Effects of Delayed Mating on Reproductive Performance and Longevity of the Indianmeal Moth

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Introduction

The Indianmeal moth, *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae), is a worldwide pest of stored raw and processed food products. Very little is known about the effects of delayed mating on reproductive capacity of this species. High concentrations of pheromone or ultrasound may affect *P. interpunctella* reproduction by delaying mating, and by reducing the fecundity and fertility. A series of laboratory experiments was conducted to determine the effects of mating delay on *P. interpunctella* fecundity, fertility, and spermatophore transfer.

Materials and Methods

Insects: *Plodia interpunctella* was reared on a turkey-mash diet at 28°C and 80% RH (14:10 L:D cycle), by seeding 200-g diet with 100, 0-24-h-old eggs. Corrugated paper spools, placed in the rearing jars (0.95-L), served as pupation sites for wandering larvae. Prior to adult emergence, pupae were removed from the spools and sexed. Male and female pupae were held in separate 0.95-L jars, and they were examined daily for adult emergence.

Mating experiments: Five males and 5 females of a specific age were introduced into separate 0.95-L jars, fitted with wire-mesh screens. Some jars contained only 5 males or 5 females. Overall there were 18 mating treatments (see Table 1). Each treatment was replicated 6 times. Eggs laid by moths were counted daily and their hatchability determined, until all the moths in jars were dead. Dead moths were preserved in glass vials containing 100% ETOH. Females were dissected to determine the number of spermatophores in bursa copulatrix.

Data analysis: Untransformed data were subjected to 1-way ANOVA using the PROC GLM procedure of SAS. LSMEANS (α=0.05) were used for mean separation. Regression analyses (PROC REG procedure) were used to examine the relationship or association between the variables studied/observed.

Results

Fecundity: Mating delay affected fecundity (F = 36.08; df = 16, 85; P = 0.0001) and number of spermatophores transferred to females (F = 21.45; df = 15, 66; P = 0.0001). Delayed mating by males, females, or both reduced fecundity (Table 1). There were about 25 fewer eggs laid for each day mating was delayed (Table 2). Typically, 1-2 spermatophores were transferred to females. Mating delays resulted in reduced spermatophore transfer (Table 1). No spermatophores were transferred if mating by male, female, or both was delayed for 5 d.

Fecundity and fertility were positively correlated with the number of spermatophores per female (Table 2). About 56 additional eggs/female, and a 52% increase in egg hatchability, was observed for every spermatophore transferred.

Table 1. Effects of mating delay on some reproductive parameters of *Plodia interpunctella*.

Treatment[a]	No. eggs/female (Mean)[b]	% Egg hatch (Mean)[b]	Mean[b] longevity (days)		No. females dissected	No. spermatophores/ female (Mean)[b]	% of females with 0-4 spermatophores				
			Female	Male			0	1	2	3	4
0 x 0	161.3 a	99.2 a	5.3 efg	4.2 e	16	2.2 a	0	6	63	31	0
0 x 1	120.3 b	99.4 a	6.1 abcde	4.9 de	29	1.8 ab	0	35	45	21	0
0 x 2	115.9 b	99.1 abc	5.0 fg	4.9 de	30	1.6 bc	0	60	27	10	3
0 x 3	72.9 c	86.7 abc	4.7 g	5.4 bcd	20	0.9 ef	15	85	0	0	0
0 x 4	57.7 cde	92.1 ab	5.9 abcde	6.5 a	24	0.6 efg	38	63	0	0	0
0 x 5	22.4 f	0.0 f	6.7 a	6.2 ab	30	0.0 i	100	0	0	0	0
1 x 0	107.4 b	96.3 ab	6.2 abcd	5.6 bcd	30	1.7 bc	0	47	37	16	0
2 x 0	78.1 c	90.8 bc	6.5 ab	5.6 bc	29	1.4 cd	3	70	14	10	3
3 x 0	71.9 c	73.4 de	6.3 abc	5.9 ab	30	1.0 de	7	86	7	0	0
4 x 0	30.9 ef	6.8 f	6.6 a	6.0 ab	29	0.5 fgh	55	35	10	0	0
5 x 0	38.5 def	0.0 f	6.6 a	5.8 abc	30	0.2 hi	77	23	0	0	0
1 x 1	116.9 b	98.1 ab	5.4 defg	4.9 cde	15	1.8 abc	0	33	53	14	0
2 x 2	68.3 c	83.4 cd	5.3 efg	4.8 de	15	1.1 de	0	93	7	0	0
3 x 3	66.4 cd	58.4 de	5.7 bcdef	5.4 bcd	21	0.9 ef	14	86	0	0	0
4 x 4	36.9 ef	18.5 f	6.3 abcd	6.0 ab	30	0.3 ghi	67	33	0	0	0
5 x 5	27.1 f	0.0 f	6.4 ab	6.0 ab	30	0.03 i	77	23	0	0	0
Female	32.5 ef	0.0 f	5.6 cdef	____							
Male	____	____	____	5.7 bc							

[a]Female x male pairs. Age of moths at the time of pairing ranged from 0 (newly-emerged) to 5 d.
[b]Means within a column followed by different letters are significantly different (P < 0.05; by LSMEANS test).

Table 2. Relationship between mating delay or number of spermatophores on fecundity, fertility, and longevity of *Plodia interpunctella*.

Response variable (Y)	Treatment variable (X)	Regression equation	R^2[a]
No. eggs/female	Male delay	Y = 142.2 – 24.4 X	0.690 **
	Female delay	Y = 158.0 – 26.4 X	0.749 **
	Male and female delay	Y = 144.7 – 26.1 X	0.706 **
	No. spermatophores	Y = 18.61 + 55.7 X	0.942 **
% Egg hatch	Male delay	Y = 115.1 – 15.7 X	0.534 **
	Female delay	Y = 117.6 – 22.0 X	0.781 **
	Male and female delay	Y = 113.2 – 21.6 X	0.727 **
	No. spermatophores	Y = 10.86 + 51.55 X	0.749**
Female longevity	Male delay	Y = 5.19 + 0.19 X	0.108
	Female delay	Y = 5.81 + 0.19 X	0.243 **
	Male and female delay	Y = 5.06 + 0.27 X	0.464 **
	No. spermatophores	Y = 6.39 – 0.45 X	0.251 *
Male longevity	Male delay	Y = 4.25 + 0.43 X	0.680 **
	Female delay	Y = 5.06 + 0.21 X	0.128 *
	Male and female delay	Y = 4.28 + 0.38 X	0.600 **
Spermatophores/female	Male delay	Y = 2.32 – 0.45 X	0.785 **
	Female delay	Y = 2.19 – 0.40 X	0.816 **
	Male and female delay	Y = 2.16 – 0.44 X	0.957**

[a]The F-test for the regression was significant at α = 0.05 (*) or α = 0.01 (**). n for each regression was 6.

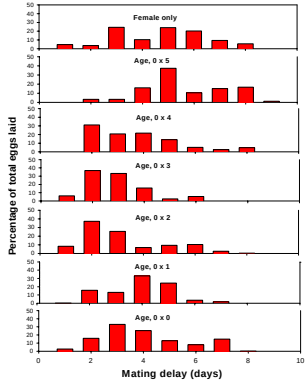

Figure 1. Effect of male delay on *Plodia interpunctella* oviposition patterns.

Male delay and oviposition patterns: The maximum oviposition period recorded was 9 d. In 0 x 0 and 0 x 1 treatments, nearly 60% of the eggs were laid by the 3rd or 4th day (Figure 1), and about 90% of the eggs were laid within 5 d. A male delay of 2-4 d resulted in eggs being laid within the 2nd or 3rd day, whereas a 5-d male delay reduced or prevented egg-laying. Unmated females also produced eggs. However, the eggs were not embryonated, and none of them hatched.

Fertility: Fertility varied among the different treatments (F = 36.08; df = 16, 85; P = 0.0001). Almost all eggs laid by females that were mated without delay hatched successfully (Table 1). A 5-d mating delay reduced hatchability to 0%. In general, there was a 16-22% reduction in egg hatchability for each day mating was delayed (Table 2).

Adult longevity: Longevity of males (F = 3.81; df = 16, 71; P = 0.0001) and females (F = 4.3; df = 16, 71; P = 0.0001) varied among the treatments. In both sexes, mating delay slightly increased longevity (Table 1).

Conclusion

Delaying male or female mating by more than 1 d will have a significant impact on fecundity, fertility, spermatophore transfer, and oviposition of *P. interpunctella*.

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