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Reproductive Potential and Embryonic Lethality of The Blowfly, *Chrysomya albiceps* (Wiedemann 1819)Influenced by Gamma Radiation

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ABSTRACT

Chrysomya albiceps play a major role as a mechanical vector for plentiful pathogens to humans and animals such as bacteria, viruses, and helminths, as well as causing myiasis in animals. The present study aimed at investigating the effect of gamma radiation on the reproductive potential and embryonic lethality of *C. albiceps.*Results showed that the number of eggs laid by *C. albiceps* females resulted from pupae irradiated with different doses of gamma radiation decreased as the dose increased. Also, the non-hatching eggs %was found to be dose-dependent *i.e.*, increased as the dose of the gamma irradiation used increased.The highest reduction in the number of eggs occurred at high doses (10 and 15 Gy) when irradiated females were crossed with non-irradiated males. Non-hatching egg % increased to record 76.6 and 66.8 at 15 and 10 Gy when irradiated females crossed with irradiated males. Gamma radiation resulted in a progressive increase in the sterility % of *C. albiceps*females as compared with the untreated group. Complete sterility (100.0%) was attained by 20 Gy for all groups. The sterility index was recorded at 96.3% when irradiated females crossed with non-irradiated males.In addition, gamma radiation-induced a progressive increase in egg lethality giving an estimated LD_{50} value of 9.3598 Gy when non-irradiated females mated with irradiated males, compared with 10.6257 Gy for egg-lethality laid by irradiated females mated with non-irradiated males. However, the LD_{50} value was 3.603 Gy when both males and females were irradiated, respectively. Generally, *C. albiceps* females were more radiosensitive than their male counterparts.

INTRODUCTION

The blowfly, *Chrysomya albiceps* (Wiedemann 1819), belonging to the family Calliphoridae, originated from the Old-World tropics and succeeded in invading a geographical region in the New World, it has a wide distribution in Africa, South Asia, different parts of Europe, South America and many parts of India (Zumpt 1965; Laurence 1981; Al-Shareef and Al-Qurashi, 2016). In Egypt, *C. albiceps* is distributed throughout Giza, Minya, Dayrout and North Sinai especially in fish markets (Salem *et al.*, 2015).

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Chrysomya albiceps has prime medical and veterinary importance, as it feeds on feces, and carrions and can act as a mechanical vector of many pathogenic agents to humans and animals such as bacteria, viruses and helminths besides causing myiasis in animals (usual livestock) and human (Grassberger *et al.*,2003; Salem *et al.*,2015; Al-Shareef and Al-Qurashi, 2016).

However, many previous studies on the development of *C. albiceps*during a variety of treatments including plant extracts (Al-Jameeli 2021), chemical compounds (Al-Jameeli *et al.*,2021) and essential oils (Cossetin *et al.*,2021), a prolix report on the effects of gamma radiation on the reproductive potential of *C. albiceps*is not available. Generally, mammals are the most radio-sensitive vertebrates as compared with reptiles, amphibians, and birds; but most invertebrates have been shown more resistant to gamma radiation than vertebrates (Bacq and Alexander, 1961). At the same time, insects show a very high degree of radio-resistance which varies among different insects' orders, as Diptera and Homoptera are more radio-sensitive than Hemiptera and Lepidoptera (Koval 1983). In addition, within a single species, radiosensitivity varies depending on age and sex. Koval *et al.*,(1980) attributed the radio resistance of insects to a molecular rationale involving the presence of an efficient DNA repair process allowing them to preserve their genetic integrity.

On the other hand, gamma radiation affected the reproductive potential of different dipteran species and the sterility percent increased as the dose increased (Jahan *et al.*,1998; Huda and Khan, 2000; Khan and Islam, 2006; Hassan *et al.*,2019). So, the present study was performed to investigate the effect of different doses of gamma radiation (as a physical agent) on the reproductive potential of the blowfly, *C. albiceps.*

MATERIALS AND METHODS

Collection and Identification of *Chrysomya albiceps*:

The blowfly, *C. albiceps* larvae were collected around Animal House, Faculty of Science (boys), Al-Azhar University, Cairo, Egypt using fish as media. The collected larvae were identified according to Tantawi and Greenberg, (1993).

***Chrysomya albiceps* Culture:**

Collected larvae were transferred to the Medical Entomology insectary, Animal House, Al-Azhar University, Cairo, Egypt. The culture of the blowfly, *C. albiceps* was maintained for six generations under controlled conditions of temperature (27±2°C), relative humidity (70±10%) and light-dark photoperiod (12-12 hrs.). The flies are kept in a wooden cage with wire (30×30×30cm); the front side, which is provided with a circular opening, is fitted to it with a cloth sleeve for routine daily feeding, handling, and cleaning. Adults are daily provided with cotton pieces soaked in 10.0% sucrose solution and milk powder. *Chrysomya albiceps* adults laid eggs on the fresh liver, the liver changed every 1-3 days. Maggots after hatching were transferred into a plastic box (25×15×10 cm) containing fresh liver and covered by gauze, larvae were fed on the liverwhen maggots were ready to start pupation, they left the moist diet into a box containing sawdust that was spread on top. Then the pupae were transferred into wooden cages (Amer *et al.*,2019).

Irradiation Process:

The irradiation process was carried out using Gamma cell-40 (cesium-137 irradiation unit), National Center for Radiation Research and Technology (NCRRT), Cairo. The dose rate was 2.3 Gy/min at the time of the present investigation.

Biological Activity:

1.The Susceptibility of *Chrysomya albiceps* Resulted From Irradiated Pupae With Gamma Radiation:

Three days old pupae were irradiated with 5, 10, 15 and 20 Gy, fecundity (No. of eggs laid) and fertility (No. of eggs hatched) were detected in the resulting females. Response percentages of non-hatching eggs were corrected using Abbotts' Formula (Abbott 1925). Three crossing combinations were set up for each dose as follows: irradiated ♂♂ × irradiated ♀♀; irradiated ♂♂ × non-irradiated ♀♀ and irradiated ♀♀ × non-irradiated ♂♂.

2.The Reproductive Potential of Irradiated *Chrysomya albiceps:*

Four replicates were performed for each dose (each one has 5 irradiated females or males vs. 5 non-irradiated insects or 5 irradiated females and males). Adults that succeeded to emerge from the irradiated pupae with each dose were collected and transferred with normal insects obtained from the colony to the wooden cages (30×30×30 cm) and fed with a dry diet (milk powder) and sucrose solution (cotton pads soaked in 10.0% sucrose solution) for four days; the adult lay an egg on the fresh liver. The number of eggs was counted by using binoculars and then the means value was calculated. Egg-hatchability and Sterility Index (SI) were estimated according to Hassan *et al.*,(2019).

Statistical Analysis:

Response percentages of non-hatching eggs were corrected using Abbotts' Formula (Abbott 1925). The LD_{25}, LD_{50}, LD_{75}, LD_{90}, LD_{95} and LD_{99} were calculated according to the method of Finney (1971). Data obtained were statistically analyzed and the variance ratios were calculated by the method of one-way ANOVA using (SPSS, ver.15). all data was recorded as Mean±SD.

RESULTS

The effect of gamma radiation on the fecundity of *Chrysomya albiceps* females resulting from 3-day-old pupae irradiated with 5, 10, 15 and 20 Gy crossed with non-irradiated males (NM) is presented in Table (1). As shown from the results, fecundity was significantly decreased (P<0.001) as the gamma-radiation dose increased, where the number of eggs laid by an irradiated female (TF) recorded 23.3±7.1 and 0.0 eggs/5 female at 15 and 20 Gy, compared with 162.0±4.4 eggs/5female for the control group.

As shown from the obtained results, the hatchability percent of eggs laid by females resulting from 3-day-old pupae irradiated with 5, 10 and 15 Gy and crossed with NM was significantly decreased as the dose of gamma radiation increased; it decreased from 98.6% for the control group to 77.7, 52.5 and 33.6% at 5, 10 and 15 Gy, respectively. Sterility percent (%) of females resulted from 3-days old pupae irradiated with 5, 10, 15 and 20 Gy was increased as the dose of gamma radiation increased, where it recorded 96.3 and 100.0% at 15 and 20 Gy, compared with 0.0% for the control congers (Table 1).

Table 1: Reproductive potential of *Chrysomya albiceps*irradiated females crossed with non-irradiated males.

Dose Gy	No. of eggs laid/5♀	Hatched eggs		Non-hatched eggs		Sterility Index (SI)
		No.	%	No.	%	%
Control	162.0±4.4[a]	159.7±5.0[a]	98.6±1.0	2.33±1.53[a]	1.45±1.0	0.0±0.0
5	103.7±6.7[d]	80.7±8.5[d]	77.7±3.7	23.00±2.65[d]	22.3±3.7	49.6±3.77
10	77.0±5.6[d]	40.3±1.5[d]	52.5±2.6	36.67±4.51[d]	47.5±2.6	74.7±1.47
15	23.3±7.1[d]	7.7±1.5[d]	33.6±4.0	15.67±5.69[b]	66.4±4.0	96.3±2.58
20	0.0±0.0	---	---	---	---	100.0±0.0

No.: Number; SD = standard deviation; a: non-significant (P>0.05); b: significant (P<0.05); c: highly significant (P<0.01); d: very highly significant (P<0.001). Means followed by the same letter in the same column are not statisticallysignificant.

The number of eggs laid by 5 non-irradiated females (NF) mated with irradiated males (TM) was decreased from 162.0±4.4 for the control group to 118.7±5.5, 94.3±7.0, 48.7±4.5 and 0.0 eggs/5female at 5, 10, 15 and 20 Gy. Values of eggs-hatchability % decreased from 98.6% for control to 66.7, 47.7 and 35.6% at 5, 10 and 15 Gy, respectively. *i.e.*, the egg-hatchability (%) was decreased and embryonic lethality was increased as the gamma-radiation dose increased. Also, sterility percentage resulted from pairing NF with TM (irradiated with 20, 15, 10 and 5 Gy) recorded 0.0, 89.1, 71.8 and 56.0%, respectively, compared with 0.0% for control congers (Table 2).

Table 2: Reproductive potential of *Chrysomya albiceps* non-irradiated females crossed with irradiated males.

Dose Gy	No. of eggs laid/5♀	Hatched eggs		Non-hatched eggs		Sterility Index (SI) %
		No.	%	No.	%	
Control	162.0±4.4[a]	159.7±5.0[a]	98.6±1.0	2.33±1.53[a]	1.45±1.0	0.0±0.0
5	118.7±5.5[d]	79.0±7.8[d]	66.7±7.1	39.67±9.61[d]	33.3±7.1	56.0±13.32
10	94.3±7.0[d]	45.0±5.3[d]	47.7±4.0	49.33±5.03[d]	52.3±4.0	71.8±2.53
15	48.7±4.5[d]	17.3±2.1[d]	35.6±1.3	31.33±2.52[d]	64.4±1.3	89.1±1.04
20	0.0±0.0	---	---	---	---	100.0±0.0

See footnote of table (1).

Data in Table (3) recorded the effect of gamma radiation on the fecundity of *C. albiceps* females resulted from 3-days old pupae irradiated with 5, 10, 15 and 20 Gy of gamma-radiation and crossed with males resulted from pupae irradiated with the same doses. The number of eggs/5female decreased to record 102.0±3.6, 77.0±4.4 and 44.7±5.5 eggs/5female at 5, 10 and 15 Gy, compared with 162.0±4.4 eggs/5female for the control group. Also, embryonic lethality (%) was increased as gamma-radiation dose increased and egg-hatchability (%) decreased from 98.6% for the control group to 23.4, 33.2 and 42.8% for 15, 10 and 5 Gy, respectively.

In addition, the sterility index of TF and crossed with TM was dose-dependent, where it increased as the dose of gamma radiation increased; it increased from 0.0% in the control group to reach 100.0, 93.4, 84.0 and 72.6% at 20, 15, 10 and 5 Gy, respectively (Table 3).

Table 3: Reproductive potential of *Chrysomya albiceps*irradiated females crossed with irradiated males.

Dose Gy	No. of eggs laid/5♀	Hatched eggs		Non-hatched eggs		Sterility Index (SI) %
		No.	%	No.	%	
Control	162.0±4.4[a]	159.7±5.0[a]	98.6±1.0	2.33±1.53[a]	1.45±1.0	0.0±0.0
5	102.0±3.6[d]	43.7±2.3[d]	42.8±1.6	58.33±2.51[d]	57.2±1.6	72.6±2.23
10	77.0±4.4[d]	25.7±3.5[d]	33.2±2.9	51.33±1.53[d]	66.8±2.9	84.0±1.72
15	44.7±5.5[d]	10.3±1.5[d]	23.4±4.7	34.33±6.11[d]	76.6±4.7	93.4±1.12
20	0.0±0.0	---	---	---	---	100.0±0.0

See footnote of table (1).

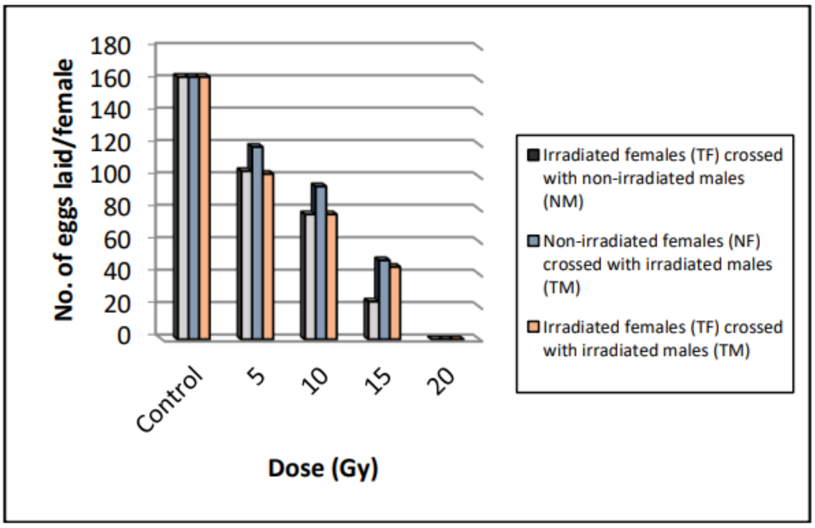

Fig. 1: Effect of gamma radiation on the fecundity of *Chrysomya albiceps.*

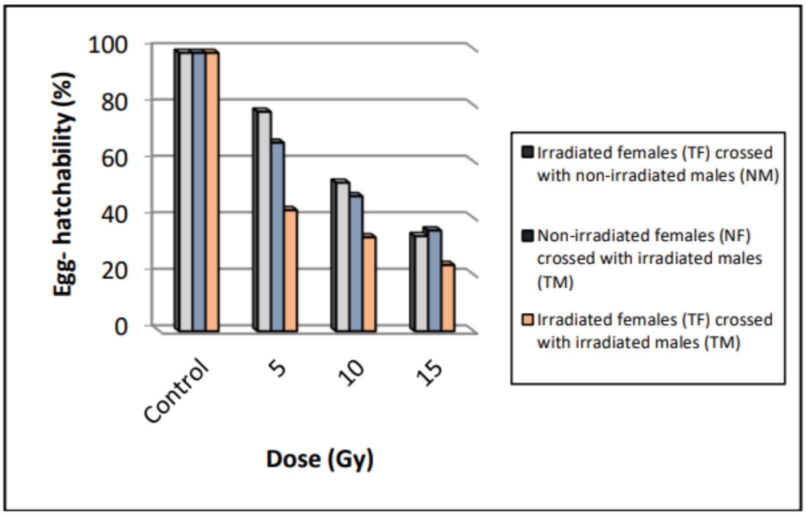

Fig. 2: Effect of gamma radiation on egg-hatchability of *Chrysomya albiceps.*

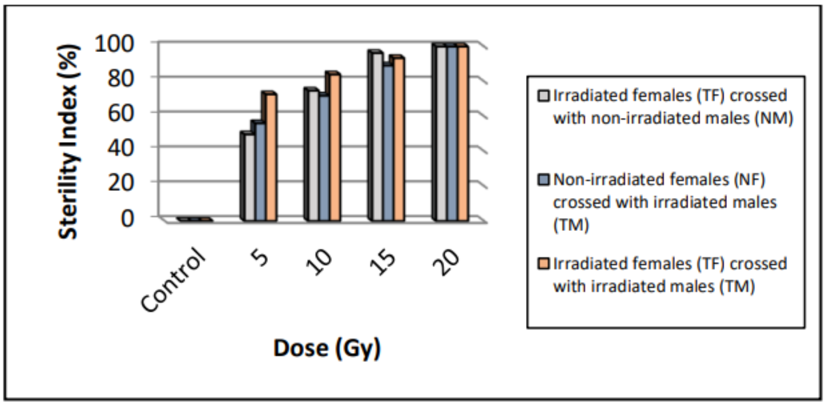

Fig. 3: Effect of gamma radiation on the sterility % of *Chrysomya albiceps.*

From obtained results, it is obvious that egg-hatchability or embryonic lethality and sterility percent in all treatments were dose-dependent, where the egg-hatchability percentages were decreased as gamma radiation doses of irradiated pupae increased, meanwhile the sterility % of females were increased as the doses of irradiated pupae increased. Also, it is obvious that the embryonic lethality or egg-hatchability values based on the calculated LD_{50} of gamma radiation indicated that, when females resulted from irradiated pupae crossed with males resulted from the irradiated pupae the highest sterility and non-hatched eggs percent occurred. In addition, the results indicated that females were more radiosensitive than males as shown from LD_{50} values in table (4), where the LD_{50} for the lethality of eggs laid by non-irradiated females mated with irradiated males was 9.3598 Gy, compared with 10.6257 Gy for egg-lethality laid by irradiated females mated with non-irradiated males. However, the LD_{50} value was 3.603 Gy when both males and females were irradiated.

Table 4: Doses of gamma radiation affecting the egg-hatchability of *Chrysomya albiceps.*

Treatments	LD	Dose (Gy)	95% Confidence limits	
			Lower limit Gy	Upper limit Gy
Irradiated ♀ × non-irradiated ♂	25	5.7521	4.9999	6.3945
	50	10.6257	9.5323	12.2992
	75	19.6285	16.0971	26.7075
	90	34.1022	25.3553	54.6049
	95	47.4615	33.2111	83.9391
	99	88.2263	55.0067	188.3265
non-irradiated ♀ × Irradiated ♂	25	3.7112	2.6592	4.5366
	50	9.3598	8.2735	10.8915
	75	23.6059	18.1404	37.1042
	90	54.2786	35.0663	117.2747
	95	89.3349	51.8566	234.2411
	99	227.449	107.7796	859.3184
Irradiated ♀ × Irradiated ♂	25	0.8339	0.1024	1.7567
	50	3.603	1.6713	4.8908
	75	15.5664	11.6387	31.9078
	90	58.1041	29.4233	391.6108
	95	127.7951	50.3855	1786.1913
	99	560.4551	137.3272	30959.1644

LD: Lethal dose

DISCUSSION

Results of the present study showed that the number of eggs laid by *C. albiceps* females resulted from pupae irradiated with different doses of gamma radiation decreased as the dose increased. Also, the non-hatching eggs %was found to be dose-dependent *i.e.*, increased as the dose of the gamma irradiation used increased.The highest reduction in the number of eggs occurred at high doses (10 and 15 Gy) when irradiated females were crossed with non-irradiated males. In addition, the non-hatching egg % increased to a record 76.6 and 66.8 at 15 and 10 Gy when irradiated females crossed with irradiated males. These results come in agreement with the previous results reviewed the effect of radiation on different insect' species recorded by Belal (2006), where the percent of emerged adults from eggs treated with 16 Gy of gamma radiations was 1.8%; Ayvaz *et al.*, (2007), whereadverse effects of gamma radiation on the percentage of egg hatched and developmentrate of the Mediterranean flour moth, *Ephestia kuehniella* were observed; Dória *et al.*, (2007), where all doses of gamma radiation tested against Mediterranean fruit fly, *Ceratitis capitata* did not allow the emergence of adults from treated eggs and Aye *et al.*,(2008), where egg hatchability of *Plodia interpunctella*was almost completely inhibited by 0.5 kGy and higher doses (from 0.1 to 1.0 kGy).

Also, the present study has shown that the sterility index of *C. albiceps* females resulting from irradiated pupae was increased as the dosage of gamma radiation increased. Gamma radiation resulted in a progressive increase in the sterility % of all different treatments as compared with the sterility percentage in the untreated group (0.0%). Complete sterility (100.0%) was attained by 20 Gy for all groups. The sterility index was recorded at 96.3% when irradiated females crossed with non-irradiated males. These results are consistent with those obtained by Puanmanee *et al.*,(2010) who reported an increase in the sterility of *Bactrocera correcta* when treated males were crossed with untreated females and the sterility % was increased as the gamma dosage increased.

In addition, results showed that *C. albiceps* females were more radiosensitive than males, where high sterility (96.3%) was recorded when females resulted from pupae irradiated with 15 Gy crossed with untreated males, compared with 0.0% in control. These results conflict with those obtained by Khan and Islam (2006), who reported that *Musca domestica* could be manipulated effectively by irradiation of newly emerged adults from 5 to 10 Gy and concluded that male houseflies are more radiosensitive than their female counterparts. Also, the present study showed that sterility of*C. albiceps*was increased with increasing dose to reach 100.0 % at 20 Gy; similar results were obtained by Donnelly (1960) for *Lucilia sericata,* Crystal (1979) for *Coclio hominivorax,* Karunamoorthy and Lalitha, (1987) for *L. cuprina,* Huda and Khan, (2000) *L. cuprina* and Hassan *et al.*,(2019) for *Musca domestica.*

As shown from the results, gamma radiation-induced a progressive increase in egg lethality giving an estimated LD_{50} value of 9.3598 Gy when non-irradiated females mated with irradiated males compared with 10.6257 Gy for egg-lethality laid by irradiated females mated with non-irradiated males. However, the LD_{50} value was 3.603 Gy when both males and females were irradiated, respectively. The percentage of non-hatched eggs increased from 1.45% in controls to record 66.4, 64.4 and 76.6% for eggs laid by irradiated females crossed with non-irradiated males, non-irradiated females crossed with irradiated males and irradiated females crossed with irradiated males at the dose of 15 Gy, respectively. These results indicate that *C. albiceps* females are more radiosensitive than their male counterparts.

Conclusion:

Generally, gamma radiation affects the reproductive potential of the blowfly, *Chrysomya albiceps*. As the doses of gamma radiation increased a progressive increase in sterility percent and a reduction in eggs-viability occurred. Also, *C. albiceps* females were more radiosensitive than males.

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