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Effect of Age on Reproduction and Sex Ratio of *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae)

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Abstract.- The Indian meal moth, *Plodia interpunctella* (Hubner), is a cosmopolitan grain feeding pest, infesting stored products in the home, grocery stores, warehouses, food processing plants and where food products are stored. Studies were conducted to determine the effect of delayed mating on its fecundity, percent egg hatching, survival to adults and sex ratio. All variables were decreased significantly with the increase in age of either sex except sex ratio. However, males continued to produce progeny up to age of 3 days when they were mated with freshly emerged females. No reproduction was occurred when 3 days old virgin females were paired with newly emerged males. There was a male biased sex ratio (54-56% males) in all delayed mating combinations. Egg laying was continued up to 8th day when 1-2 days old males and 1 day old females were mated with newly emerged females and males. Significantly high fecundity per day was achieved on 2nd, 3rd and 4th day after mating in all treatments.

Key words: *Plodia interpunctella*, fecundity, hatching, sex ratio.

INTRODUCTION

Indian meal moth, *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae) is wide spread and cosmopolitan moth pest of stored food including grain, raw and processed cereals, oilseeds, dried fruits, dried vegetables, nuts, and animal feed (Perez-Mendoza and Aguilera-Pena, 2004; Ozyardimci *et al.*, 2006). Previous research work highlights its development and reproduction on different food under variable climatic conditions (Mbata, 1985; Allotey and Goswami, 1990; Johnson *et al*., 1995; Arbogast, 2007). Certain attributes of adult insects change obviously as the individual ages. Delay in mating of adults has been shown to effect significantly on the fecundity, viability of eggs in many Lepidoptera families (Wakamura, 1990; Walker, 1991; Knight, 1997; Fadamiro and Baker, 1999). Mbata (1985) recorded the effects of delayed female mating on the ovipostion of *P. interpunctella,* whereas, Huang and Subramanyam (2003) described the effects of delayed mating in either sex on its reproductive performance. The effects of delayed mating in both males and females on fecundity, egg hatching, adult life and progeny sex ratio of *P. interpunctella* on a wheat bran artificial diet have not been investigated.

The investigations in present studies will be useful in IPM of *P. interpunctella* by developing mating disruption strategies using pheromones as reported by Knight (1997), using ultrasound as shown by Acharya and McNeil (1998) and using irradiation techniques (Kwon *et al*., 2004; Ayea *et al.,* 2008) for suppressing *P. interpunctella* populations.

MATERIALS AND METHODS

The culture of *P. interpunctella* was maintained on a wheat bran diet (Reed, 1998) under controlled temperature (25±2˚C), humidity (65±5% RH) and 14 h light: 10 h dark cycle conditions in 5.0 l glass jars. Eggs of the insect were seeded on the diet in glass jars, covered on top with white muslin cloth. Corrugated paper spools were placed above the diet in each jar for pupation sites for wandering larvae. Pupae collected from spools were sexed using characters described by Butt and Cantu (1962). Male and female pupae were placed in separate jars that were checked twice daily, and moths of age less than one hr, one, two and three days were used in experiments.

There were a total of 6 mating treatments. Newly emerged virgin females (age less than one hr) were paired with 1–3 days old virgin males

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(treatments 1–3). Newly emerged virgin males (age less than one hr) were paired with 1–3 days old virgin females (treatments 4–6). Each treatment was replicated 10 times by introducing the moths in glass jars (10×5 cm). After insect pairing, jars were covered with small pieces of muslin cloth. The glass jars were checked daily for number of eggs laid by females after sieving through the eggs from diet. The longevity of adults was recorded until all adults were dead. Collected eggs were placed daily in Petri dishes of size 25×10 mm along with rearing diet. After the complete larval development, the pupae were sexed and the ratio of emerged adults was recorded.

The data on the number of eggs per female, percent eggs hatching, survival to adults, sex ratio was subjected to one way analysis of variance using DMR test (Steel and Torrie, 1980) to determine the treatments differences.

RESULTS AND DISCUSSION

The number of eggs laid per female (Table I) was different among treatments ($F= 78.38$; $df= 5$; $P <0.05$). Significantly high fecundity (196 eggs) was recorded after pairing of newly emerged females with one day old males followed by other treatment combinations. However, fecundity was at par (171 and 173 eggs) in treatments when male was delayed by 2 days for pairing with newly emerged male and when female was delayed by one day for pairing with newly emerged male. Fecundity by *P. interpunctella* was highest when there was no mating delay for females and it was reduced where mating was delayed for females only. Similar findings were recorded by Barrer (1976) for *Ephestia cautella* and Huang and Subramanyam (2003) for *P. interpunctella.* A fecundity range of 73-120 eggs/female was recorded by Huang and Subramanyam (2003) when newly emerged female was mated with 1-3 days old males partially disagree with the range of 56–196 eggs in the present research. Results regarding daily oviposition (Table II) showed that on first day very few eggs were laid in all treatments ($F= 23.96$; $df= 5$; $P <0.05$). However, the peak oviposition occurred on third day after mating ($F= 75.63$; $df= 5$; $P <0.05$). When newly emerged females were mated with 1-3 day old males, most of the eggs (60- 70%) were laid on second, third and fourth day after mating. When newly emerged males were mated with one day old female, 84% of the eggs were laid from 2-5 day after mating. Our results were partly comparable to that reported by Mbata (1985). He reported that about 34–58% and 84-97% of the eggs were laid by *P. interpunctella* within 2-4 days after mating where males and females were mated without delay or where the male was delayed by one day, respectively. Results are also comparable to Huang and Subramanyam (2003), who reported that when newly emerged females were mated with newly emerged or one day old males, most of the eggs (roughly 60%) were laid on the third and fourth day after mating. When newly emerged females were mated with 2–3 days old males, 2–70% of the eggs were laid on the second and third day after mating. Egg hatching varied among the treatments ($F, 20.11$; $df, 5$; $P <0.05$).

According to Huang and Subramanyam (2003), when male and female moths of *P. interpunctella* were mated without delay, about 99% of the eggs laid were viable. For each day that mating of virgin male or female was delayed, egg viability decreased by 22%/d. The same is true in our results, when 87.3% and 86.5% was achieved after mating of one day old males with virgin females and one day old females with virgin males were mated respectively.

Average survival to adult among treatments ranged from 36 to 73% (Table I). A comparison among treatments showed that mating delay had a small, but significant, effect on the percent survival to adults ($F= 19.42$; $df= 5$; $P <0.05$). The maximum survival to adult was 73.5 % when one day old males were mated with newly hatched virgin females and at par to 71.4 % when one day old females were paired with newly emerged males. Similarly, the minimum adult survivals of 35.6 and 37.7 % were recorded in treatments where 3 day old males and 2 day old females were mated with newly emerged females and males, respectively. The results concluded that survival to adult decreased with the delay in age for mating of both sexes. No previous work on the percent survival to adult has been published to compare with our results.

Table I.- Effect of age on fecundity, egg hatching, survival to adult and progeny sex ratio of *P. interpuctella*.

Age (d)		No. of eggs/female	Egg hatching (%)	Survival to adults (%)	Sex ratio	
Male	Female				Male	Female
1	0	196.3 ± 1.73 a	87.3 ± 0.61 a	73.5 ± 1.03 a	1.17	1.00
2	0	170.8 ± 2.69 a	80.3 ± 0.96 a	67.9 ± 1.19 a	1.18	1.00
3	0	56.9 ± 16.04 b	44.7 ± 12.20 b	35.6 ± 9.78 b	1.26	1.00
0	1	173.1± 7.45 a	86.5 ± 0.42 a	71.4 ± 0.93 a	1.25	1.00
0	2	29.1 ± 9.98 c	42.7 ± 14.24 b	37.7 ± 12.57 b	1.25	1.00
0	3	0.00 ± 0.00 d	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00	0.00

Means (±SE, n=10) with similar alphabets in a column are statistically similar at P < 0.05

Table II.- Daily eggs per female of *P. interpunctella* laid after mating at different age.

Age (d)		Number of eggs laid per female on day								Total eggs/ female
Male	Female	1	2	3	4	5	6	7	8	
1	0	18.7± 1.20 a	41.1± 2.43 a	51.5± 1.21 a	43.2± 1.32 a	28.9± 2.43 a	9.0± 1.68 a	3.0± 1.04 a	0.9± 0.60 a	196.30
2	0	15.3± 0.98 a	31.7± 2.54 b	45.1± 1.72 ab	38.3± 2.11 b	24.9± 2.41 a	11.0± 1.68 a	3.5± 0.98 a	1.0± 0.80 a	170.8
3	0	8.2± 2.28 b	15.7± 4.32 c	17.1± 4.93 c	10.6± 3.49 c	4.1± 1.28 b	1.3± 0.81 b	0.00± 0.00 b	0.00± 0.00 a	56.9
0	1	15.0± 0.63 a	30.0± 1.37 b	41.2± 1.28 b	44.2± 1.97 a	28.30± 1.97 a	9.7± 1.48 a	3.7± 1.45 a	1.0± 0.66 a	173.10
0	2	6.0± 2.28 b	12.4± 4.49 c	07.4± 3.89 d	3.4± 1.40 d	0.20± 0.79 b	0.00± 0.00 b	0.00± 0.00 b	0.00± 0.00 a	29.10
0	3	0.00± 0.00 c	0.00± 0.00 d	0.00± 0.00 e	0.00± 0.00 d	0.00± 0.00 b	0.00± 0.00 b	0.00± 0.00 b	0.00± 0.00 a	0.00

Means (±SE, n=10) with similar alphabets in a column are statistically similar at P < 0.05

Males to females' sex ratio varied among treatments. However, the number of males was dominant over females in all mating treatments. Almost the similar males to females ratio numbering 1.17: 1.00 and 1.18: 1.00 was achieved from treatments having 1-d and 2-d old males mated with newly emerged females. Similarly, almost equal ratios were recorded from treatments having 3 d old males, 1 d and 2 d old females mated with newly emerged females and males, respectively (Table I). However, overall results showed a male biased sex ratio (54-56% males) in delayed mating of either sex.

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