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EFFECTS OF GAMMA RADIATION ON THE PROGENY OF IRRADIATED *EPHESTIA CAUTELLA* (WALKER) (LEPIDOPTERA: PYRALIDAE) MALES*

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Abstract—One-day-old P_1 males of *Ephestia cautella*, Baghdad strain, were treated with 0.15, 0.20 and 0.25 kGy of γ radiation and mated in groups (15 pairs) with untreated virgin females. Radiation effects were assayed by determining percentage of egg hatch, mating ability and F_1 sex ratio. Our results showed the greater the initial dose, the greater the reduction in the percent egg hatch, and the greater the male-to-female ratio. Radiation effects on F_1 males were greater than the effect on the P_1 males. Furthermore, the results showed that the effects on F_1 males were greater than the effects on F_1 females. These results were confirmed cytologically by examination of the developing meiotic germ cells of F_1 males which showed that the meiotic nuclei carried multiple translocations. Such chromosomal aberrations explain the sterility observed in the F_1 male generation.

INTRODUCTION

The fig moth *Ephestia cautella* (Walker), is a serious pest of stored dry-dates and causes damage during harvest, storage, processing and exportation (Hussain, 1985). Two important factors that contribute to its seriousness on dry dates include its ability to develop resistance to insecticides (Zettler *et al.*, 1973; Attia, 1981; Dakhil, 1987) and the tendency of larvae to feed inside date fruit, thus achieving an additional measure of protection from direct contact with insecticides. These considerations highlight the need for effective new methods for controlling *E. cautella*.

In the past two decades, Amuh (1971) and Ahmed *et al.* (1971) have suggested the possibility of using the sterile-insect release technique for controlling *E. cautella*, and Ahmed *et al.* (1972) extended this concept to the possibility of using partially sterilized males. Several studies on the radiosensitivity of *E. cautella* have appeared (Amoako-Atta and Partida, 1976; Brower, 1979; Al-Hakkak *et al.*, 1985), but these were concerned mainly with sterility of the P_1 generation. The objective of the current study was to assess the effect of different doses of γ radiation on *E. cautella*, using the Bagdad strain (Ahmed *et al.*, 1984) to obtain basic information about the effects of substerilizing doses of irradiation on reproductive abilities.

MATERIALS AND METHODS

The stock culture of the *E. cautella*, Baghdad strain used in the present study has been described by Ahmed *et al.* (1984). 1–24 hr-old adult males were irradiated with 0.0, 0.15, 0.20 and 0.25 kGy from a 60 Co-irradiator with a dose rate of 13.7 kGy/hr. Treated (T) males were paired in groups (15 pairs each) with normal (N) females (N × T) in lantern globes (800 ml) as were normal (N) males, also in groups of 15 pairs each, with normal females (N × N). Several lantern globes (replicates) were held in an incubator at 25 ± 1°C; 50–60% r.h. After 72 hr, eggs were collected and 250 from each replicate (i.e. lantern globe) (Table 1) were taken to check the hatch after 7 days, while the rest were kept in jars containing about 250 g of the standard medium (Ahmed *et al.*, 1984) and incubated till the emergence of adult F_1 progeny. Females were dissected and the number of spermatophores in the bursa copulatrix counted to determine mating status.

Progeny from the P_1 N × N and N × T crosses were used as illustrated in Table 3. In all cases, treatments were subjected to analysis of variance, and differences between means were tested for significance ($P < 0.05$) with Duncan's multiple range test (Steel and Torrie, 1980). Sex ratio distortion was evaluated using the chi-square test.

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Table 1. Effects of γ irradiation of adult male *E. cautella* on reproduction of P_1 adults (P_1 male adults 1–24 hr old when irradiated)

Dose of radiation (kGy)	No. of replicates*	Crosses (♀ × ♂)†	Eggs/female (% of control)‡	Egg hatch (% of control)‡	Spermatophores per female‡
0.0	10 (15)	N × N	100 a	100 a	1.06 ± 0.48a
0.15	14 (15)	N × T	69.19 b	37.74 b	1.12 ± 0.62a
0.20	9 (15)	N × T	99.62a	42.56 b	1.13 ± 0.53a
0.25	19 (15)	N × T	60.23 b	12.78 c	0.99 ± 0.45a

*Figures in parentheses represent the number of pairs per replicate.
†N, Normal males or females; T, treated males.
‡Means followed by the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test).

For cytogenetical investigation, gentle squash preparations were made of the testes of F_1 males and stained with the Feulgen reaction following fixation in 3 parts alcohol: 1 part acetic acid.

RESULTS AND DISCUSSION

Table 1 showed significant ($P < 0.05$) reduction in egg hatch with the reduction most clearly demonstrated when the P_1 male was irradiated with 0.25 kGy (87% sterility). The high dosage also decreased somewhat the number of eggs per female although the mean number of spermatophores per female was not influenced (Table 1). Male-to-female ratios in the F_1 progeny appeared to be affected (Table 2). The skewed sex ratios favouring males are in agreement with results obtained by other authors for different lepidopterous species (North, 1975; Brower, 1981; Carpenter *et al.*, 1983; LaChance, 1983).

The effects of irradiation in the F_1 generation were evidenced by a significant ($P < 0.05$) reduction in egg hatch (Table 3) indicating lower reproductive capabilities than those of the parental crosses, although eggs per female and number of spermatophores per female were little affected. These results were significantly influenced by the dose given to the P_1 and the sex of the F_1. The greatest effect was expressed with inbred F_1 female × F_1 male from P_1 N × T or with F_1 male from

Table 2. Sex ratio distortion in F_1 *E. cautella* when P_1 males are treated with gamma radiation

Dose of radiation (kGy)	No. of females	No. of males	Percent male	χ^2	P	Male:female ratio
0.0 (Control)	270	287	51.53	0.2594	0.1	1.06:1
0.15	110	254	69.78	28.4835	0.01	2.31:1
0.20	130	313	70.65	37.7979	0.01	2.41:1
0.25	18	61	77.27	11.7025	0.05	3.39:1

Table 3. Fecundity, fertility and mating ability of F_1 progeny of *E. cautella* treated with γ radiation

Dose of radiation (kGy)	No. of replicate*	Eggs/female (% of control)‡	Egg hatch (% of control)‡	No. of spermatophores/ female‡
		N male × N female†		
0.0	7 (5)	100a	100a	1.06 ± 0.27a
		F_1 male × N female†		
0.15	12 (5)	40.58dc	0.46c	0.93 ± 0.32ab
0.20	3 (15)	43.79cde	0.0c	0.68 ± 0.11ab
0.25	14 (1)	30.93ef	0.0c	0.14 ± 0.36c
		F_1 male × F_1 female†		
0.15	4 (5)	25.49f	1.3c	0.47 ± 0.26b
0.20	3 (7)	56.04bc	0.0c	0.96 ± 0.29ab
0.25	2 (1)	43.30cde	0.0c	0.5 ± 0.71b
		N male × F_1 female†		
0.15	5 (5)	62.11b	8.52b	0.95 ± 0.21ab
0.20	3 (7)	66.10ab	1.86c	0.72 ± 0.14ab
0.25	7 (1)	50.10dc	0.0c	1.0 ± 0.58ab

*Figures in parentheses represent the number of pairs per replicate.
†N, progeny from P_1 N × N; F_1, progeny from P_1 N × T.
‡Means followed by the same letter are not significantly different ($P > 0.05$; Duncan's multiple ranged test).

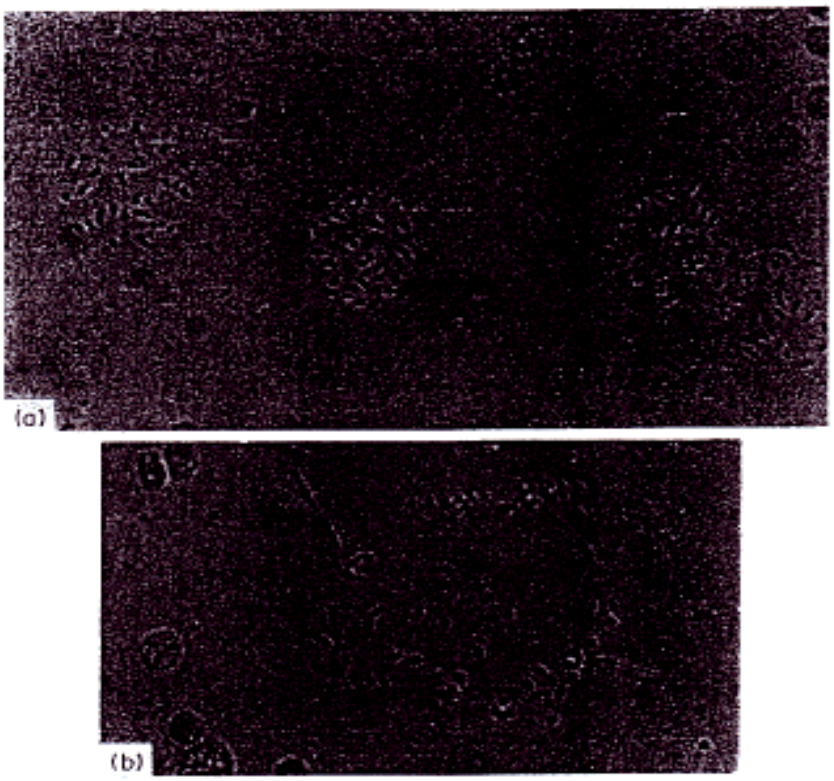

Fig. 1. Squash preparations of testes of the fig moth *E. cautella*; (a) spermatocyte I cells from a normal non-irradiated F_1 male showing 30 chromosome pairs, (b) spermatocyte I cells from an F_1 male whose paternal parent had received 0.2 kGy. The cells have multiple translocation involving different pairs of chromosomes (arrows show multiple translocations)

N × T mated with normal female. These results were confirmed cytogenetically (Fig. 1) as developing meiotic germ cells of F_1 males (Spermatoctocyte I) carried multiple translocations.

The results of this study clearly demonstrated that F_1 males are more sterile than their irradiated P_1 male parents. Further research designed to determine whether existing F_1 progeny with low fertility (Table 3) will establish a new population is needed, in addition to studies concentrating on the competitiveness of sterile F_1 progeny.

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REFERENCES

Ahmed M. S. H., Al-Hakkak Z. S. and Al-Saqur A. M. (1971) Exploratory studies on the possibility of integrated control of the fig moth *Ephestia cautella* (Walker). *Proc. Panel Application of Induced Sterility for Control of Lepidopterous Populations*, Vienna, 1970; pp. 1–6. IAEA, Vienna.

Ahmed M. S. H., Al-Hakkak Z. S. and Al-Saqur A. M. (1972) Inherited sterility in the fig moth *Cadra* (*Ephestia*) *cautella* (Walker). *Proc. 4th Int. Conf. Peaceful Uses Atom. Energy*, Geneva, 1971; Vol. 12, pp. 383–389. IAEA, Vienna.

Ahmed M. S. H., Kadhum A. A., Hameed A. A., Ali S. R. and Al-Hakkak Z. S. (1984) Cytoplasmic analysis of *Ephestia cautella* adult females collected in different regions in Iraq. *J. stored Prod. Res.* **20**, 151–152.

Al-Hakkak Z. S., Ali S. R. and Ahmed M. S. H. (1985) Differential sterility induced by gamma radiation in the adult males of six strains of *Ephestia cautella*. *J. Biol. Sci. Res.* **16**, 217–226.

Amoako-Ata B. and Partida G. J. (1976) Sensitivity of almond moth pupae to gamma radiation (Lepidoptera: Pyralidae). *J. Kans. ent. Soc.* **49**, 133–140.

Amuh I. K. A. (1971) Potentialities for application of the sterile-male technique to the control of the cocoa moth, *Cadra cautella* (Walk). *Proc. Panel Application of Induced Sterility for Control of Lepidopterous Populations* Vienna, 1970; pp. 7–11. IAEA, Vienna.

Attia F. I. (1981) Insecticide resistance in pyralid moths of grain and stored products. *Gen. Appl. Ent.* **13**, 3–8.

Brower J. H. (1979) Radiosensitivity of adults of the almond moth. *J. econ. Ent.* **72**, 43–47.

Brower J. H. (1981) Reproductive performance of inbred or outbread F_1 and F_2 progeny of adult Indian meal moth females or males × females partially sterilized by gamma irradiation. *Ann. ent. Soc. Am.* **74**, 108–113.

Carpenter J. E., Young J. R., Knipling E. F. and Sparks A. N. (1983) Fall armyworm: inheritance of gamma-induced deleterious effects and potential for pest control. *J. econ. Ent.* **76**, 378–382.

Dakhil S. H. (1987) Phosphine, resistance in the fig moth *Ephestia cautella* (Walker) (Lepidoptera : Pyralidae). M.Sc. Thesis, College of Agriculture, University of Baghdad.

Hussain A. A. (1985) *Date Palms and Dates with their Pests in Iraq*. Ministry of High Education, Basrah University Press.

North D. T. (1975) Inherited sterility in Lepidoptera. *Ann. Rev. Ent.* **20**, 167–182.

LaChance L. E. (1983) *Genetic Methods for the Control of Lepidopteran Species: Status and Potential*. Joint Food and Agriculture Organization, IAEA, Division of Isotope and Radiation Applications of Atomic Energy for Food and Agriculutral Development.

Steel R. D. and Torrie J. H. (1980) *Principles and Procedures of Statistics*, 2nd edn McGraw-Hill, New York.

Zettler J. L., McDonald L. L., Redlinger L. M. and Jones R., D. (1973) *Plodia interpunctella* and *Cadra cautella* resistance in strains to malathion and synergized pyrethrins. *J. econ. Ent.* **66**, 1049–1050.