, for one or two hours, alone, since all the differences between the treated populations and controls were insignificant. However, the application of 10±2° C for one or two hours or 31% R.H. for three hours alone resulted in highly lengthened larval durations than those of the controls where differences were highly significant.

In the case of combined application of oxygen, partial vacuum, temperature or humidity with gamma irradiation, the larval duration was considerably varied. For example, exposure to oxygen for one hour followed by gamma radiation after one or two hours resulted in highly significant ($P < 0.01$) increase in larval duration, whereas its application with gamma after only half an hour resulted in a slight significant increase ($P < 0.05$).

On the other side, partial vacuum or temperature (in both mating combinations) or humidity (in the combination of treated females with normal males) when combined with gamma irradiation, larval development was completely stopped or died soon after emergence. However, in the combination of treated males with normal females, humidity combined with gamma rays resulted in significantly longer larval duration than that of the control.

The pupal duration seemed to be not affected by exposure to 31% R.H. alone as there was slight insignificant differences in pupal durations than those of the controls. However, the other factors alone or combined with gamma radiation resulted in highly significant increases when compared to controls.

Pupation and adult emergence:

The results indicate that, treatment of the parental pupae with oxygen (one or two hours), temperature (one or two hours), humidity (for three hours), partial vacuum (for one or two hours) or gamma radiation alone; had a profound effect on larval pupation in the F_1 generation. There was a noticeable highly significant reduction ($P < 0.01$) at partial vacuum or gamma treatments or significant ($P < 0.05$) at the other treatments, in the percent of pupation when compared to the control in both mating combinations. This effect was also highly significant when these factors were applied in combination of gamma irradiation in all cases of time periods.

Moreover, the larvae that hatched form eggs deposited by normal females crossed with males treated as pupae with partial vacuum or temperature for one hour followed by exposure to gamma dose after 1/2, one or two hours, did not reach the pupal stage and died at the third or fourth larval instar. However, some of the larvae reached the pupal stage when low temperature was applied for one hour and followed by gamma irradiation after two hours, but did not complete their development to the adult stage.

Regarding the effect on the percent of adult emergence, it is obvious that, none of the treatments increased the percentage of adult emergence as the percent emergence was highly decreased compared to control except when low temperature was applied for one or two hours alone. Recorded data indicated 100% pupal mortality in the F_1 generation by the application of partial vacuum alone for two hours or partial vacuum followed by gamma radiation. The same effect was observed when pupae were exposed to humidity for three hours then followed by gamma radiation and the produced treated females were crossed with normal males.

The effects of such factors combined with radiation have not been investigated by other workers. However, the effect of radiation alone on the rate of development of F_1 generation was determined by some authors. On mosquitoes, Tantawy *et al.,* (1966) in their work on *Anopheles pharoensis* reported that their results secured from parental pupae irradiated with gamma rays demonstrated that dominant lethal in the egg, larval and pupal stage of F_1 offspring resulting from irradiated pupae were most effective during the egg stage followed by the larval stage and complete lethality was achieved at 4500 R and 5000 R, respectively. They added that gamma rays showed no significant effects on the F_1 pupal stage, i.e. adults would emerge from most of the pupae in spite of high doses of gamma radiation.

Almost similar results were arrived at by Abdel-Malek and Ahmed (1972) on *Culex pipiens molestus* and Abdel-Malek *et al.,* (1978) on *Aedes caspius.* The results of these investigations are to a great extent similar to the present results.

It seems that the effects of the other factors i.e., partial vacuum, oxygen, temperature and humidity, applied alone to the parental pupae on the F_1 progeny were not studied before as no literature on such studies were available.

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