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Effects of number of cowpea seeds on oviposition, adult emergence and fecundity of *Callosobruchus maculatus* (F.)

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ABSTRACT

The cowpea seed beetle, Callosobruchus maculatus (F.), a predominantly seed feeding beetle was investigated in the Pest Management Laboratory of the Department of Crop, Soil and Pest Management, the Federal University of Technology Akure to determine whether the number of cowpea seeds provided will affect its oviposition, adult emergence and fecundity. Different number of seeds (5, 10, 15 and 20) was infested with 5 pairs of 24 to 48 hours old C. maculatus in petri dishes and allowed to oviposit on the seeds for 14 days. The setups were laid out in Completely Randomized Design and replicated three times. Data were taken on the number of eggs laid, seed with and without eggs, seeds with and without holes and weight loss caused by C. maculatus. The result from the study indicated no significant differences p> 0.05 in number of eggs laid, seeds with and without eggs, emerged adults, seed without holes, fecundity and weight loss. However, there were significant differences p< 0.05 in the number of seeds with eggs and seeds with holes. From the study, it was concluded that number of seeds provided did not affect oviposition, emergence of adults and fecundity in the C. maculatus. Although, these parameters increased with the increase in the number of seeds provided.

Key words: adult emergence, cowpea seed, fecundity, oviposition

INTRODUCTION

Cowpea (*Vigna unguiculata* Walpers) is one of the five most important legumes in the tropics and provides the protein for most people in the region and nitrogen to the soils (Duke, 1990) and it is important as an alternative source for expensive animal protein (Ileke *et al*., 2013). Cowpea is a food and animal feed crop grown in semi-arid tropics covering Africa, Asia, Europe, United States and Central and South America. It originated and was domesticated in Southern Africa and was later moved to East and West Africa and Asia (AGRONIGERIA, 2015). Many insect pests have been reported attacking cowpea both in the field and in storage among which is the cowpea seed beetle (Adebayo *et al*., 2013).

The cowpea seed beetle, *Callosobruchus maculatus* (Fab.), is the most important storage pest of cowpea throughout the tropics (NRI, 1996) and their reproductive behaviour has been studied (Tran and Credland, 1995). *Callosobruchus maculatus* is a species of beetle known commonly as the cowpea seed beetle. It is a member of the leaf beetle family, Chrysomelidae, and not a true weevil. *Callosobruchus* was formerly a genus in the family Bruchidae (seed beetles) but now in the family Chrysomelidae (Kergoat *et al*., 2007). They multiply rapidly in storage, giving rise to a new generation every month in grain at 25°C. Several damaged cowpea seeds are therefore riddled with adult exit holes and defaced with egg covers which leads to reduced weight, poor food value and low seed viability (Ofuya, 2003). Females are darker overall, while males are brown. The plate covering the end of the abdomen is large and dark in colour along the sides in females, and smaller without the dark areas in male (Beck and Blummer, 2009). The larvae of this species feed and develop exclusively on the seed of legumes (Fabaceae) hence the name bean beetle. The adults do not require food or water and spend their limited lifespan (one - two weeks) mating and laying eggs on beans. (Olotuah *et al*., 2007). *C. maculatus* females and males live an average of 7 days under laboratory conditions and very few survive more than 2 weeks at 25ºC. The beetles have a short generation time (22-28 days at 28°C) (Messina 1993, Fox 1993). The varieties of cowpea that are most common for the beetle to lay their eggs on are black eyed peas, mung beans and adzuki beans. *Callosobruchus maculatus* lay eggs on the pods of legume hosts as they approach maturity in the field but emergence usually occurs after harvest (Booker, 1967). In storage, *C. maculatus* lay eggs on the seeds. Larval development and pupation are completed entirely within a single seed. In the laboratory, among a small group of similar small sized seeds, females tend to lay on the relatively larger seeds but in a large volume of seeds, individual females lay in a cluster of about 20 cm^3 with the highest egg density at the centre (Stolk *et al.*, 2001). The eggs are small, flat and white and, despite being only 0.75 mm long, they are readily visible on the surface of seeds (Beck and Blummer, 2009). This present study seeks to find out whether the number of cowpea seeds presented will determine oviposition, adult emergence and fecundity of individuals in *Callosobruchus maculatus* (F.).

MATERIALS AND METHODS

Study location

The experiment was carried out in the Pest Management Laboratory of the Department of Crop, Soil and Pest Management at the Federal University of Technology, Akure, Nigeria. Experiment was conducted under laboratory conditions of 26-28°C temperature and 60-75% relative humidity.

Collections of materials

The initial culture of *C. maculatus* adults was derived from colony originating from infested cowpea seeds bought from Isinkan market in Akure, Nigeria. They have been left to breed at laboratory temperature and relative humidity. Oloyin variety of cowpea used for the experiments was obtained from a local market around the Southgate of the Federal University of Technology Akure and was stored at temperature of 10°C to disinfest and prevent infestation insects.

Culturing of *C. maculatus*

The cowpea seeds (Oloyin) were removed from the cold storage and acclimatized to room temperature on work bench in the laboratory. Adult beetles were separated by sieving from the seeds in the old culture and use to infest 200g of cowpea seeds placed in plastic containers. The containers were covered with the netted lid to allow for ventilation while preventing contamination by other insects. The culture was left on the shelf for subsequent emergence of adults. This served as sub-culture from which freshly emerged adults male and female of *C. maculatus* were obtained for the experiments.

Seeds preparation

The stock cowpea seeds used for this study were acclimatized and sorted. Clean seeds were picked out for the experiment to permit high visibility of eggs and to facilitate egg counting as well as to guide against using of already infested seeds. Seeds of similar sizes were used since female beetle are known to prefer large seeds for oviposition.

Experimental Procedures

The clean uninfested cowpea seeds (5, 10, 15 and 20) were handpicked into the Petri-dishes and infested with 5 pairs of 24-48hrs adults of *C. maculatus* and left to oviposit for 7 days. The Petri dishes were wrapped together in triplicate with paper tape to keep out other insects. After 7 days of oviposition, data were collected on the number of eggs laid, seeds with and without eggs, emerged adults, seeds with and without holes, fecundity of individual and weight loss due to infestation.

Identifying the sex of *C. maculatus*

A day after emergence, the adult beetles were sexed by the examination of the elytra pattern. The females are maculated with four elytra spots whereas males are plain with less distinct spots.

Data analysis

All data in counts were square root transformed before subjected to the Analysis of Variance using SPSS 15.0. Where differences existed, means were separated using Tukey's HSD at 5% level of significance.

RESULTS AND DISCUSSION

Results

The results in Table 1 revealed no significant difference in the number of eggs laid, seeds without eggs and adult emergence of the *C. maculatus* when exposed to different number of seeds. More eggs were laid on 15 and 20 seeds but was not significantly different $p>0.05$. The number of emerged adults increased with increasing number of seeds but was not significantly different from those of 5 and 10 seeds. However, significant differences $p<0.05$ exist in seeds with eggs with seeds in the Petri-dishes containing 5 seeds having highest number of eggs than others and were significantly different $p<0.05$. There was no significant difference in the number of seeds without eggs.

Table 1: Mean number of eggs laid, emerged adults, seeds with and seeds without eggs

Number of seeds	Eggs laid	Emerged adults	Seed with eggs	Seeds without eggs
5	5.73a	2.98a	4.53a	0.71a
10	9.20a	3.44a	3.94b	0.71a
15	9.62a	3.47a	3.24c	0.71a
20	9.80a	3.53a	2.45d	0.71a

Means in the same column with the same letter are not significantly different at $p<0.05$ using Tukey's test.

Results in Table 2 showed that the mean number of seeds riddled with holes by *C. maculatus* was significantly different $p<0.05$ among the number of seeds presented.

Seeds with highest number of holes were from the 20 seeds and was significantly different $p<0.05$ from those of 5, 10 and 15 seeds. The seeds without holes and weight loss were not significantly different $p>0.05$ in term of the number of seeds presented, though the highest weight loss was recorded from the 20 seeds.

Table 2: Mean number of seeds with holes, seeds without holes, fecundity and weight loss

Number of Seeds	Seeds with holes	Seeds without holes	Weight loss
5 seeds	2.45d	1.00a	0.11a
10 seeds	3.27c	1.00a	0.16a
15 seeds	3.94b	1.14a	0.17a
20 seeds	4.49a	1.14a	0.33a

Means in the same column with the same letter are not significantly different at $p<0.05$ using Tukey's test.

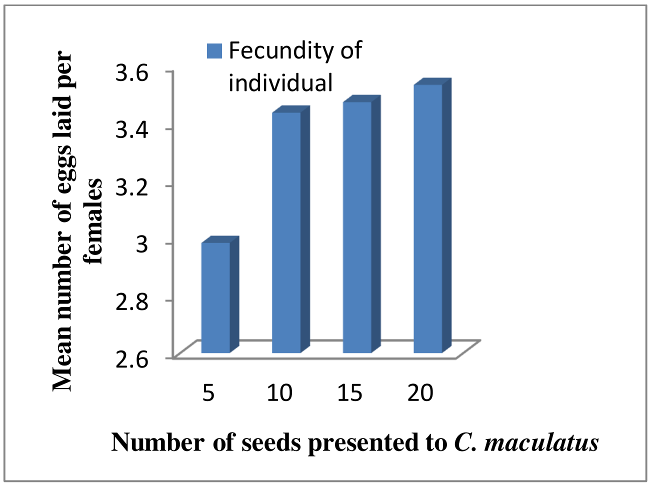

Figure 1: Fecundity of individual *C. maculatus*

From the result in Figure 1, the fecundity of the individual female insect increased as the number of seeds presented increased. Five seeds had the least number of eggs laid per female while the 20 seeds had the highest number of eggs laid per female *C. maculatus.*

Discussion

The findings in this study showed clearly that the number of seeds offered does not affect the performance of *Callosobruchus maculatus*. Although oviposition, fecundity (number of eggs laid per female) and adult emergence increased with increase in the number of seeds presented. The number of seeds or quantity has been discovered not to significantly influence the performance of *C. maculatus* in storage (Adebayo, 2016). It has been reported by Dick and Credland (1986a) that the rates of population increase in a store depend on many factors but differences in oviposition rate determined in the laboratory are unlikely to have major effects on the beetles. Survival rates of the immature stages in the seeds are much more variable and of much greater importance. The relationship between egg production and the seed density can be described better by an asymptotic curve, $y = \beta^\circ(1 - e^{B}.1^{x})$ which represents the gradual increase of egg production to an upper limit β° as x (the seed density) increases (Cope and Fox, 2003).

El-Sawaf (1956) and Howe and Currie (1964) determined the effects of abiotic factors on rates of development. On the basis of their observations the optimum conditions are 30 °C and 70 % R.H. which were similar to the condition under which this study was conducted. But it might be expected that these would vary with different populations. The host in which development occurs affects the rate of development (Chandrakantha and Mathavan, 1986; Boeke *et al.*, 2004) and there are numerous accounts of failed or exceptionally slow development in seeds of resistant cowpeas or other species (Dick and Credland, 1986b). Heavy infestation of seeds leads to a rise in temperature and this will result in a change, usually an increase in the rate of development.

Equal seed size was used in carrying out the experiment, this could have accounted for the distribution in egg-laying by females. According to Mitchell (1990), females distributed eggs in manner inconsistent with the hypothesis that they base oviposition decisions on the relative surface area of seeds; they distribute eggs in a manner that reflects relative mass of seeds better than relative seed surface area. Many factors affect the number of eggs laid by females. Some studies have revealed that populations from different areas vary in their fecundity on the same number, species and cultivar of host seeds (Appleby and Credland, 2003) although others found minimal differences (Boeke *et al.*, 2004). The number of seeds available to each female also affects their fecundity but the simplistic experiment of providing each female with separate groups of seeds conceals a more complex phenomenon. If several females (3) have access to 60 Californian cowpea seeds, there is a marked reduction in the total number of eggs laid compared with the number expected if each beetle had been provided with 20 seeds (Credland, unpublished). According to the results from this experiment, the number of seeds available had no significant difference on the fecundity, although females laid more eggs when sufficient seeds were present. The number of emerged adults increased with the number of seeds provided. This could be as a result of the quantity of host made available for the beetles to oviposit on. The weight loss observed showed that number or quantity of seeds whether small or large would not influence the performance of the beetles. Once the beetles are able to survive in the seeds and emerged as adults, loss will be caused and this will depend on how many adults emerged from the seeds. Generally, the conditions of the hosts have been reported to be important in infestation, oviposition and development of the *C. maculatus* (Ofuya and Agele, 1989; Adebayo and Eyo, 2014).

CONCLUSION AND RECOMMENDATIONS

The results from the study indicated no significant differences $p>0.05$ in oviposition, adult emergence, seeds without holes, seeds without eggs, fecundity and weight loss. But there were significant differences $p< 0.05$ in the number of seeds with eggs and seeds with holes. The varying number of seeds provided in this study did not influence the performance of the *C. maculatus.* As the food quantity accessible to the female *C. maculatus* increases, the more the amount of eggs laid due to larger amount of resources available for larval survival and subsequent development and emergence of adults. *C. maculatus* will survive, oviposit and develop in seeds that are in good condition, cause damage and subsequently loss in weight of the infested seeds. Based on the study, it is recommended that for experimental purpose where large number of beetles is required, large quantity of substrates should be provided.

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