Acta Entomology and Zoology 2024; 5(2): 283-291

Acta Entomology and Zoology

E-ISSN: 2708-0021
P-ISSN: 2708-0013
Impact Factor (RJIF): 5.83
www.actajournal.com
AEZ 2024; 5(2): 283-291
Received: 24-10-2024
Accepted: 26-11-2024

Heba A Elshanat
Cotton and Crop Mites Research Department, Plant Protection Research Institute, Agricultural Research Center Dokki, Giza, Egypt

Sayed RM
Natural Products Research Department, National Center for Radiation Research and Technology, Egyptian Atomic Energy Authority, Cairo, Egypt

Mariam A El Sanady
Cotton and Crop Mites Research Department, Plant Protection Research Institute, Agricultural Research Center Dokki, Giza, Egypt

Hussein AM
Vegetables and Ornamental Plants Department, Plant Protection Research Institute, Agricultural Research Center Dokki, Giza, Egypt

Corresponding Author:
Heba A Elshanat
Cotton and Crop Mites Research Department, Plant Protection Research Institute, Agricultural Research Center Dokki, Giza, Egypt

Influence gamma Irradiated on some biological aspects of predator mite *Cheyletus malaccensis* (Oudemans) (Trombidiformes: Cheyletidae)

Heba A Elshanat, Sayed RM, Mariam A El Sanady and Hussein AM

DOI: https://www.doi.org/10.33545/27080013.2024.v5.i2d.246

Abstract
Due to the problems caused by mite pests in agricultural crops, the modern trend in controlling these pests is to search for a safe control program that includes mite predators and enhances their capabilities. Therefore, the aim of this research was to study the effect of use gamma rays with low doses (2, 4, 6 and 8 Gy) on female and male vitality predatory mite *Cheyletus malaccensis*. Three experiments were conducted, the first involved exposing a female to radiation and then mating her with a normal male. The second involved mating irradiated males with normal females. The third involved mating irradiated females with irradiated males. All three conditions were compared with the control (non-irradiated) condition. The biological aspects of the predatory mite were monitored and measured, and the results showed that its life cycle and age were significantly shortened when exposed to low radiation doses (2 and 4 gray), which leads to an increase in the number of generations in the three cases, extending the egg-laying period, increasing the number of eggs, and increasing the predator's ability to prey. The effect of radiation on females exposed to radiation increases the lifespan of females in the first and third cases, while in the second case it remains unaffected compared to the control. Meanwhile, the lifespan of males exposed to radiation increases in the second and third cases, while in the first case it remains unaffected compared to the control. The female sex ratio was greater than the male sex ratio in the first and third cases of females exposed to radiation, while the male sex ratio was greater than the female sex ratio in the second case compared to the control. The daily egg production rate also increased compared to the control. This indicates a significant number of acarid predators, and this represents a success in biological control, a trend we are pursuing.

Keywords: *Cheyletus malaccensis*, gamma ray, longevity, consumed feeding, hatchability

Introduction

Cheyletus malaccensis is a significant predatory mite widely used in the biological control of pests that affect stored products, such as *A. farris*, *A. siro*, *Aleuroglyphus ovatus* (Troupeau), *Caloglyphus redickorzevi* (Zachvatkin), *Caloglyphus rodriguezi* Samsinak, *Lepidoglyphus destructor* (Schrank), *Rhizoglyphus echinopus* Fumouze and Robin, *T. putrescentiae*, and small insects such as eggs, young larvae or nymphs of moths and beetles (Hughes, 1976 [6]; Yousef, 1982 [18]; El-Shannat, 2009 [4]; Al-Shammery, 2014) [1]. *C. malaccensis* was first reported in Egypt in connection with pests infesting stored grains and seeds (Wafa, 1966) [17]. Additionally, its presence has been documented in association with stored goods and household dust in both the Philippines and India (Corpuz-Raros,1988 [3] and Putatunda, 2005) [11]. The biological impact of ionizing radiation depends on both the total dose (the overall energy absorbed) and the dose rate (the energy absorbed per unit of time). Much of the research on high radiation doses has concentrated on their detrimental effects, such as the increased occurrence of cancer and developmental defects (Tubiana, 2009) [16]. The physiological effects of low radiation doses cannot be predicted by simply extrapolating from the effects of higher doses. However, there is substantial evidence suggesting that low doses of radiation can activate immune responses and enhance the antioxidant system (Pollycove, 2007) [10]. While the biological effects of low radiation doses are not fully understood, increasing evidence indicates that they may have positive effects on lifespan (Marples and Collis, 2008) [8]. Additionally, low-dose irradiation in bees has been shown to boost the expression of genes involved in foraging behavior and activate the metabolic factors necessary for this activity (Sayed, 2018) [13].

Therefore, this study aimed to discovering the effect of low doses of gamma rays on some biological performance and consumed feeding of F1 of irradiated adults (female & male) and eggs of different ages of predator mite *C. malaccensis* (Oudemans).

Materials and method

Rearing of *Cheyletus malaccensis*

The predator mite *C. malaccensis*was reared in laboratory at 30ºC and 90% relative humidity in plastic chamber (jar) (5 cm in diameter, 4 cm in depth). The bottom of the jar was covered with a mixture of plaster of Paris: Charcoal (9:1) and tightly covered by a piece of glass slide. The culture of the most abundant predatory mite, *C. malaccensis* was reared and fed on egg of grain mite *Tyrophagus putrescentiae* to study certain biological parameters of *C. malaccensis*, each pair of predators (adult female and male) was confined in each rearing unit and was supplied with sufficient of prey eggs. Adult were removed after one day to another unites and the eggs were left till hatching. The newly hatched larvae were singly transferred to another previously mentioned rearing cells. Each cell was covered with glass slide and tightly fixed by rubber bands as mentioned by Rakha *et al.* (1991) [12] and Salem *et al.* (2005) and supplied with a known number of the acarid mite, *Tyrophagus putrescentiae* eggs, Numbers of consumed or punctured eggs were counted and replaced daily.

Irradiation Source

The gamma irradiation process was performed at NCRRT, EAEA Cairo, Egypt; using Cs^{137} cell with dose rate of 0.579 rad/sec.

Biological Experiments

Adults Irradiation

Newly emerged adults (male and females) *Cheyletus malaccensis* were gamma irradiated with 2, 4, 6 and 8Gy. For each dose, 3combination were set up (irradiated ♂ X irradiated ♀, unirradiated ♂ X irradiated ♀ and irradiated ♂ unirradiated ♀). The control group was the combination of unirradiated ♂X unirradiated ♀.

Three replicates were prepared for each combination in each dose and the control and kept at and 30ºC and 90 relative humidity, then microscopic examination and recording the data of observations for each replicate was recorded each 12 hours.

The fecundity (No. of eggs laid/♀), fertility (No. of eggs hatched) and % of hatchability was determined according to El-Shazly (1993) [5].

$$\text{Hatchability \%} = \frac{\text{No.of hatched eggs}}{\text{No. of eggs laid}} \times 100$$

Irradiated egg experiment

Four groups of different egg ages (0-12h., 12-24h., 24-36h. and 36-48h. old) were prepared in 5 cm petri-dishes “each contain of100 eggs”. The dishes were irradiated with2, 4, 6 and 8Gy. Same number of unirradiated eggs was used as the control group. 3 replicates were conducted for the control each egg dose and age. The hatchability percentage and the sex ratio for the hatched individuals were recorded.

Statistical analysis

Minitab programmed was used to adjust and analyses the obtained results using one-way ANOVA, followed by Tukey Pairwise Comparisons test to examine the significant differences ($P \leq 0.05$) across the means of the treatments.

Results

First case of irradiated female mated with normal male

The results shown in table (1) the periods of egg incubation, total immature stages, life cycle and life span for the second generation (F2) from laid egg of the pre-mentioned parents. Results show that the egg incubation period for the control and 8 Gy recorded the same result 5 days, while it decreases to 4 days at 6 Gy and one day at 4, 2 Gy respectively. Statistically significant differences between the control and each value of irradiation dose were noticed.

Total immature stages for females recorded the same result 15.33 days in the control and 8 Gy, while it recorded 13.67 days in 6 Gy and decreased to 7.67and 8.67 days at 4 and 6 Gy treatments that with a clear statistically significant differences between all values. Total immature stages for the males showed the same pre-mentioned trend for the females as it was recorded the same result 7.67 days in the control, 8 and 6 Gy and decreased to 2.67 and 3 days for 2 and 4 Gy respectively.

Life cycle (egg- adult) for the females showed recorded 20,33 days in control and 8 Gy while it took the period decrease to18.10 and 8.67 days at 6.2 and 4Gy, respectively, with a clear significant difference between the values and control. Also, males' life cycle was 12.67 days in control and 8 Gy became less to 11 days at 6 Gy while it looks the same period 4 days at 4 and 2Gy to, respectively, showing also significant differences between each value and the control.

Duration of life span showed a considerable difference between males and females as it was longer in females in all levels of irradiation 2, 4, 6 and 8 Gy. Females recorded 38, 35.67, 31 and 29 days compared with control it took 37 days, which were clearly longer than those of males which recorded only 26 days for 8 Gy and control, the same value 17.33 days at 2 and 4Gy also respectively. All values of life span significantly differed in between males and females and control.

Table 1: Effect of irradiation on duration of different stages of *Cheyletus malaccensis* when irradiated female mated with normal male.

Radiation doses (Gy)	Egg Incubation Period	Total Immature Stages		Life Cycle (egg -adults)		Life Span duration (days) (parent female - F1 adult)	
		♀	♂	♀	♂	♀	♂
Control (0)	5±0^{A}	15.33±0.88^{A}	7.67±0.33^{A}	20.33±0.88^{A}	12.67±0.33^{A}	37±1^{A}	26±0.57^{A}
2	1.33±0.33^{B}	8.67±0.33^{B}	2.67±0.33^{B}	10±0^{B}	4±0^{C}	31±0.57^{B}	17.33±0.33^{B}
4	1±0^{B}	7.67±0.88^{B}	3±0^{B}	8.67±0.88^{B}	4±0^{C}	29±0.57^{B}	17.33±0.33^{B}
6	4±0.33^{A}	13.67±0.88^{A}	7±0^{A}	18±1.15^{A}	11±0^{B}	35.67±0.88^{A}	24.67±0.33^{A}
8	5±0^{A}	15.33±0.88^{A}	7.67±0.33^{A}	20.33±0.88^{A}	12.67±0.33^{A}	38±0.57^{A}	26±0.57^{A}
F-value	90	21.26	97	44.29	454.5	27.76	102.89
P- value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Result in Table (2) showed that female longevity ranged between 16,67days for control. The female longevity period increases as the radiation dose decreases. Where it recorded17.67,20.33 and 21.0 days, respectively, when exposed to 2,4, 6 and 8 Gy. Which mean female longevity, were in inverse relationship with increasing the dose of irradiation. Statistically significant differences between the control and each value of irradiation dose were noticed.

Daily eggs rate for females recorded 12.67, 12.67 eggs/days when exposed to 2 and 4 Gy while decreased to 9.33 and 7 Gy, when exposed to 6,8 Gy, compared with 12.0 eggs/days, for control with significant differences between the control and each level of irradiation were noticed.

Hatchability percentage of the eggs from females irradiated with 2,4 and 6 Gy recorded 96.97, 97.92 and 97.03, respectively, then decreased to 93.0% when recorded at 8Gy. in comparison with 97.5% for eggs from females of control (nonirradiated).

Sex ratio (Female: Male) recorded 1:0.70, 1: 0.62 1: 0.59, for females irradiated with 6,2,4 then increased to 1:0.87 when the females irradiated with 8Gy, with compared the control population recorded 1: 0,62. It is notable to mention that male longevity recorded 13.33 days for both control and all levels of irradiation.

Table 2: Effect of irradiation on adult longevity (female and male), daily eggs rate, hatchability percentage and sex ratio of *Cheyletus malaccensis* when irradiated female mated with normal male.

Radiation doses (Gy)	Female longevity (days)	Daily eggs rate	Male longevity (days)	% Hatchability	Sex ratio Female: Male	
Control (0)	16.67±0.33B	12±0A	13.33±0.33A	97.5±0AB	1	0.72
2	21±0.57A	12.67±0.33A	13.33±0. 33A	96.97±0.6AB	1	0.62
4	20.33±0.33A	12.67±0.33A	13.33±0. 33A	97.92±0.13A	1	0.59
6	17.67±0.33B	9.33±0.33B	13.33±0. 33A	97.03±1.69AB	1	0.70
8	17.67±0.33B	7±0C	13.33±0. 33A	93±1.32B	1	0.87
F-value	22.86	93.67	0.00	3.93		
P- value	0.000	0.000	1.00	0.036		

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Result in Table (3) showed that during period total immature of female predator number of eggs consumed 58.33,50,42.6 and 34.67 prey at 4,2,6 and 8 Gy, respectively, compared with 42 prey for control, while male consumed the same number 30 prey in all irradiated value 2,4,6, 8Gy and control. During period pre-oviposition female predator number of eggs consumed 9 prey both 6 Gy and control 7.33, 11, 13 prey at 8,2, 4Gy while increased predation rate in oviposition period where recorded 88 prey for control and 6 Gy,67.67 prey at 8 Gy and increased to 95, 120 prey at 2 and 4 Gy. While postoviposition period it was consumed 15 prey for control and 6 Gy,10.67 prey at 8 Gy increased to 30,35 preys at 2,4 Gy

Table 3: Effect of irradiation on the number of eggs consumed feeding different stages of *Cheyletus malaccensis* when irradiated female mated with normal male.

Radiation doses (Gy)	Total immature		Female duration			Male duration	Life span	
			Pre-oviposition	Oviposition	Post-oviposition			
	♀	♂	♀	♀	♀		♀	♂
Control (0)	42±0C	30±0A	9±0C	88±0B	15±0C	44.33±0.33A	154±0C	74.33±0.33A
2	50±0B	30.33±0.33A	11±0B	95±0B	30±0B	44±0A	186±0B	74.33±0.33A
4	58.33±1.67A	30.33±0.33A	13±0A	120±0A	35±0A	44±0A	226.33±1.67A	74.33±0.33A
6	42.67±0.67C	30±0A	9±0C	88.33±0.33B	15±0C	44.33±0.33A	155±0.57C	74.33±0.33A
8	34.67±0.33D	30±0A	7.33±0.33D	67.67±0.33C	10.67±0.33D	44±0A	120.33±1.2D	74±0A
F-value	120.97	0.75	214	177.71	5126.5	0.75	1746.04	0.25
P- value	0.000	0.580	0.000	0.000	0.000	0.580	0.000	0.903

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

On the other side, male duration male consumed the same number 44 prey in all irradiated value 2,4,6, 8Gy and control. The predator female consumed in life span 120, 155,186,226.33 and 154 prey at 8,6,2,4Gy and control, respectively. While male consumed the same number 74.33 prey in all irradiated value 2,4,6, 8Gy and control. Statistically significant differences between the control and each value of irradiation dose were noticed.

Second case of irradiated male mated with normal female: The results shown in table (4) the periods of egg incubation, total immature stages, life cycle and life span for the second generation (F2) from laid egg of the pre-mentioned parents. Results show that the egg incubation period for the control and 8Gy recorded the same result 5 days, while it decreases to 4 days at 6Gy and one day at 4 and 2Gy, respectively.

Total immature stages for females recorded the same result15,33 days in the control and 8Gy, while it recorded 13.67 days in 6 Gy and decreased to 7.67and 8.67 days at 4 and 6Gy treatments that with a clear statistically significant differences between all values. Total immature stages for the males showed the same pre-mentioned trend for the females as it was recorded the same result 7.67 days in the control, 8 and 6Gy and decreased to 2.67 and 3 days for 2 and 4Gy, respectively.

Life cycle (egg- adult) for the females showed recorded 20,33 days in control and 8Gy while it took the period decrease to18, 10 and 8.67 days at 6,2 and 4Gy, respectively, with a clear significant difference between the values and control. Also, males' life cycle was 12.67 days in control and 8Gy became less to 11 days at 6Gy while it looks the same period4 days at 4 and 2Gy to, respectively, showing also significant differences between each value and the control.

Duration of life span showed a considerable difference between males and females as it was longer in females in all levels of irradiation 2, 4, 6 and 8Gy. Females recorded 37, 34.67, 25.33, and 26.67 days compared with control it took 37 days, which were clearly longer than those of males which recorded only 26 days for 8Gy and control, the value 25.33, 22.67 and 22.33 days at, 6,4 and 2Gy, respectively. All values of life span significantly differed in between males and females and control.

Table 4: Effect of irradiation on duration of different stages of *Cheyletus malaccensis* when irradiated male mated with normal female.

Radiation doses (Gy)	Egg Incubation Period	total immature stages		Life Cycle (egg -adults)		Life Span duration (days) (parent female - F1 adult)	
		♀	♂	♀	♂	♀	♂
Control (0)	$5±0^{A}$	$15.33±0.88^{A}$	$7.67±0.33^{A}$	$20.33±0.88^{A}$	$12.67±0.33^{A}$	$37±1^{A}$	$26±0.57^{A}$
2	$1.33±0.33^{B}$	$8.67±0.33^{B}$	$2.67±0.33^{B}$	$10±0^{B}$	$4±0^{C}$	$26.67±0.33^{B}$	$23.33±0.33^{BC}$
4	$1±0^{B}$	$7.67±0.88^{B}$	$3±0^{B}$	$8.67±0.88^{B}$	$4±0^{C}$	$25.33±1.2^{B}$	$22.67±0.33^{C}$
6	$4±0.33^{A}$	$13.67±0.88^{A}$	$7±0^{A}$	$18±1.15^{A}$	$11±0^{B}$	$34.67±1.45^{A}$	$25.33±0.33^{AB}$
8	$5±0^{A}$	$15.33±0.88^{A}$	$7.67±0.33^{A}$	$20.33±0.88^{A}$	$12.67±0.33^{A}$	$37±1^{A}$	$26±0.57^{A}$
F-value	90	21.26	97	44.29	454.5	28.66	12.22
P- value	0.000	0.000	0.000	0.000	0.000	0.000	0.001

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Result in Table (5) showed that female longevity took the same value for all 16,67 days at 2,4,6,8Gy and control. The daily eggs rate recorded constant value 12 egg/day for all levels of irradiation and was similar in control without any statistically differences in between. Male longevity recorded 13.33 for all control and 8Gy, and increased to 14.33, 18.67,19.33 days at 6,4,2 Gy.

Hatchability percentage of the eggs recorded an increase after 2Gy irradiation, then decreased with increasing the radiation doses, showing 84.33%,88.33%,94.16%,99.16%to doses 8,6,4,2 Gy, respectively in comparison with 97.5% for eggs from females of control (nonirradiated). Statistically significant differences between the control and each value of irradiation dose were noticed.

Sex ratio (Female: Male) recorded increased 1:0.37, 1: 0.57, 1: 0.70, and 1::2.50 in Inversely related to dose 8,6,4,2 Gy in comparison with 1:0.72 of control (nonirradiated).

Table 5: Effect of irradiation on adult longevity (female and male), daily eggs rate, hatchability percentage and sex ratio of *Cheyletus malaccensis* when irradiated male mated with normal female.

Radiation doses (Gy)	Female longevity (days)	Daily eggs rate	Male longevity (days)	% Hatchability	**Sex ratio** Female: Male	
Control (0)	$16.67±0.33^{A}$	$12±0^{A}$	$13.33±0.33^{B}$	$97.5±0^{A}$	1	0.72
2	$16.67±0.33^{A}$	$12±0^{A}$	$19.33±0.33^{A}$	$99.16±0.83^{A}$	1	2.50
4	$16.67±0.33^{A}$	$12±0^{A}$	$18.67±0.33^{A}$	$94.16±0.83^{B}$	1	1.70
6	$16.67±0.33^{A}$	$12±0^{A}$	$14.33±0.33^{B}$	$88.33±0.83^{C}$	1	1.57
8	$16.67±0.33^{A}$	$12±0^{A}$	$13.33±0.33^{B}$	$84.33±0.33^{D}$	1	1.37
F-value	0.00	0.00	78.80	88.91		
P- value	1	1	0.000	0.000		

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Result in Table (6) showed that during period total immature of female predator the same number of eggs consumed 45,33 prey at all irradiated value and control, respectively, while male consumed the same number consumed 30 prey in 8Gy and control, while consumed 60,55,39.33 prey Inverse relationship at doses 6,4,2Gy.

During period pre-oviposition female predator number of eggs consumed 9.33 prey both all value and control while increased predation rate in oviposition period where recorded 89.33 prey for control and all Gy values. While postoviposition period it was consumed 15.33 prey for control and all doses Gy.

On the other side male duration male consumed the same number 44 prey in irradiated value 8 Gy and control. The predator female consumed in life span 159.33prey at all irradiated value and control, while male consumed the same number 74.33 prey in 8 Gy and control, while increased to 88.67, 133.33,140.67 prey with

Table 6: Effect of irradiation on the number of eggs consumed feeding different stages of *Cheyletus malaccensisi* when irradiated male mated with normal female.

Radiation doses (Gy)	Total immature		Female duration			Male duration	Life span	
	♀	♂	Pre-oviposition	Oviposition	Post-oviposition		♀	♂
Control (0)	45.33±0^A	30±0^D	9.33±0^A	89.33±0^A	15.33±0^A	44.33±0.33^D	159.33±0^A	74.33±0.33^D
2	45.33±0^A	60±0.33^A	9.33±0^A	89.33±0^A	15.33±0^A	80.67±0^A	159.33±0^A	140.67±0.33^A
4	45.33±0^A	55±0 ^B	9.33±0^A	89.33±0^A	15.33±0^A	78.67±0^B	159.33±0^A	133.33±0.33^B
6	45.33±0^A	39.33±0^C	9.33±0^A	89.33±0^A	15.33±0^A	49.33±0.33^C	159.33±0^A	88.67±0.33^C
8	45.33±0^A	30±0^D	9.33±0^A	89.33±0^A	15.33±0^A	44±0^D	159.33±0^A	74.33±0^D
F-value	0.00	8824	0.00	0.00	0.00	2232.29	0.00	4280.32
P- value	1	0.000	1	1	1	0.000	1	0.000

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Third case of Irradiated male mated with irradiated female

The results are shown in table (7) the periods of egg incubation, total immature stages, life cycle and life span for the second generation (F2) from laid egg of the pre-mentioned parents. Results show that the egg incubation period for the control recorded 5 days and6,5.33, 2,2.33days at 8,6,4,2 Gy, respectively. Statistically significant differences between the control and each value of irradiation dose were noticed.

Total immature stages for females recorded 15.33 days in the control, while it recorded 18.33,16.67,11.67,10.67 days at 8,6,2,4 Gy treatments that with a clear statistically significant differences between all values. Total immature stages for the males showed the same pre-mentioned trend for the females as it was recorded result4.67, 5, 9,9.67days, respectively, and the control, 6.67days

Life cycle (egg- adult) for the females showed recorded 20.33 days in control and14,12.67, 23.67,24.33 at 2, 4, 6,8Gy, respectively, with a clear significant difference between the values and control. Also, males' life cycle was 12,67 days in control and became to 14.33, 15.67 days at 6,8 Gy while it became less look the same period4 days at 2, 4Gy to, respectively, showing also significant differences between each value and the control.

Duration of life span showed a considerable difference between males and females as it was longer in females in all levels of irradiation 2, 4, 6 and 8 Gy. Females recorded 42, 39.67,33 and 35 days compared with control it took 37 days, which were clearly longer than those of males which recorded only 26 days for 2Gy and control, the value 25.67, 28.33 and 29 days at 4,6,8 Gy, respectively. All values of life span significantly differed in between males and females and control.

Table 7: Effect of irradiation on duration of different stages of *Cheyletus malaccensis* when irradiated male mated with irradiated female.

Radiation doses (Gy)	Egg Incubation Period	total immature stages		Life Cycle (egg -adults)		Life Span duration (days) (parent female - F1 adult)	
		♀	♂	♀	♂	♀	♂
Control (0)	5±0^B	15.33±0.88^AB	7.67±0.33^B	20.33±0.88^AB	12.67±0.33^C	37±1^BC	26±0.57^C
2	2.33±0.33^C	11.67±0.33^BC	4.67±0.33^C	14±0^BC	7±0^D	35±0.57^CD	26.33±0.33^BC
4	2±0^C	10.67±0.88^C	5±0^C	12.67±0.88^C	7±0^D	33±0.57^D	25.67±0.33^C
6	5.33±0.33^AB	16.67±0.88^A	9±0^A	23.67±1.15^A	14.33±0^B	39.67±0.88^AB	28.33±0.33^AB
8	6±0^A	18.33±0.88^A	9.67±0.33^A	24.33±0.88^A	15.67±0.33^A	42±0.57^A	29±0.57^A
F-value	75.75	16.6	78	14.97	251.67	23.20	11.22
P- value	0.000	0.000	0.000	0.000	0.000	0.000	0.001

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Result in Table (8) showed that female longevity took the increased value to 17.67, 20.3, 3.21 at 8,6,4, 2Gy compared with 16.67 at control. The daily eggs rate recorded constant value 12 egg/day for all 8Gy, while was 14, 14.67, 15.67 of irradiation and was similar in control without any statistically differences in between. Male longevity recorded 13.33 for all control and 8Gy and increased to 14.33, 18.67, 19.33 days at 6,4,2 Gy.

Hatchability percentage of the eggs recorded increase 80,83.76%,99.89%respectively, in related to dose 6,8,4,2Gy in comparison with 97.5% for eggs from females of control (nonirradiated).

Sex ratio (Female: Male) recorded increased 1:0.53, 1: 0.74, 1: 0.79, and related to dose 8,6,2,4 Gy in comparison with 1:0.72 of control (nonirradiated). Statistically significant differences between the control and each value of irradiation dose were noticed

Table 8: Effect of irradiation on adult longevity (female and male), daily eggs rate, hatchability percentage and sex ratio of *Cheyletus malaccensis* when irradiated male mated with irradiated female.

Radiation doses (Gy)	Female longevity (days)	Daily eggs rate	Male longevity (days)	% Hatchability	Sex ratio Female: Male	
Control (0)	16.67±0.33^{B}	12±0^{C}	13.33±0.33^{B}	97.5±0^{B}	1	0.72
2	21±0.57^{A}	15.67±0.33^{A}	19.33±0. 33^{A}	99.89±0.10^{A}	1	0.74
4	20.33±0.33^{A}	14.67±0.33^{B}	18.67±0. 33^{A}	99.89±0.111^{A}	1	0.79
6	17.67±0.33^{B}	14±0^{B}	14.33±0. 33^{B}	80±0^{D}	1	0.74
8	17.67±0.33^{B}	12±0^{C}	13.33±0. 33^{B}	83.76±0.16^{C}	1	0.53
F-value	22.86	60	78.8	9372.08		
P- value	0.000	0.000	0.000	0.000		

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Result in Table (9) showed that during period total immature of female predator the same number of eggs consumed 42prey at 6Gyand control,50,58.33,42,34.67prey at 2,4, 8Gy, respectively. While male consumed the same number consumed 30 preys in 8 Gy and control, while consumed 60,55,39.33 prey inverse relationship at doses 6,4, 2Gy.

During period pre-oviposition female predator number of eggs consumed 9preyfor both 6Gy and control, while increased predation rate in oviposition period where recorded 88.33 prey for control and 6Gy.95, 120.67prey at 2,4, 8Gy.While postoviposition period it was consumed 15prey for control and 6 Gy, 30,35,10.67prey at 2,4,8Gy.

On the other side male duration male consumed the same number 44 prey in irradiated value 8 Gy and control. The predator female consumed in life span 120, 159.33, 186, and 226.33 prey at 2,6,8, 4Gy irradiated and compared 154 prey control, while male consumed the same number 74,33 prey in 8Gy and control, while increased to 88.67, 133.33,140.67 prey with 6,4, 8Gy.Statistically significant differences between the control and each value of irradiation dose were noticed.

Table 9: Effect of irradiation on the number of eggs consumed feeding different stages of *Cheyletus malaccensis* when irradiated male mated with irradiated female.

Radiation doses (Gy)	Total immature		Female duration			Male duration	Life span	
	♀	♂	Pre-oviposition	Oviposition	Post-oviposition		♀	♂
Control (0)	42±0^{C}	30±0^{D}	9±0^{C}	88±0^{C}	15±0^{C}	44±0^{D}	154±0^{C}	74.33±0.33^{D}
2	50±0^{B}	60±0^{A}	11±0^{B}	95±0^{B}	30±0^{B}	80.6744±0.67^{A}	186±0^{B}	140.67±0.67^{A}
4	58.33±1.67^{A}	55±0^{B}	13±0^{A}	120±0^{A}	35±0^{A}	78.67±0.33^{B}	226.33±1.67^{A}	133.67±0.33^{B}
6	42±0 ^{C}	39.33±0.33^{C}	9±0^{C}	88.33±0.33^{C}	15±0^{C}	49.33±0.33^{C}	155±0.57^{C}	88.67±0.67^{C}
8	34.67±0.33^{D}	30±0^{D}	7.33±0.33^{D}	67.67±0.33^{D}	10.67±0.33^{D}	44±0 ^{D}	120.33±1.2^{D}	74.33±0.33^{D}
F-value	141.38	8824	214	7955.75	5126.5	2623.33	1746.04	4301.59
P- value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

The effect of irradiation with gamma ray doses (2,4,6,8 and control) for three cases of the first case was through irradiating the female then mated with normal male. The second case was irradiated males mated with normal females, while the third case was irradiated females mated with irradiated males. in the first case was through irradiating the female then mated with normal male number of eggs, it was recorded the highest percentage eggs which exposed to 2Gy reflecting a trend of decreasing number of eggs with increasing dose of irradiation it 4,6,8Gy, compared with control. The second case was irradiated males mated with normal females rate of number of eggs in this period there is no difference between all ray doses (2,4,6,8 and control). in the third case was irradiated females mated with irradiated males similarity with first case it was recorded the highest percentage eggs which exposed to 2Gy reflecting a trend of decreasing number of eggs with increasing dose of irradiation it 4,6, 8Gy.

The figure, also shows that the number of eggs was affected in the first and third cases where the female was irradiated and increased compared to the low doses (2,4Gy), while it was almost equal compared to the doses (2,4,6,8and control) in the second case where the female was not irradiated.

The number of eggs laid by females exposed to radiation increased in the first and third cases compared to the second case where the female was not exposed to radiation.

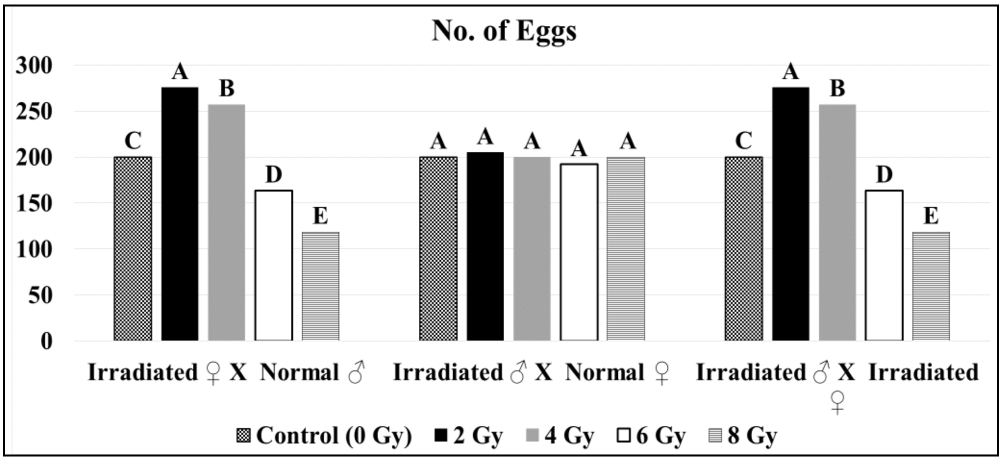

Fig 1: The effect of irradiation with different doses for three cases of female-male mating on the number of eggs

Table (10) showed the predator mites egg hatchability, and shows the sex ratio (females: males), (F:M), for the individuals resulted from 4 different ages eggs: >12 hours, 12-24 hours,24-36 hours and 36-48 hours. Result showed that the newly laid eggs (0-12) hours were extremely affected by irradiation as there was no any hatchability for all doses of irradiation. The egg (12-24) hours were affected by irradiation as there was no hatchability for 6 and 8 Gy but on 2 and 4 Gy recorded low percentages of hatchability. The eggs of (24-36) and (36- 48) hours recorded higher percentages of hatchability especially for the doses of 2,4Gy it was 53.33, 44.67%respectively when age egg (24-36) hours and recorded93.33% when age egg (36-48) hours.

Also, Table (10) shows the sex ratio for the mites resulted from the different pre-mentioned ages as (F:M). Control sex ratio recorded 1:0.7, then it was noticed that females increased by irradiation, e.g. in case of (24-36) hours this ratio recorded (1:0.61). Increasing females' numbers were noticed also in eggs of (36-48) hours age as it recorded (1:0.6), (1:0.5), (1:0.67) and (1:0.76) for the 4 levels of irradiation respectively.

Table 10: Effect of gamma ray on various eggs ages.

Egg age Radiation doses (Gy)	% Hatchability				Sex ratio Female: Male			
	0-12h.	12-24h.	24-36h.	36-48h.	0-12h.	12-24h.	24-36h.	36-48h.
Control (0)	100 ± 0^{A}	100 ± 0^{A}	100 ± 0^{A}	100 ± 0^{A}	1:0.7	1:0.7	1:0.7	1:0.7
2	0 ± 0^{I}	7.33 ± 0.33^{G}	53.33 ± 0.33^{D}	93.33 ± 3.33^{AB}	-	1:0.41	1:0.61	1:0.6
4	0 ± 0^{I}	4.33 ± 0.33^{G}	44.67 ± 2.9^{D}	93.33 ± 1.67^{AB}	-	1:0.38	1:0.59	1:0.5
6	0 ± 0^{I}	0 ± 0^{I}	33.33 ± 3.33^{E}	86.67 ± 1.67^{B}	-	-	1:0.76	1:0.67
8	0 ± 0^{I}	0 ± 0^{I}	23.33 ± 1.67^{F}	71.67 ± 1.67^{C}	-	-	1:0.57	1:0.76

- Values represent the mean of 3 replicates.
- Means in the same column that do not share a same capital letter are significantly different (one way ANOVA followed by Tukey Pairwise Comparisons)

Discussion

It is easy to conclude that irradiation for the female parent led to increase the female longevity period to 1-1.25 folds than its similar value of control, without change in males' longevity period. Also, irradiation for male parent led to increase the longevity male period to 1-1.45 folds than the control, without any effect on the female longevity period. That means females were sensitive for the treatment of irradiation, and were clearly response for the irradiation. Similarly, irradiation with the low doses 2 and 4Gy for males led to increase the number of males, and irradiation for females with the same low doses led to an obvious increase in number of females in the population.

In the first case, Irradiated female mated with normal male the results showed that Female longevity was different for all 2,4,6,8 Gy and control, while the male longevity was uniform (13,33) for all 2,4,6, 8Gy and control. This explains why when a female is irradiated, she is affected Female longevity. When in the second case, Irradiated male mated with normal female the results showed that Female longevity was uniform 16.67 for all 2,4,6, 8Gy and control, while the male longevity was different (for all 2,4,6, 8Gy and control) This explains why when a male is irradiated, she is affected male longevity. In the third case, Irradiated female mated with male mated the results showed that Female longevity and male longevity were different for all 2,4,6, 8Gy and control) This explains that radiation affects the longevity of females and males.

The effect of radiation on irradiated females mated increases their Female longevity in the first and third cases, while in the second case; it remains unaffected compared with the control. While, the male longevity of irradiated males increases in the second and third cases, while in the first case, it remains unaffected compared with the control.

The daily egg rate also increases compared to the control group, in the first case and increases more in the third case, while in the second case it remains unaffected and constant with all doses (2, 4, 6, and 8) and the control group, as shown in Figure 1.

The sex ratio of females is greater than the sex ratio of males in the first and third cases of irradiated females, while the sex ratio of males is greater than the sex ratio of females in the second case of irradiated males compared to the control.

The life cycle in the first and second cases. The results were similar for the male, female and control, while they affected in the third case.

While the life span in the three cases was affected for the male, female and control, where it was less for the female with the low doses (2, 4 Gy) compared to the control.

In the first and third cases, the female consumes the same number of eggs, while in the second case, she consumes a fixed number for each radiation dose (2, 4, 6, 8 gray) and the control group, respectively.

In the second and third cases, the male consumes the same number of eggs, while in the first case, he consumes a fixed number for each radiation dose (2, 4, 6, 8 gray) and the control group, respectively.

Generally, the results were in accordance to those of Scott and Di Palma (2006) [15]; Sayed *et al.* (2017 &2018) [13, 14], they reported that low-dose radiation activates the body's responses.

Irradiation with low doses of gamma ray caused no and decreased hatchability percentage in (0-12) & (12-24) hour's age eggs. It increased hatchability and females in (24-36) & (36-48) hour's age eggs especially at 2,4Gy. Our study obtained by Baohe *et al.* (2016) [2] who found that the no larvae appeared when eggs aged 0-12 h old were exposed to radiation. All adult individuals produced from irradiated eggs aged 12-24 h are females, and the number of females produced from irradiated eggs aged 24-48 h increased with increasing radiation dose. Kim *et al.* (2015) [7] who found that the eggs were four days old showed greater tolerance to the irradiation compared with younger ones. Our study agree with Osouli *et al.* (2013) [9] who found that when two-day old eggs were irradiated at 100, 300 and 350 Gy, the resulting adult stages were 100% females.

Conclusions

Currently, developing a safe pest control program is a goal for all researchers. This work aims to enhance the role of predators in biological control, using the effect of gamma rays on predator *Cheyletus malaccensis* the results were the effect of radiation on predators reduces the life span this leads to an increase in the number of generations and a lengthening of the egg-laying period. It increases the number of eggs and increases the predator's ability to prey, thus consuming a larger number. This is a success in biological control, which is the direction we are seeking.

References

1. Al-Shammery KA. Influence *Cheyletus malaccensis* (Acari: Cheyletidae) in Hail, Saudi Arabia. Life Sci. 2014;11(5):260-266.
2. Baohe Z, Endong W, Jiale L, Xuenong X. Impact of Gamma Irradiation on Reproduction and Sex Determination in *Phytoseiulus persimilis* Athias-Henriot. Chinese J Biol Cont. 2016;32(6):681-688.
3. Corpuz-Raros LA, Sabio G, Velasco-Soriano M. Mites associated with stored products, poultry houses and house dust in the Philippines. Philipp Entomol. 1988;7:311-321.
4. El-Shannat HA. Ecological and biological studies on some important pests of stored grain and seeds [MSc thesis]. Kafr El-Sheikh (EG): Kafr El-Sheikh University; 2009. 178 p.
5. El-Shazly NM. Quantitative evaluation of food intake and assimilation by *Spilostethus pandurus* (Scopoli) (Hedmiptera; Lygaeidae). Bull Entom Soc Egypt. 1993;71:109-117.
6. Hughes AM. The mites of stored food and houses. 2nd ed. UK: London; 1976. 400 p.
7. Kim J, Shin E, Lee S, Park CG. Effect of gamma ray irradiation on egg hatchability and F1 eggs of *Tetranychus urticae* (Acarina: Tetranychidae) with small scale-up validation. J Asia-Pacific Entomol. 2015;18(3):597-600.
8. Marples B, Collis SJ. Low-dose hyper-radiosensitivity: past, present, and future. Int J Radiat Oncol Biol Phys. 2008;70:1310-1318.
9. Osouli Sh, Ziaie F, Haddad Irani Nejad K, Moghaddam M. Application of gamma irradiation on eggs, active and quiescence stages of *Tetranychus urticae* Koch as a quarantine treatment of cut flowers. Rad Phys Chem. 2013;90:111-119.
10. Pollycove M. Radiobiological basis of low-dose irradiation in prevention and therapy of cancer. Dose Response. 2007;5:26-38.
11. Putatunda B. Mites (Acarina) associated with stored food products in Himachal Pradesh, India: a taxonomic study. J Entomol Res. 2005;29:79-82.
12. Rakha MA, El-Naggar MEE, El-Sebbay II. Biological studies on the predacious mite *Cheyletus malaccensis* (Oudemans) (Acari: Cheyletidae) when fed on eggs of *Lasioderma serricorne* L. Egypt Soc Biol Control Pests. 1991;77:83.
13. Sayed RM, Sawires SG, Abdel-Rafei MKh. Changes in metabolic activities and gene expression associated with gamma irradiation of honey bee *Apis mellifera* worker. 2018;127(5):426-441.
14. Sayed RM, Sawires SG, Ali HM. Promotion of Some Biological Aspects in *Apis mellifera* Linnaeus Workers by Gamma Irradiation. Entomol News. 2017;127(2):165-177.
15. Scott BR, Di Palma J. Sparsely ionizing diagnostic and natural background Radiations are likely preventing cancer and other genomic-instability-associated diseases. Dose-Response. 2006;5:230-255.
16. Tubiana M. Prevention of cancer and the dose-effect relationship: the carcinogenic effects of ionizing radiations. Cancer Radiotherapie. 2009;13:238-258.
17. Wafa AK, Zaher MA, El-Kifl AH, Hegazy MA. Survey of stored grain and seed mites (Acarina). Bull Soc Entomol d'Egypte. 1966;50:225-232.
18. Yousef AA, Zaher MA, Kandil MM. Effect of prey and temperature on the development and biology of *Cheyletus malaccensis* Oudemans (Acari: Cheyletidae). Z Ang Entomol. 1982;93:39-42.