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Fecundity and preferential oviposition by pulse beetle, *Callosobruchus maculatus* F on chickpea (*Cicer arietinum* L.) var Dollar

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ABSTRACT

In a laboratory experiment female *Callosobruchus maculatus* distributed eggs on healthy chickpea seeds in a manner that maximizes the amount of resources allocated to each offspring under favourable condition. The female preferred seeds having more quantity of resources to meet the nutrition of her offspring, seeds having healthy seed coat over damaged ones, fresh seeds over infested seeds for laying higher number of eggs under normal day light condition over the total dark. This was more so in presence of multiple copulating males over single one. Host deprivation did not have any influence on fecundity.

Key words: *Callosobruchus maculatus*, Chickpea, Fecundity, Seed coat.

INTRODUCTION

Pulses are generally stored for a year in various types of storage structures until harvest of next crop wherein a sizeable loss is observed due to infestation of number of insects. The bruchid (*Callosobruchus maculatus* F.) is cosmopolitan in nature and capable of attacking wide range of legume namely green gram, black gram, chickpea, pigeon pea and lentils (Sharma, 1984). The larvae bore into the pulse grains which become unsuitable for human consumption, viability as seeds, or for the production of sprouts. The larvae of this species feed and develop exclusively on the seed of legumes, while, the adults do not require food or water and spend their limited lifespan (one- two weeks) in mating and laying eggs on seeds (Kergoat *et al.*, 2007). Bruchids are the most notorious among the insects of chick pea and cause 50 per cent damage during storage in three to four months (Caswell, 1981) although the infestation starts in the field and continues in storage. Within a period of six months the loss has been estimated to be around 30-40 per cent, sometimes even in the severe cases of infestation the damage can reach even up to 100 per cent (Lal and Raj, 2012). Females lay eggs on the surface of host seeds and on emergence the larvae burrow into the seeds where their entire development is completed. The grubs cannot move among seeds and thus restricted to the seed that their mother has chosen for them. When larvae cannot move among hosts, a female's oviposition decision is determined by the environment within which her progeny will complete development. Thus, oviposition decisions should be based in part on resource quality as the females preferred higher quality resources (Mitchell, 1975). Ovipositional behaviour of *C. maculatus* is closely related to the size of the seed, mating, thickness of seed coat, photoperiod etc. Hence detailed studies were conducted on seeds of chickpea var. dollar to assess the effect of host seed on ovipositional behaviour of *C. maculatus*.

MATERIALS AND METHODS

The experiments were conducted in the laboratory of Entomology, Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh, India. The stock culture of pulse beetle (*C. maculatus*) for the experiments was maintained on healthy chickpea (*Cicer arietinum* L.) kabuli var. Dollar and reared in plastic containers with mouth covered by muslin cloth tightly secured by rubber bands and the whole system was maintained at 27± 2°C in BOD incubator. The detail methodology of each experiment is outlined below:

Experiment 1: To study the oviposition and fecundity of female, single pair of newly emerged adults was released in a Petridish (9.5 cm diameter) containing single seed of chickpea var. Dollar. The seed was replaced by another fresh seed for every 24 hours till death of the insects. The total number of egg laid by a single female during her life time was recorded.

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Experiment 2: To observe the mating behaviour, a pair of newly emerged adults from the stock was released on Petridish (14.2 cm diameter) having host seed. The observation on premating and mating behaviour, mating time and ovipositional duration were made.

Experiment 3: To study the ovipositional behaviour of female *C. maculatus* on relative preference towards the size of host seed, two sets of seeds namely, large (average length 1.35 cm and breadth 0.84 cm) and small (average length 0.95 cm and breadth 0.72 cm) sized were considered. The experiment was conducted in two conditions, one with free choice wherein a mixture of small and large sized host seeds were given to the insect for laying eggs and other with no choice wherein the insect was exposed separately with small and large sized seeds in separate Petridishes and thus giving no preference with respect to seed size for laying eggs. A pair of newly emerged adults was released on host seeds of different sizes under above conditions and observation on number of eggs laid was recorded after six days of release. Observation was made on number of eggs laid during their life time.

Experiment 4: To examine the effect of seed coat on ovipositional behaviour of female insect, healthy as well as physically damaged seeds were confined with a pair of newly emerged adults under no choice condition in a Petridish (14.2 cm diameter).

Experiment 5: To observe the effect of seed texture on ovipositional preference of female *C. maculatus*, smooth and rough surfaced seeds were exposed to a pair of insects under no choice condition.

Experiment 6: To assess the ovipositional preference, one pair of female *C. maculatus* was allowed to lay eggs under no choice condition on fresh seeds and also seeds having previously laid egg by another female. Previously laid eggs were marked to distinguish from fresh eggs at the start of the experiment. Number of eggs laid on the seeds was recorded.

Experiment 7: To estimate the effect of photoperiod on oviposition of female *C. maculatus*, two sets of treatment, one in normal daylight (average day length of 12 hours) condition and other in total dark condition were imposed. The data were recorded after six days of release of newly emerged single pair of insect.

Experiment 8: In this experiment the courtship behaviour of female *C. maculatus* with multiple males was explored. Here three sub sets of experiment each having a single female with two, three and four males, respectively, in separate vial were established for mating purpose.

Experiment 9: To observe the effect of host deprivation period on oviposition, a newly emerged female was kept for one day starvation in one vial and another female for eight days in other vial. Then each of them was allowed for mating with newly emerged male and exposed for oviposition as detected in experiment.

In each of the above experiments the data were recorded after six days of insect release and each experiment was repeated ten times.

Statistical analysis: The data were subject to paired t-test to evaluate female discrimination ability towards host seeds and other environmental conditions for oviposition.

RESULTS AND DISCUSSION

A single pair of newly emerged adults immediately after releasing on host seed, did not go for mating. Instead, the both moved around the host and then go for mating. On an average, the beetles took 4½ minutes for first mating. After that the female moved around the seed surface and the periphery of the petridish and started laying eggs 1 hour and 35 minutes after mating. Similar behaviour was also reported by Wasserman (1985) who reported that ovipositional behaviour of *C. maculatus* consisted of three phases like patrolling the seed surface, preparation for oviposition and oviposition. The female beetle took about 2 minutes and 56 seconds for laying a single egg and continued to lay higher number of eggs upto eight days of mating and thereafter the trend declined (Figure 1).

The egg laying behaviour of female *C. maculatus* was significantly affected ($p \leq 0.05$) by the size of chick pea seeds. The beetle displayed strong preference (t=2.81* and 3.94*) towards the large sized (average length 1.35 cm and breadth 0.84 cm) seeds over small (average length 0.95 cm and breadth 0.72 cm) seeds under both free choice as well as no choice condition (Figure 2 and 3) indicating the ability of females to judge the nutrient resource (seed mass) in a better way for their off spring during oviposition. Ofuya (1998) also

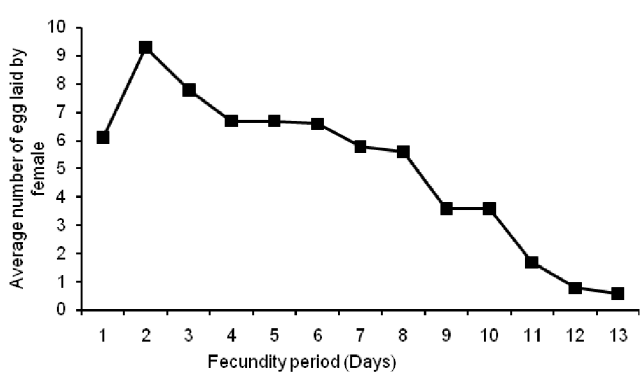

Fig 1: Average egg laid by single female *C.maculatus*/seed during her life time

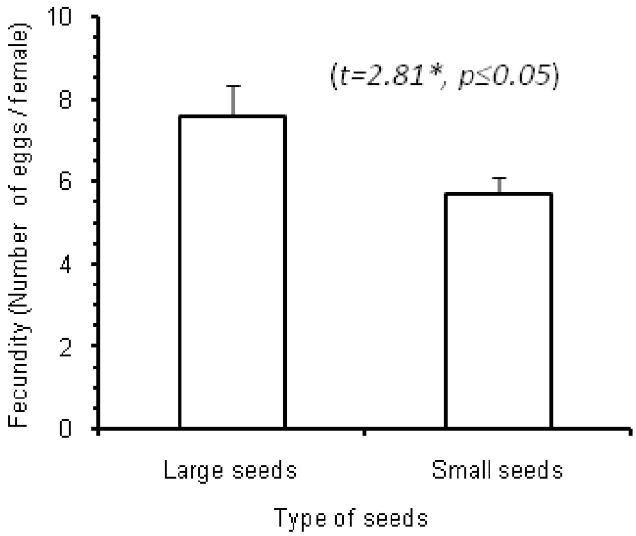

Fig 2: Seed size on fecundity under free choice condition; (error bars represent the standard error of mean)

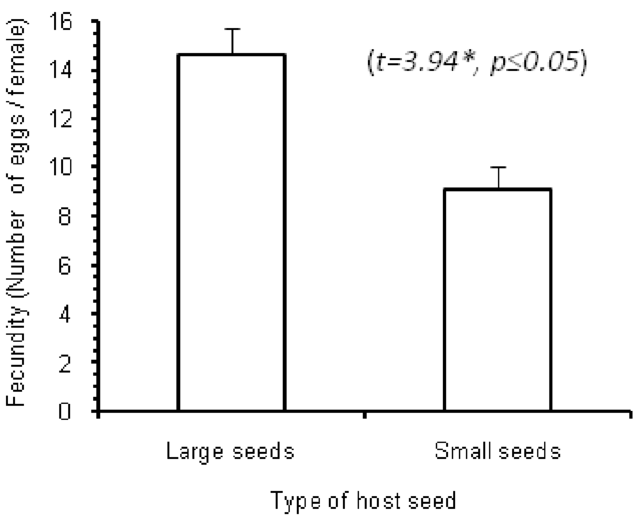

Fig 3: Seed size on fecundity under no choice condition; (error bars represent the standard error of mean)

reported that *C. maculatus* preferred large sized seeds for oviposition but seed size did not influence the developmental period. In a study, Jones and Vamosi (2010) identified the discrimination behaviour of female towards the host seed size to increase fitness through increased fecundity of the offspring generation.

The ovipositional behaviour of female *C. maculatus* on seed coat characteristics showed that there was significant difference (t= 3.71*, p≤ 0.05) between the choices adopted. The female, generally, preferred to lay more eggs on seeds having healthy seed coat (14.6 eggs/seed) in comparison to physically damaged one (10.1 eggs/seed). This variation in egg laying behaviour (Figure 4) might be due to the chemical cues associated with seed coat. Chandra and Ghosh (2006)

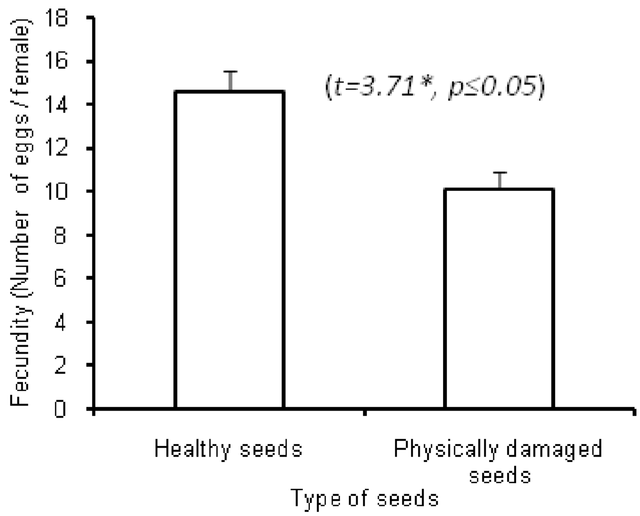

Fig 4: Seed coat on fecundity; (error bars represent the standard error of mean)

reared *C. maculatus* on whole and decorticated grains of various pulses to study its development. The average fecundity per female varied with beetles reared on whole grains. The beetles had a higher oviposition preference for whole grain than decorticated one.

The morphology of seed coat showed significant influence (t= 4.83*, p≤ 0.05) on the ovipositional behaviour of pulse beetle. The female beetle laid maximum number of eggs (7.8 eggs/seed) on seeds having smooth seed coat over the rough ones (Figure 5). Relative less preference of the beetle for seeds with rough coatings may be due to thicker testa or poor nutritive quality of seed cotyledon or due to presence of more linoleic acid which affect oviposition and larval feeding (Sarwar, 2012). Ajayi and Lale (2001) in their findings also revealed that the texture of seed coats affects the oviposition as well as development.

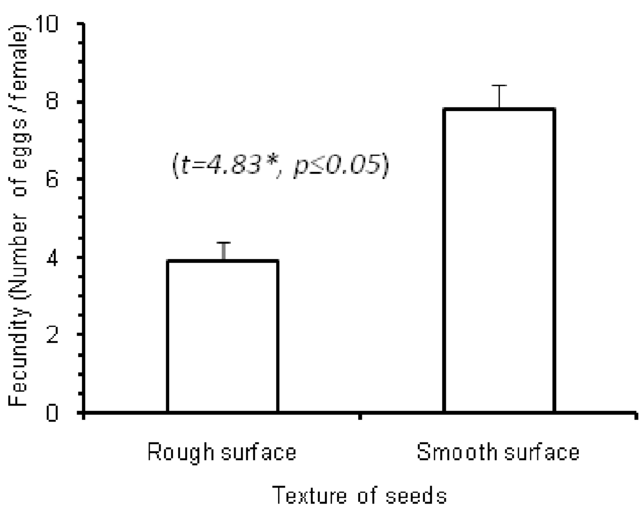

Fig 5: Seed texture on fecundity; (error bars represent the standard error of mean)

The female beetle showed significant difference (t= 11.41*, p≤0.05) in ovipositional preference on fresh seeds rather than seeds infested by another female (Figure 6) as reported by Messina and Renwick (1985a). Ofuya (1998) reported that the female *C. maculatus* was able to discriminate between seeds with varying numbers of larvae before oviposition and it preferred seeds without larvae. Yang *et al*. (2006) presented through model simulation that seed size discrimination ability may be adaptive when females could discriminate among numbers of eggs already laid on seeds. Therefore, females should experience stronger selection pressure to discriminate between seeds of two different sizes when there are no pristine seeds remaining (Cope and Fox, 2003). Females will then choose to oviposit on seeds that have a below-average egg load (Messina and Renwick, 1985b) because competition with other larvae may result in reduced fecundity of emerging females (Vamosi, 2005).

The pulse beetle recorded significant difference (t= 7.11*, p≤0.05) in its ovipositional preference under normal photoperiod of alternate light and dark and total dark condition and the female preferred to lay more eggs under normal photoperiod of 12 hours of day over total dark condition (Figure 7).

There was significant variation (p≤0.05) in the courtship behaviour of female *C. maculatus* when kept with multiple numbers of male. On average, the number of egg laid by a single female was recorded as 24.5, 34.4, 36.1 and 73.2 when copulated with one, two, three and four males, respectively. Although there was no significant relation between the number of eggs laid and number of copulating males but with the increase in number of males, the female fecundity rate was also increased (Figure 8). The present

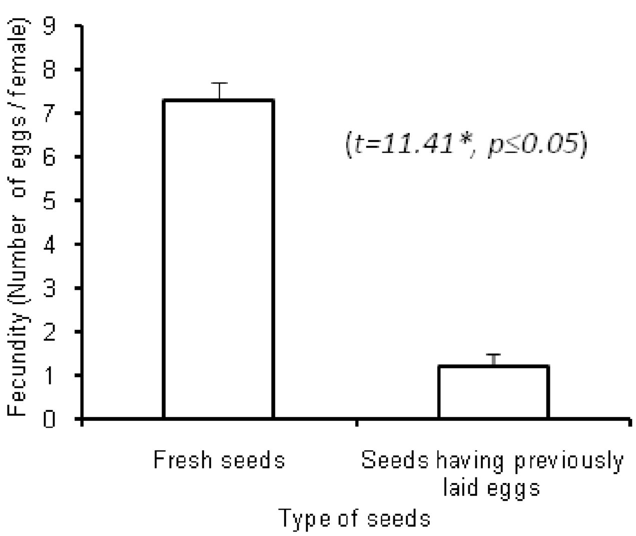

Fig 6: Oviposition on fresh and previously infested seeds; (error bars represent the standard error of mean)

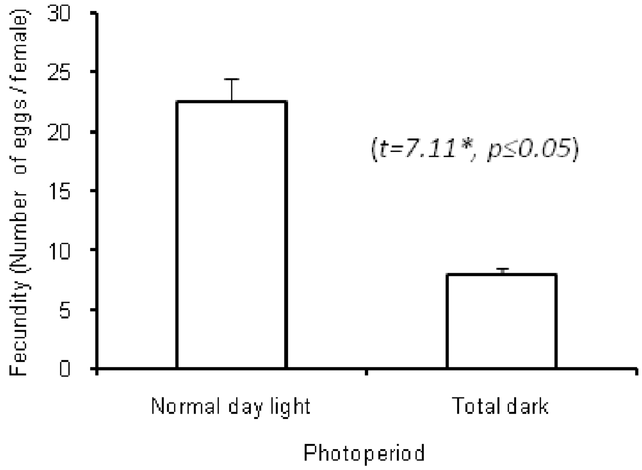

Fig 7: Photoperiod on fecundity; (error bars represent the standard error of mean)

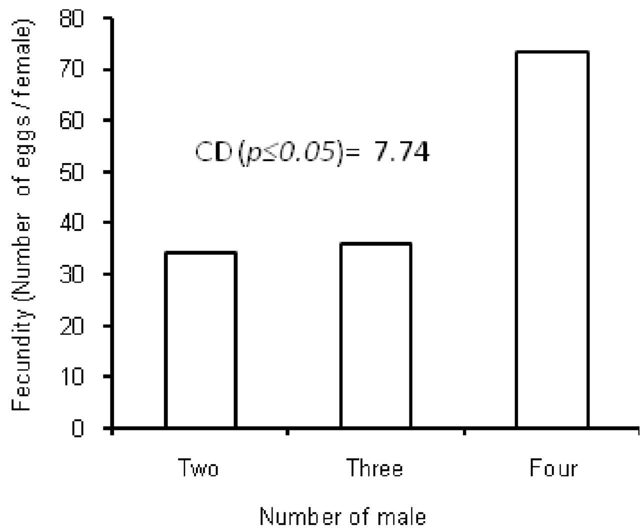

Fig 8: Multiple males on fecundity

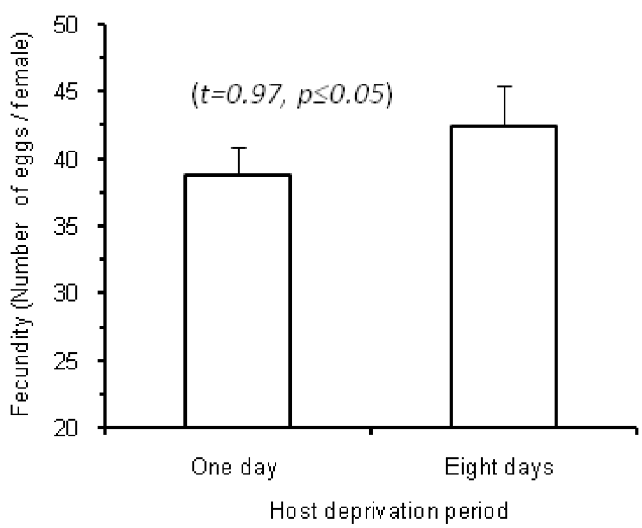

Fig 9: Host deprivation period and fecundity; (error bars represent the standard error of mean)

finding is in agreement with the finding of Eddy *et al.,* (2000) who reported that females copulating with multiple males laid more eggs than those copulating repeatedly with the same male.

The pulse beetle showed no significant difference (t= 0.97, $p\leq 0.05$) between the number of eggs laid by the female under one and eight days host deprivation period. On an average, *C. maculatus* laid 38.8 and 42.4 eggs in one and eight days host deprivation period, respectively (Figure 9). The finding is as against Lin *et al.,* (2004) who reported that the rate of reproduction in *C. maculatus* increased with increasing duration of host deprivation.

Thus, it can be concluded that the female pulse beetle showed wide variations in its ovipositional behaviour/preference due to variations in different parameters viz., host seed size, seed coat characteristics, seed morphology, seed infestation, photoperiod and number of copulating males but not on the length of host deprivation period. The beetle exhibited some level of host size discrimination. However, this discrimination was accompanied by other factors as stated above. The insect not only preferred larger seeds with smooth coating, but also preferred fresh healthy seeds under normal photoperiod with many males for its oviposition. Further research is required to identify the chemical cues associated with the host seed for in depth study of ovipositional behaviour of the female.

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