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Cost of mating: a study on physiological trade-offs between fecundity and longevity in laboratory reared *Helicoverpa armigera* (Hubner) female moths

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Abstract
Oviposition by the female moths of *H. armigera* began on the third day of emergence; however, mating stimulated earlier oviposition. Hence, we carried out experiments to demonstrate trade-off between fecundity and longevity and to know their relationship in *H. armigera* female moths. Investigation showed that there was twofold increase in fecundity of mated females mated for once and virgin females survived one week more than the mated female moths. Fecundity and longevity are coupled and are negatively related decreasing the lifespan of virgin females may be because of diversion of more resources for egg development and oviposition, leaving fewer resources for survival.

Keywords: *Helicoverpa armigera,* mating, trade-offs, fecundity, longevity

1. Introduction

The study carried out on *Drosophila subobscura* by Maynard Smith in 1958 [1] is one of the first experimental manipulations to demonstrate the existence of a trade-off between reproduction and survival, the so-called "cost of reproduction". An additional evidence for a trade-offs between reproduction and lifespan comes from manipulative experiments carried out by Leroi [2]. Survival costs of reproduction are widespread. As far as now, reproduction tends to shorten lifespan is been reported in most organisms [3-7].

"Costs of reproduction" [8], a "trade-offs" between life history traits [9, 10], reproductive trait and survivorship results in an increase reproductive trait thereby improving fitness ("reproductive success") is coupled to a decrease in another life history trait survivorship that reduces fitness. Such trade-offs between survival and reproduction can have at least two different sources [3]: on the one hand, fecundity or fertility might reduce survival because of the costly production of gametes, and on the other hand, survivorship might be decreased due to the elevated mortality risk associated with courtship and mating behaviour (or with some other behavioural aspect of reproduction or intersexual interaction).

H. armigera is identified as the single most damaging insect by the Indian Council of Agricultural Research on cotton and legumes and also the major biotic constraint to increased crop production in Indian subcontinent. This pest commonly damages over 50% of the yield of cotton and pulse crops including pigeon pea and chickpea. Therefore it becomes important to study every aspect linked to this insect in order to understand it fully, so that a better control methodology can be devised against it in future.

2. Materials and methods

2.1 Insect rearing

H. armigera larvae (NBAII-MP-NOC-01) procured from NBAIR, Bengaluru, were reared on modified semi-synthetic chickpea diet formulated by Shobha *et al*. 2009 [11]. The 3rd instar larvae were maintained individually in vials to avoid cannibalism (plastic cup, size: 4.2 x 4.5 cm).The physical conditions provided during mass rearing: 25 ºC during the photophase and at 23 ºC during the scotophase, 65±5% Relative Humidity and 16 light: 8 dark photoperiod in a B.O.D incubator. Pupae were collected and sexed based on characteristics of their exterior paramera. The male and female pupae were kept separately in plastic containers (25 x 15 x 8 cm) until adult emergence to ensure age and virginity. All female adults used in this study were 2-day-old.

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2.2 Fecundity and longevity study of female moths

The experiment was set up with two groups of females: (1) virgin females (n = 30) (2) mated females (n = 30). Group 2 females were obtained when virgin females mated with naive males of age 2-6 day old in the ratio 1: 2 (Female: Male).The females which are mated for 1hour were selected for bioassay. The experimental moths were kept individually in an oviposition chamber (plastic cups, size: 8.5 x 6.5 cm) covered with a black cloth serving as an oviposition substrate. 10% honey (v/v) solution was provided as food for the moths. The eggs of each moth were counted daily till the death. Total number of eggs laid till death indicated the fecundity and their lifespan longevity. The results from females living less than 5 days were not considered. The experiment was replicated 3 times.

2.3 Statistics

Data on fecundity and longevity were not normally distributed and thus analysed using nonparametric Wilcoxon Rank-Sum test. The relationship between fecundity and longevity of females was analysed using a linear regression analysis. Rejection level was set when $\alpha < 0.01$ in all analyses. All analyses were made using R, version 3.0.2 software.

3. Results

The fecundity was significantly different between the treated groups (W = 176, $p < 0.01$; Fig. 1). A significant difference was observed in the fecundity of mated females which laid more eggs compared to virgin moths. The mean total number of eggs laid throughout the lifespan is double than the virgin females.
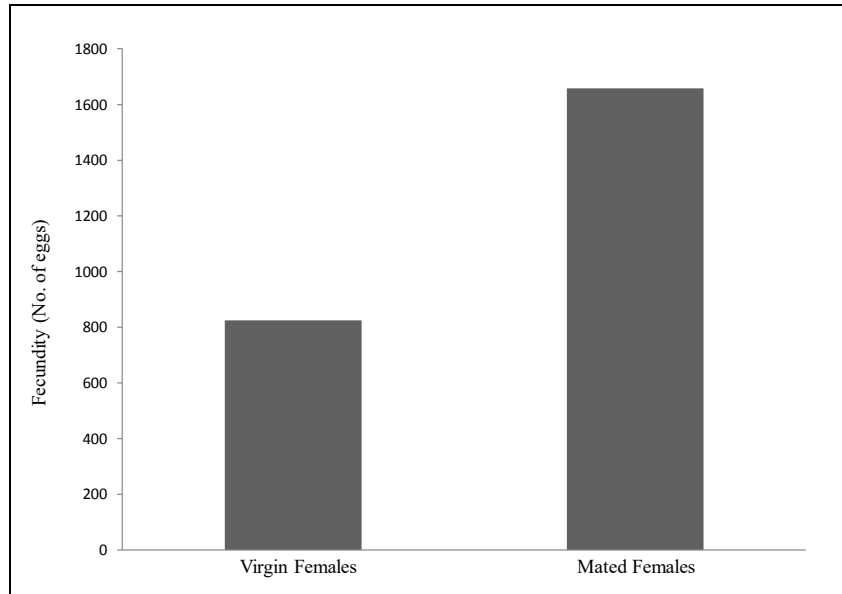

Fig 1: Mean fecundity: showing significant difference between virgin and mated females ($p < 0.01$) after Wilcoxon Rank-Sum test.

In longevity studies (Fig. 2) a significant difference was observed between the groups (W = 771.5, $p < 0.01$). The difference was more significant with mated moths which had shorter lifespan than virgin moths. The virgin females live one week more the mated females. When regression analysis was carried out between fecundity and longevity it was found that both are coupled and they are negatively related (Fig. 3).
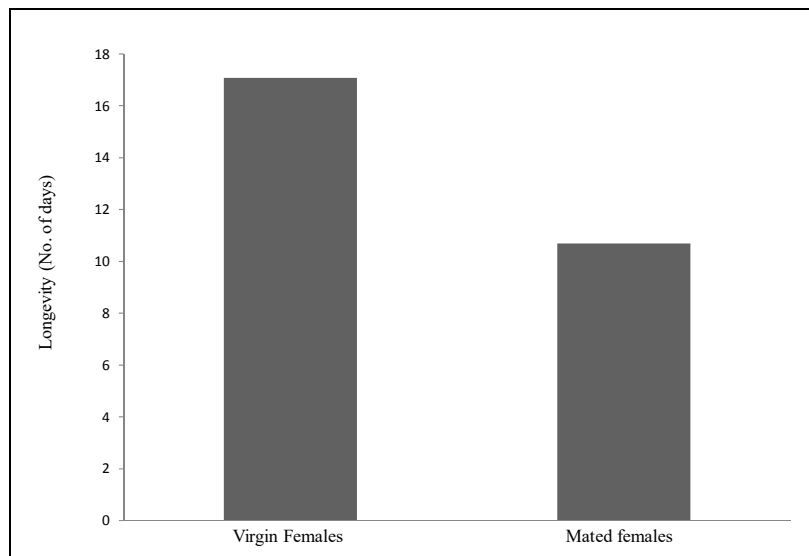

Fig 2: Mean longevity: showing significant difference between of virgin and mated females ($p < 0.01$) after Wilcoxon Rank-Sum test
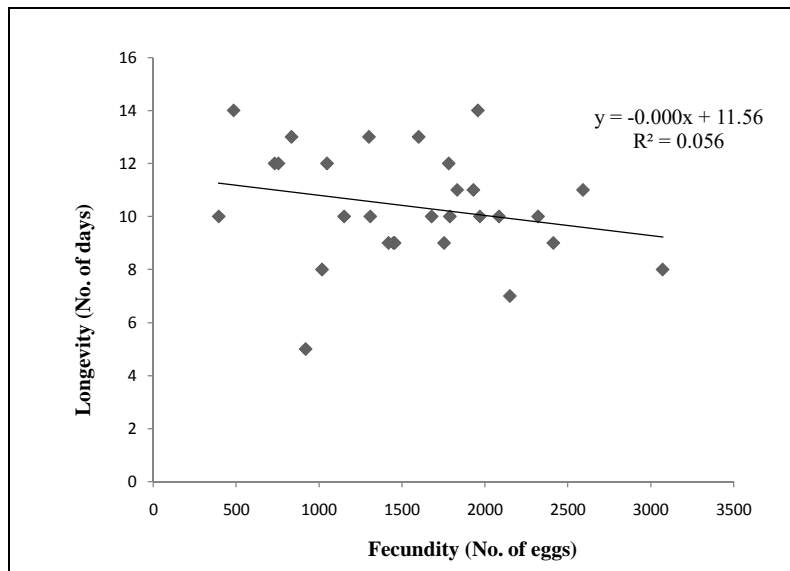
$$y = -0.000x + 11.56$$
$$R^2 = 0.056$$

Fig 3: Relationship between fecundity and longevity in mated *H. armigera* females

4. Discussion

A virgin female lives significantly longer than a mated female [12]. A number of authors [13-16] reported that mated females showed shorter longevity. Our study also supports this view. Several hypotheses were put forward to explain the reason behind this physiological behaviour. According to some researchers the antagonistic co-evolution between the sexes has thus been compelled males to adapt to intra sexual competition and intersexual selection that have detrimental effects on their mates [17, 18]. Such male effects can shorten female longevity due to physical damage from spiky male genitalia during mating [19, 20], other forms of traumatic insemination, [13-21] or altered female reproductive schedules by male toxic ejaculates [22-24].

The premature death of the mated female is due to a combination of factors. First, the energetic requirements of progeny production take their toll. Second, just the presence of males (even in the absence of mating) also decreases the female's life span [25, 26]. Perhaps this is due to her inability to stop and rest and eat as she is continually being chased by males. A third component to her shortened life is independent of either of these, and requires the receipt of seminal fluid from the male [15, 27]. To counter this female has evolved multiple-mating strategy which benefits her to increase genetic fitness as well as to harness more nutrients from the male.

At the physiological level, trade-offs between survival and reproduction is thought to be caused by competitive allocation of limited resources into reproduction versus somatic maintenance and survival [28-31]. Aging might evolve because natural selection favours alleles that increase the competitive allocation of energetic resources into reproduction at the expense of investment into maintenance, repair, and survival [18]. The accumulation of reactive oxygen species from high levels of oxidative metabolism enabling reproduction might impair survival [32, 33]. In other cases, bodily maintenance, defence, or repair functions might be down regulated because their activation would interfere with optimal reproductive performance [34].

5. Acknowledgements

6. References

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