

EFFECTS OF GAMMA RADIATION ON THE ACTIVITY OF THE MOSQUITO *CULEX PIPPIENS L.*

I. EFFECTS ON THE ATTRACTION OF THE MOSQUITO TO LIGHT, COLOURS AND HOST

By

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ABSTRACT

The present work was carried out to investigate the effects of gamma radiation at three doses: 40, 80 and 120 Gray. On the response of the adult mosquito *Culex pipiens* complex when irradiated in the larval, pupal or adult stage, to the surrounding environmental factors as light, colour and host.

There was no effect of any of the doses applied on the response of both sexes of the adult mosquito to light whether the irradiation was applied at the larval or the pupal stages. When the adult females were irradiated at 120 Gray there was a significant decrease in its response when compared to control females.

The colour preference of the control adults was in the order, pink, green, yellow, blue (the least preferable). When adults were irradiated in the larval stage at 40 Gray they preferred the pink colour. While when they were irradiated in the pupal stage at 40 Gray, the males preferred the green colour while the females preferred the pink colour, the blue colour still the least preferable. At 80 and 120 Gray both males and females preferred the pink colour and the blue was the least preferable too. When adults were irradiated at 40 Gray the pink colour was preferable and the blue was still less preferable. However with increasing the dose to 80 and 120 Gray, the attraction to the blue colour was increased and that to the pink colour was decreased.

There was no significant effect on the response of the females to host when they were irradiated in the larval stage at 40 Gray. However there were significant decreases in the attraction of females to host when they were irradiated in the pupal stage at high doses tested. When newly emerged adults were irradiated with 40 Gray no significant effect was observed on the female response to host, while at 80 and 120 Gray there was a significant reduction.

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INTRODUCTION

Culex pipiens L. is one of the most widespread culicid mosquito and the research on its control has recently been increased because of its importance as a transmitter of *Wuchereria bancrofti* and Rift Valley fever (Hoogstraal *et al.*, 1979 and Meegan *et al.*, 1980).

The successful experiment carried out by Knipling (1955) and his co-workers which led to the eradication of the screw worm fly *Cochliomyia hominivorax* from the South Eastern of America, by the sterile male technique, made the use of ionizing radiation as one of the approaches in insect control.

Many records have been obtained on the bad effects of gamma radiation on the vitality and consequently competability of the insects in the normal populations. The effect on the overall performance of the insect arises from a number of individual performance traits. Aspects of the function quality of the sterilized mosquitoes used in an eradication or control program can be evaluated by measuring their overall performance or by measuring their individual performance traits viz: orientation to habitat, sexual activity, sexual physiology ..etc.

In the present series of research papers, different individual traits thought to be affected by radiation at different doses were investigated in a hope that results obtained from this study may contribute to a proper understanding and offering help to the mosquito control program using the sterile insect technique.

MATERIALS AND METHODS

A. Rearing of the Mosquito

The original culture of *C. pipiens* complex was obtained from field and collections of larvae were carried out from EL-Gabal EL-Asfar, Qalubia Governorate (20 km northeast of Cairo), Egypt.

Eggs were collected and used to initiate the colony. The stock colony was successfully maintained in the laboratory at room temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and 60-80% R.H. The colony has been maintained up till the end of the work in the Entomology Laboratory of Radiobiology Department, Atomic Energy Authority and the Middle Eastern Regional Radioisotopes Center for the Arab Countries, Dokki, Cairo.

B. Irradiation Procedure

Irradiation was conducted from the ^{60}Co Gamma Cell Unit installed at the Middle Eastern Regional Radioisotopes Center for the Arab Countries. At the beginning of the experiments the dose-rate was 40 rad/sec.

C. Experimental Techniques

In the experiments carried out for measuring the effects of irradiation on the response of adults to some surrounding environmental factors such as light, colours, and host, the following design was used (Fig. 1). The apparatus consists of 5 cubic wooden and screen cages $20 \times 20 \times 20$ cm. connected to each other as shown in the figure. The central cage (E) is connected to the other 4 cages (A, B, C and D) by connecting rectangular polywooden tubes to be totally dim.

Between each connecting tube and the central cage exists one inner opening (2×2 cm.) and between each outer cage and the connecting tube there is an other similar opening. All openings are used as entrances for mosquitoes and can be opened or closed from outside when desired.

a - Colour Experiments

The cage (E) was darkened by a black cloth and the adults of both sexes were enclosed inside and all openings were closed. The tested colours were brushed on an artboard paper 20×60 cm which in turn fits into the three outer sides of the outer cages A, B, C and D. The whole apparatus with mosquitoes in it was put in dark for half an hour for acclimatization, then the experiment was started at sun-set time by opening the outer entrances first, then the inner ones surrounding the mosquitoes. The numbers of mosquitoes of both sexes entering or attracted to the different colours in cages A, B, C and D were counted and recorded. The experiment was carried out for normal (unirradiated) mosquitoes as well as irradiated ones. Five replicates were done.

The colours used were flourescent dust, soluble in acetone. These colours were Aurora Pink, Saturn Yellow, Signal Green and Horizon Blue (daylight flourescent pigments produced by Switzer Brothers Inc. Cleveland, Ohio, USA). The wave lengths of these colours were measured by UV spectrophotometer and the obtained wave lengths were 550, 440, 420 and 370 nm. for pink, yellow, green and blue, colour respectively.

b - Light Experiments

The central cage (E) was illuminated from above (100 cm-high) by an electric lamp (50-watt). Cages A, B, C and D were darkened completely. One outer cage

Effect of gamma radiation on Mosquitoes

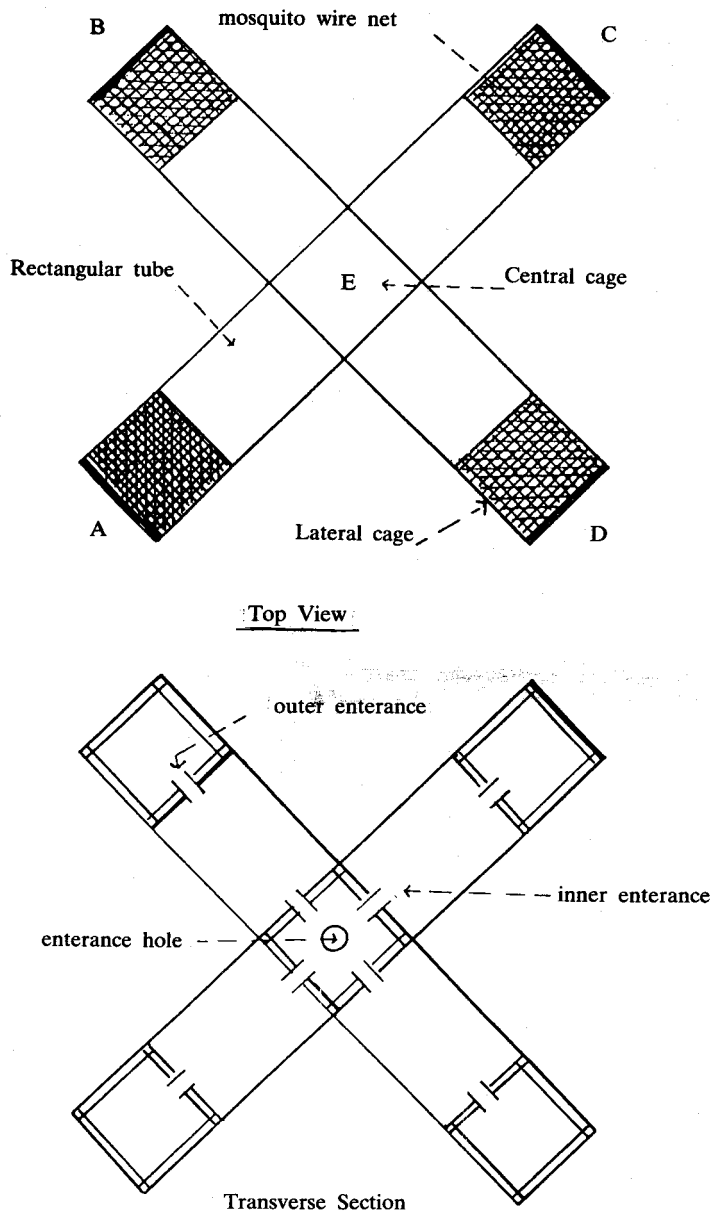


Fig. 1. Experimental Cage

contained unirradiated mosquitoes, while the other outer cages contained the irradiated mosquitoes. After half an hour darkening, the outer entrances were opened first and then the inner ones at sun-set time. Numbers of mosquitoes of both sexes leaving the outer cages to the central one were counted next morning representing the numbers of mosquitoes attracted to light after treatment with different doses. Three replicates were done.

c - Food Attraction Experiments

Resembled those of the light experiments except for having a pigeon inside the central cage (E) instead of light. Female mosquitoes were placed inside the peripheral cages (without being darkened). Number of irradiated females with different gamma doses attracted to the pigeon were counted. Three replicates were done.

RESULTS AND DISCUSSION

1 - Response to Light

Mosquitoes especially the females are attracted to houses mainly by light. Several studies have been made about the responses of mosquitoes to light of different wave lengths but in only a few cases the relative brightness of the different colours have been taken in account. The present study was focussed on the effect of gamma radiation on the response of the mosquito to electric light of known intensity.

Table (1) shows the effects of gamma radiation applied to the larval, pupal or young adult stages on the 3-day-old adult response to light.

Table 1

Effect of gamma radiation applied to larvae, pupae or adult stages on the response of 3 day-old adult *Culex pipiens* to light.

Dose (gray)	Irradiated stage	% Mosquitoes attracted to light \pm S.D.	
		Males	Females
Control	3rd harval instar	96.9 \pm 3.4	98.7 \pm 2.3
40		93.1 \pm 2.3	92.2 \pm 2.6
Control	One day old pupae	97.0 \pm 3.4	98.7 \pm 2.3
40		97.7 \pm 3.9	94.3 \pm 9.8
80		95.2 \pm 8.3	91.5 \pm 2.5
120		90.0 \pm 5.6	92.2 \pm 1.2
Control	Newly emerged adults	97.0 \pm 3.4	98.7 \pm 2.3
40		89.5 \pm 1.8	91.1 \pm 8.4
80		90.0 \pm 10	91.1 \pm 7.8
120		89.6 \pm 4.7	85.5 \pm 2.1

When larvae were irradiated at 40 Gray the produced adults showed on change in their response to light. Above 40 Gray no adults were produced, consequently no results were obtained after larval irradiation.

When pupae were irradiated, insignificant differences were observed between the irradiated and unirradiated pupae.

In case of irradiated newly emerged adults, the same result was obtained. No significant differences were obtained at 40 or 80 Gray. However, at 120 Gray there was a significant decrease in the response of the females to light than all the other treatments.

2 - Colour Discrimination and Colour Preference

The attractiveness of different coloured surfaces for landing female mosquitoes is an inverse function of the intensity of reflected light between 4750 and 6250°A, no correlation with intensity was found outside these limits (Brown, 1954). This indicates an insensitivity to the deeper shades of red, to infra-red and to violet and ultraviolet light. The aim of the present study was to investigate whether gamma radiation could change the normal sensitivity of the mosquitoes to their usual colour preference.

The data on Figs. (2-4) illustrate the effects of 3 doses of gamma radiation applied to the larvae, pupae or newly emerged adults, on the colour preference of the adults mosquitoes (3-day-old).

Irradiating the 3rd instar larvae with more than 40 Gray caused death of the larvae, poor pupation or inhibition of adult emergence. So, no data could be obtained for irradiation of the larvae at 80 or 120 Gray in both males and females. Although insignificant preference to a certain colour in the control males, was observed, it seemed that, the 40 Gray irradiation stimulated the males and females to prefer the pink colour, while the blue colour was the least preferable for normal males and females and the least preferable colour was the green for irradiated males and the yellow for irradiated females (Fig. 2).

Irradiation of one-day old pupae with 40 Gray produced males or females with no significant preference to certain colour, but still the blue colour was the least preferable. The same results were obtained at 80 Gray.

At 120 Gray, 31.6, 20.4, 26.0 and 13.0% of the males preferred the pink, yellow, green and blue colours, respectively, and 29.9, 25.4, 24.5 and 20.3% of females, (Fig. 3).

When the males were irradiated 24 hours after eclosion a similar stimulation to the pink preference was observed at 40 Gray as in the case of larval and pupal

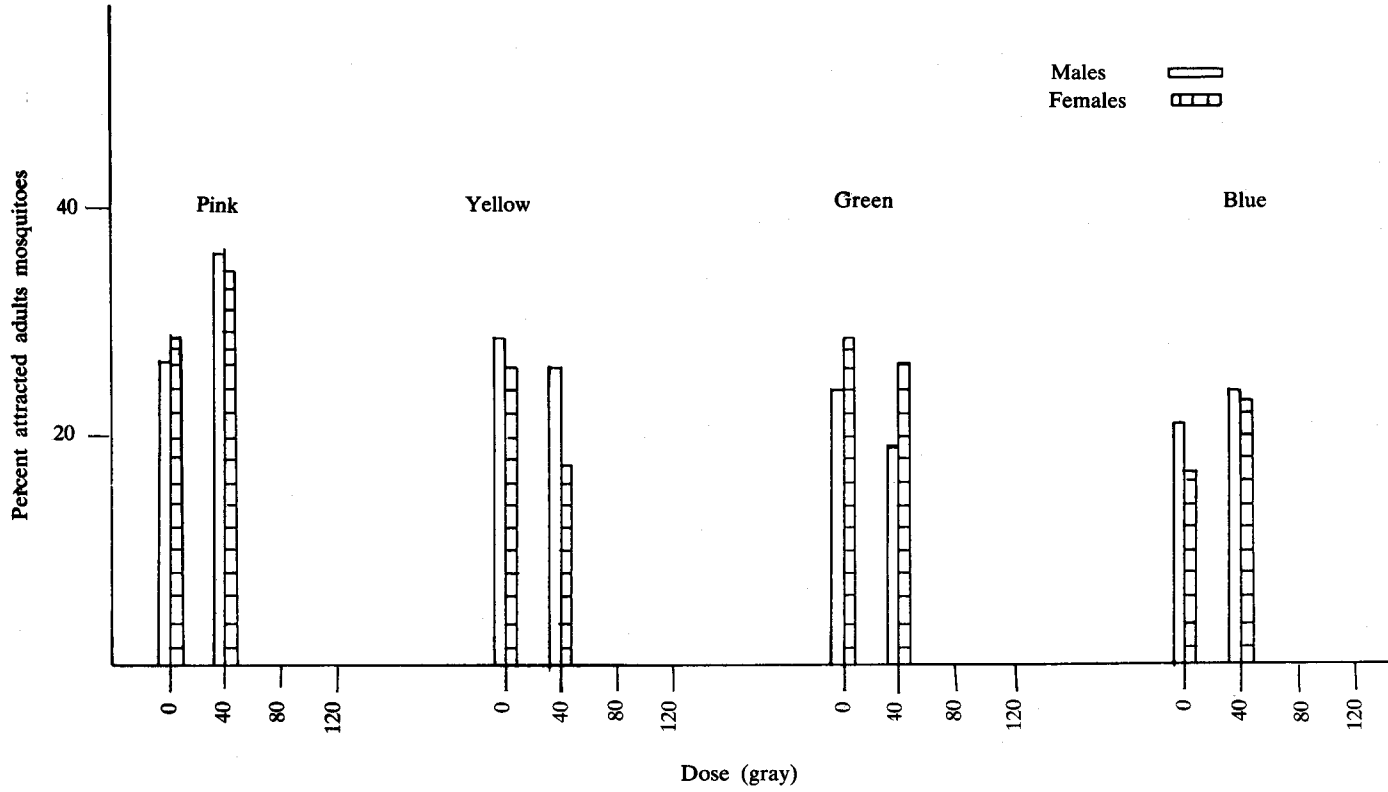


Fig. (2) Effect of gamma radiation applied to the larval stage on the response of adult *Culex pipiens* to different colours.

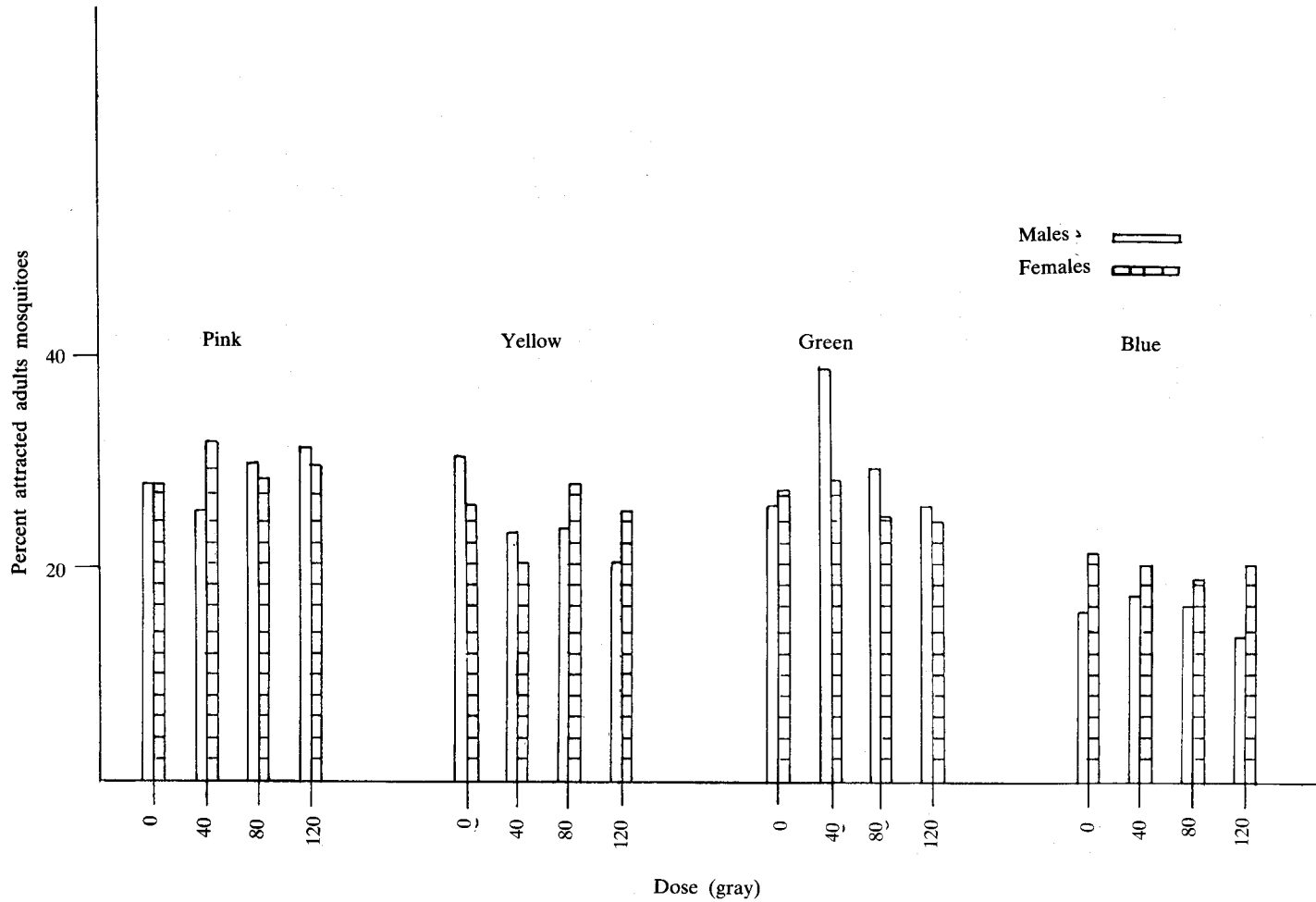


Fig. (3) Effect of gamma radiation applied to the pupal stage (one day old) on the response of *Culex pipiens* to different colours.

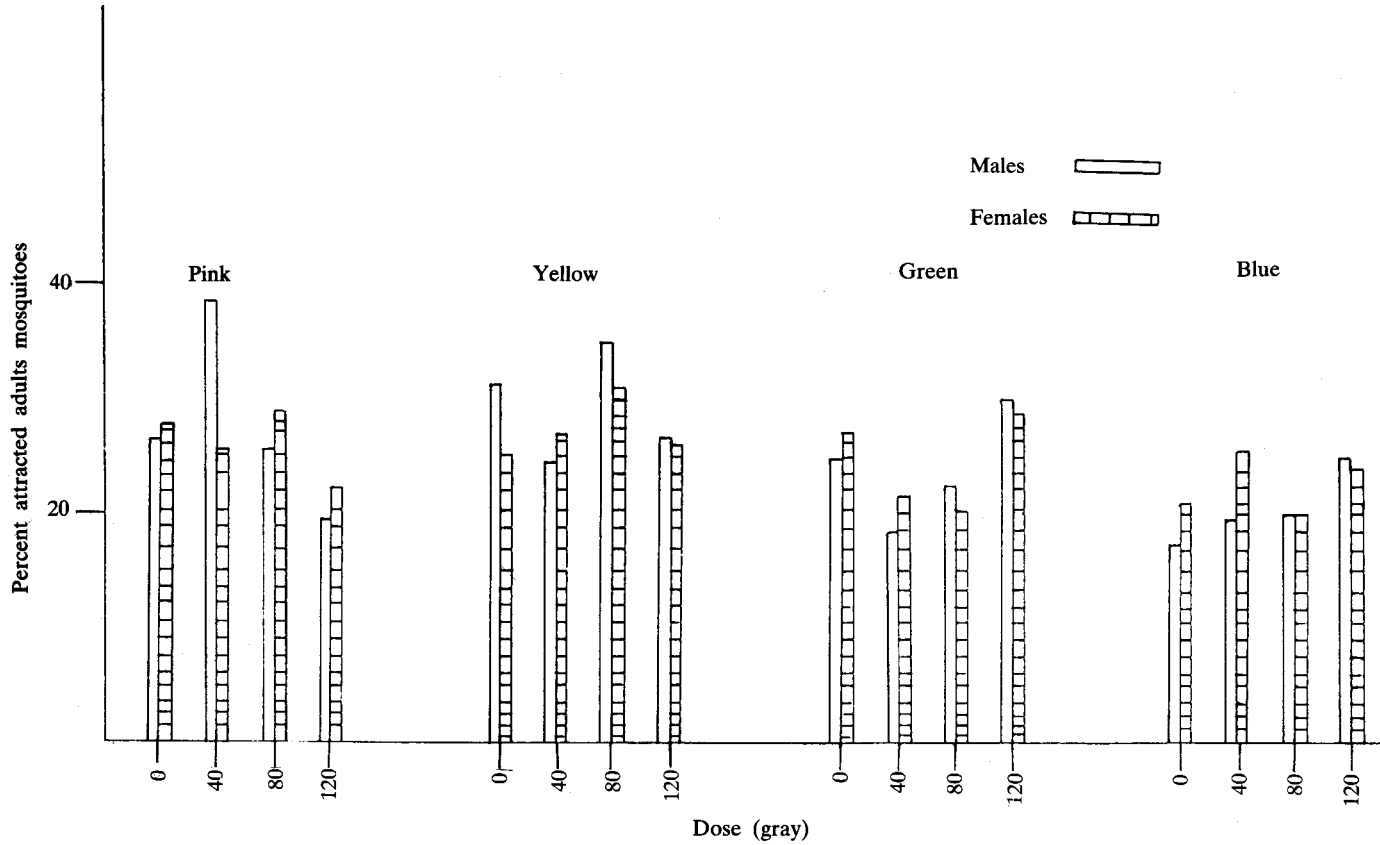


Fig. (4) Effect of gamma radiation applied to newly emerged adults on the response of three days old adult *Culex pipiens* to different colours.

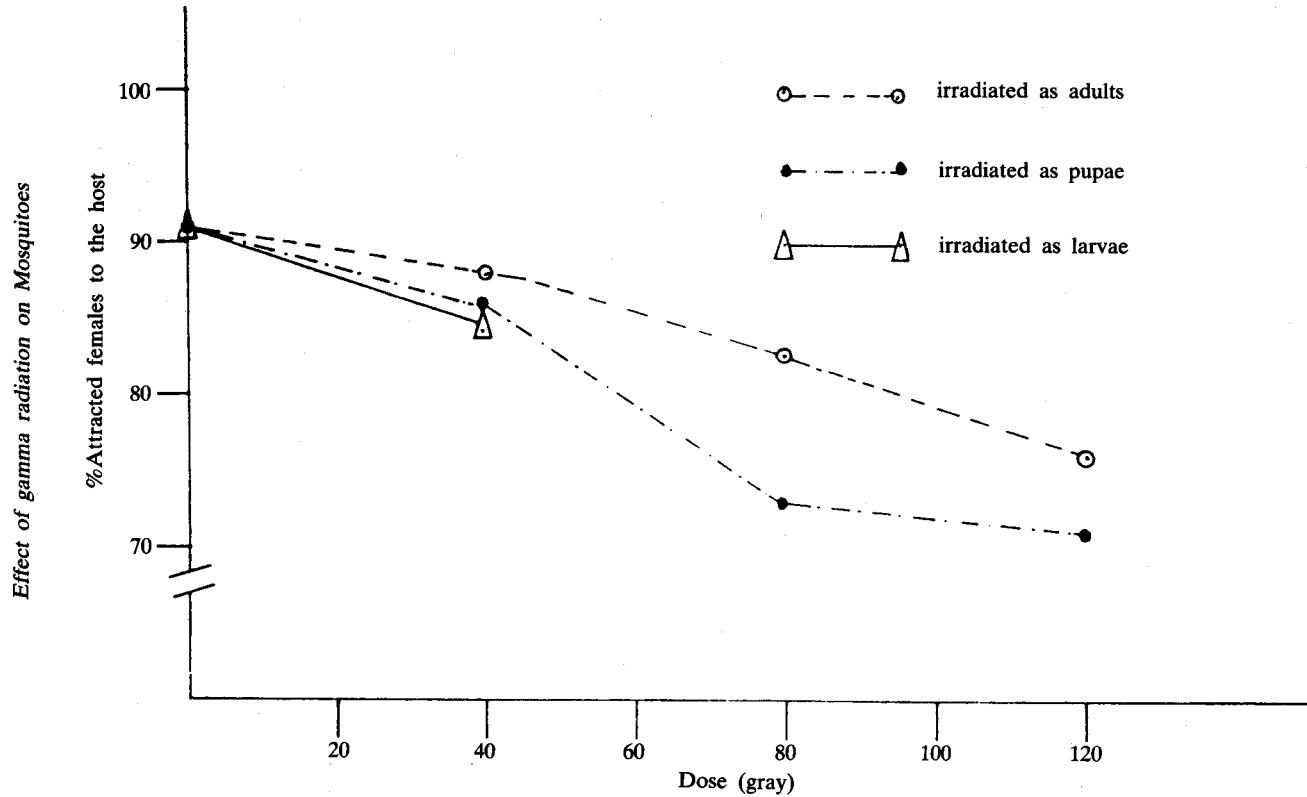


Fig. (5): Effect of gamma radiation applied to the larval, pupal or adult stage of *C. pipiens* on the female (3-day-old) fasting after sugar meal) attraction to the host (pigeon).

irradiation. After this dose the normal numbers of males (as controls) were attracted to the pink colour. Females showed nearly equal preference to all colours tested. Irradiation of adults as a whole seemed to increase the adult preference to the blue colour than when pupae were irradiated (Fig. 4).

From the fore-going results it has been shown that gamma radiation had no clear effects on the light or colour preference of the males or females mosquito except at a very rare cases. This result was obtained at whether the larvae, pupae or adults were irradiated. For a SIT (Sterile Insect Technique) program, this results is very important as the released mosquitoes should not be affected by gamma radiation in their visual response.

Nearly similar results on the colour preference of the normal mosquitoes were obtained at by some authors as Howlett (1910), Eckstein (1920) and Brighenti (1930) working with *Anopheles maculipennis* who concluded that mosquitoes were most attracted by carmine red, violet and yellow, and least attracted by cobalt blue or dark green, Brett (1938) showed that *Aedes aegypti* preferred black and red was the most attractive than several colours with a lower refraction factor, while blue was repellent than several colours with higher refraction factor. However others reported different results. For example Brown (1951, 1954) studied the attractiveness of coloured cloths to some Canadian mosquitoes. The order of attractiveness was: black, red, blue, brown, green and yellow.

3 - Response to Host

The factors which have been implicated in the location and recognition of the host by mosquitoes are heat, moisture, carbon dioxide, odour and various visual factors (Clements, 1963).

The manner in which mosquitoes are attracted to objects heated above air temperature in laboratory and field experiments leaves no doubt that body temperature is an important factor in host finding (Howlett, 1910; Brown, 1951; Peterson and Brown, 1951).

The data obtained are illustrated on Fig. (5). No significant effect was observed on the response of the females mosquito when they were irradiated in the larval stage at 40 Gray to the pigeon.

When pupae were irradiated, the produced females showed a significant reduction in their response to host especially at high doses.

Irradiated newly emerged adult females showed insignificant decrease in their response to host at 40 Gray, while significant reduction was observed at 80 and 120 Gray.

The attraction of the female mosquito to host, as is known, is dependent on various factors of which temperature, moisture, CO_2 , odour...etc were important. In this result, the total attraction was studied. More details on this point should be studied later.

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تأثير أشعة جاما على نشاط بعوضة كيو لكس بينز

١ - التأثير على انجذاب البعوضة للضوء والالوان والعائل

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و احمد شومان

يشتمل هذا البحث على تأثير أشعة جاما بثلاث جرعات هي ٤٠ ، ٨٠ ، ١٢٠ جراى على استجابة بعوضة الكيولكس بينز عندما تشمع في طور اليرقة أو العذراء أو الطور اليافع لبعض العوامل المحيطة بها مثل الضوء والالوان والعائل . وتتخص النتائج المتحصل عليها فيما يلي :

- لم يكن هناك تأثيراً ملحوظاً لجميع الجرعات المستعملة على استجابة الحشرة للضوء سواء كانت التشميع في الطور اليرقي أو طور العذراء ، بينما عندما شمعتم الالانثى في الطور اليافع بالجرعة ١٢٠ جراى كان هناك انخفاضاً ملحوظاً في استجابتها للضوء بمقارنتها بالانثى التي لم تشمع .
- كان ترتيب تفضيل الحشرات غير المشععة للالوان هي : الوردى الشفقي - الأخضر اشاري - أصفر زحل - الأزرق بلون الاقح . وعندما شمعتم الحشرات في طور اليرقة بالجرعة ٤٠ جراى فضلت اللون الوردى وعندما شمعتم في طور العذراء بالجرعة ٤٠ جراى فضلت الذكر اللون الأخضر ، بينما فضلت الاناث اللون الوردى وما زال اللون الأزرق الأقل تفضيلاً . وعند الجرعتين ٨٠ ، ١٢٠ جراى فضلت كل من الاناث والذكور اللون الوردى بينما ظل اللون الأزرق أقل تفضيلاً . وعندما شمعتم الحشرات في الطور البالغ بالجرعة ٤٠ جراى كان اللون الوردى هو المفضل أما الأزرق فكان الأقل تفضيلاً . ولكن عند الجرعات الاعلى ٨٠ ، ١٢٠ جراى فقد ازداد الانجذاب للون الأزرق بينما الانجذاب قل للون الوردى .

- لم يكن هناك تأثير للجرعة الاشعاعية ٤٠ جراى في الطور اليرقي على استجابة انثى الطور البالغ نحو العائل بينما كان هناك تأثيراً معنوياً عندما شمعتم العذارى على استجابة الالانثى نحو العائل عند الجرعات العالية . وعند تشميع الطور البالغ بالجرعة ٤٠ جراى لم يكن هناك تأثير ملحوظاً على استجابته للعائل بينما كان هناك تأثيراً معنوي على هذه الاستجابة عند الجرعتين ٨٠ ، ١٢٠ جراى .