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Effects of larval competition on the performance of fed and non-fed populations of *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae)

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Abstract
Experiments were conducted to evaluate the effects of larval competition on the performance of fed and non-fed populations of *Callosobruchus maculatus* (F.) at the Pest Management Laboratory of the Department of Crop, Soil and Pest Management, the Federal University of Technology Akure (FUTA), Ondo State, Nigeria at conditions of 28±2^{0}C temperature and 55±10% relative humidity. Twenty (20) seeds of Ife brown cowpea were infested with 3 pairs of fed and non-fed populations of *C. maculatus* in petri dishes with three replications to test for the effects of feeding and larval competition on *C. maculatus.* Results indicated that fed population of *C. maculatus* lived longer (13days) and had shorter development period (23days) compared with 10 and 29 days in the unfed population. Fed insects showed significant differences ($p<0.05$) in the number of eggs laid (12.46), emerged adults (4.53) and weight loss (0.95) in seeds with higher value compared with the unfed insects. Larval competition significantly affected emergence of F1 adults, subsequent oviposition and emerged F2 adults in both fed and unfed *C. maculatus*.

Keywords: *Callosobruchus maculatus*, performance, larval competition, populations

1. Introduction
Several insect pests pose problem to the production of cowpea both on the field and in the store. The most pestiferous of the stored insect pest of cowpea is the cowpea seed beetle, *Callosobruchus maculatus* (F.) [2]. *C. maculatus* has been identified to be a very serious pest stored cowpea [1, 2] and is capable of causing 100 per cent infestation in cowpea within 5 months of storage in Africa [3]. The damage is done by larvae feeding inside the seed, which often result in about 30 per cent loss in seed weight in storage [4]. *Callosobruchus maculatus* causes the major losses in stored legume grains [5], field infestation as low as one or two percent of pod infested with bruchids eggs may lead to 80% of the pods attacked after six to eight months of storage [6].

Damaged seeds are riddled with adult emergence holes, defaced with egg covers and reduce weight and viability [5, 7]. Heavy attack on bruchids cause severe powdering and weight loss [8]. [5] listed the damage caused by *Callosobruchus maculatus* to include seed weight loss, poor seed quality, contamination of produce and predisposition to pathogen attack. *C. maculatus* infest the cowpea before harvest and causes both quantitative and qualitative loss to seeds in storage facilities [9, 10]. Under traditional storage conditions 100% infestation of cowpea occurs within 3-5 months of storage [6]. *C. maculatus* also causes reduction in market value and germination of the infested seeds [5].

Once the female has mated and is ready to lay the eggs, she must determine egg location and distribution. Female *C. maculatus* prefer to lay their eggs on the smooth “cheek” of the bean. They avoid the wrinkled tops of the bean, and they avoid legumes that do not have smooth surfaces [11]. *C. maculatus* females also have some unknown method to determine the mass of each bean they encounter. When the beetles are presented with a combination of bean sizes (a mix of small and large), they distribute their eggs so that each larva has access to roughly the same amount of nutrients [12]. Their method is not based on surface area, but rather on the mass of the bean and the number of eggs already present. *Callosobruchus maculatus* adults do not need to feed and spend their time as adults mating and ovipositing or egg laying [13] but has been suggested to benefit from artificial feeding [14]. Despite the beetles not needing to eat, if offered sugar water, yeast, or plain water, adult beetles will eat. This eating replenishes spent

resources and affects how many eggs the female will lay [15]. In a study, females were provided with water, sugar, or nothing. The females with access to sugar lived longer and laid more eggs than those without that access [16]. Therefore, the present study seeks to evaluate the effects of larval competition on the performance of fed and non-fed populations of *Callosobruchus maculatus*.

2. Materials and Methods

2.1 Study site

The experiment was conducted in the entomology section of the Analytical Laboratory of Department of Crop, Soil and Pest Management, the Federal University of Technology Akure, Nigeria under prevailing laboratory conditions of 28±2^{0}C temperature and 55±10% relative humidity.

2.2 Source of materials

Two cowpea varieties used in this study were Oloyin and Ife brown. Ife brown was obtained from FUTA farm, while Oloyin was obtained from a local market in Akure (Oja Arakale). Oloyin was used mainly for the culturing of *C. maculatus*, while Ife-brown was used for the investigations. Sugar cube (St Louis) was purchased from NAO Supermarket, Akure and Coconuts were also purchased from a market (Oja Oba) Akure, Ondo State.

2.3 Culturing of *Callosobruchus maculatus*

Initial culture of *Callosobruchus maculatus* was derived from previously infested cowpea seeds in kilner jars in the laboratory of the Department where the temperature was 27±2ºC and relative humidity ranged from 55-75%. Prior to infestation, clean uninfested Ife brown seeds were sterilized in oven at 70 ºC for 3hours [17]. In three plastic containers, two hundred and fifty grammes (250g) of cowpea seeds were measured and covered with fine net. The seeds were then infested with adults of *Callosobruchus maculatus*. After 7 days of oviposition the adult *Callosobruchus maculatus* were sieved out and the set up left on the shelf for the emergence of new adults. Newly emerged adults of *Callosobruchus maculatus* (1-2 days old) from the culture were used for the investigations. *Callosobruchus maculatus* were offered with Sugar, Coconut, distilled water.

2.4 Preparation of treatments

The Coconut, Sugar and distilled water offered to *Callosobruchus maculatus* were prepared by dilution and no food served as control. Concentrations of 5%, 10%, 15%, 20% of both Sugar and Coconut was obtained by dissolving 5g, 10g, 15g and 20g of sugar cube and 5, 10, 15 and 20mls of coconut water in 100 ml of water distilled.

2.5 Experiment procedures on the feeding and larval competition in *C. maculatus*

One hundred (100) grammes of cowpea seeds (Ife brown) were infested with 10 males and 10 females of newly emerged adults in 10 plastic containers were fed with different concentrations of Sugar, Coconut and distilled water up to the fourth (4th) generation. Feeding was done by placing cotton wool soaked in the solution of sugar and coconut in small bottle covers placed in the plastic containers. Non-fed culture (where insects were offered nothing) was also set up as control. Twenty (20) seeds of Ife brown were infested with 3 pairs of fed *Callosobruchus maculatus* in petri dishes with each concentration replicated three times to test for the effects of feeding on *Callosobruchus maculatus*. The initial weight of seeds were determined, while at the 14th day, the number of eggs laid, seed with and without eggs were counted and recorded. Three weeks (21 to 25 days after oviposition) number of adults that emerged taken daily for 7 days, seeds with and without holes was counted while the developmental period and weight loss of seeds were also determined.

Separate experiment was also conducted to test for the effects of larval competition on the oviposition, adult emergence and weight of *Callosobruchus maculatus.* The adults were fed with coconut solution (15%) 15ml in 100ml of distilled water while in non-fed the adults were not provided with food. The number of eggs laid, emerged adults and weight of emerged adults were recorded.

2.6 Data analysis

All data collected as counts were square root transformed before analysis. SPSS statistical package was used while analysis of variance was employed to determine difference where existed and separated using Duncan Multiple Range Test at 5% level of probability.

3. Results

3.1 The longevity of the fed and non-fed populations of *Callosobruchus maculatus*

The results from Table 1 showed the longevity and developmental period of fed and non-fed populations. The populations fed with sugar lived longer while populations fed with coconut had shorter developmental period. The non-fed populations had the highest developmental period.

Table 1: Longevity and developmental period of *Callosobruchus maculatus*

Treatments	Longevity (days)	Developmental period (days)
Sugar	13±1	23±2
Coconut	11±1	20±2
Distilled water	12±1	27±2
Non-fed	10±1	29±2

3.2 Effects of feeding on the *Callosobruchus maculatus*

From the results in Table 2, it was observed that feeding had effects on oviposition in *Callosobruchus maculatus* and was significant ($P<0.05$) with highest number of eggs laid by insect fed with 10% of coconut solution and lowest with 5%. Similar trend occurred in seeds with eggs, though no significant differences exist among the treatments. Different trend was observed in weight loss where highest weight loss was recorded for seeds obtained from insect fed with 10% coconut. This 0.99% weight loss was significantly different from weight loss of 0.20% recorded for *Callosobruchus maculatus* fed with 5% coconut (Table 2).

Table 2: Effects of feeding on number of eggs laid, seeds with eggs and weight loss in Cowpea infested by *C. maculatus*

Treatment	Oviposition	Seed with eggs	Weight loss (g)
Sugar 5%	8.10ab	4.49a	0.72ab
Sugar 10%	10.01ab	4.53a	0.99a
Sugar 15%	12.46ab	4.53a	0.95a
Sugar 20%	10.21ab	4.29a	0.92a
Coconut 5%	8.02c	4.23a	0.20b
Coconut 10%	14.14a	4.53a	0.99a
Coconut 15%	10.08ab	4.49a	0.34c
Coconut 20%	6.91b	4.42a	0.51c
Distilled water	12.77ab	4.53a	0.14b
Non-fed	8.16ab	4.01a	0.13b

Means followed by the same letter in column are not different at 5% using Tukey's Test.

3.3 The Daily emergence of adults in fed and non- fed populations of *Callosobruchus maculatus*

The results in Table 3 showed the daily emergence of *Callosobruchus maculatus* as affected by feeding. Emergence of most adults of *C.s maculatus* occurred within the three days. Highest number of emerged adult occurred with *C. maculatus* fed with 20% of distilled water, 15% of coconut, 5% of sugar and 15% of sugar at day 1 and was significantly different from what was recorded for the non-fed, 20% of coconut and 5% of coconut at P<0.05. Similar trend was observed at day 2 as highest emergence was observed in insect provided with distilled water which was significantly different (P<0.05) from emergence from insect that were not fed. From day 3 to day 6, similar trend was observed with day 2 as highest and least emergence was recorded in insect fed with distilled water and 5% of coconut solution respectively. However, highest number of emerged adult occurred with *C. maculatus* that were not fed at day 7 which was significantly different from those fed with 5% of coconut.

Table 3: Daily emergence of adults in fed and non- fed populations of *Callosobruchus maculatus*

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Sugar 5%	2.92a	3.49ab	3.13ab	2.49b	1.61ab	1.74a	1.52ab
Sugar 10%	2.34ab	3.05abc	2.73abc	3.13ab	2.75a	2.06a	1.61ab
Sugar 15%	2.87a	2.38c	1.97c	2.86ab	2.14ab	2.29a	2.37ab
Sugar 20%	1.99ab	2.54c	2.35bc	3.50ab	2.38ab	2.18a	2.16ab
Coconut 5%	1.00b	1.00d	1.00d	1.00c	1.00b	1.00a	1.00b
Coconut 10%	2.30ab	3.49ab	3.36a	3.28ab	2.80a	1.96a	2.57ab
Coconut 15%	3.33a	2.82bc	2.82abc	2.92ab	2.44ab	1.61a	2.06ab
Coconut 20%	1.00b	1.00d	1.00d	1.00c	1.00b	1.00a	2.67ab
Distilled water	3.33a	3.71a	3.42a	3.77a	2.79a	2.15a	2.76ab
Non-fed	1.00b	1.00d	1.00d	1.00c	1.00b	1.52a	3.32a

Means followed by the same letter in column are not different at 5% using Tukey's Test.

3.4 Effect of larval competition on oviposition, adult emergence and weight of *Callosobruchus maculatus*

Results from the effects of larval competition on *C. maculatus* showed in Table 4 revealed that highest number of emerged adults was recorded on seeds obtained from insects fed with 10% Sugar and contained 10-12 eggs. This was significantly different P<0.05 from emergence from seeds infested with non-fed insect and contained an egg.

Higher number of eggs was laid by adult on seeds obtained from insect fed 15% sugar with 10-12 eggs and was significantly different P<0.05 from non-fed with 1 egg. The trend observed in oviposition showed that higher number of adults emerged from seeds with higher number of eggs per seed; however this was different from the result of non-fed with 10-12 eggs.

The highest and least weight of *Callosobruchus maculatus* was observed in insect fed of 15% sugar solution and contained 1 egg. There was no significant difference in the weights of the *Callosobruchus maculatus* as affected by the treatments. There were significant differences in the number of emerged F2 adults. Highest number of adults emerged from seeds infested by insect fed with sugar solution and contained 6-8eggs and was significantly different from the value obtained from the non-fed with an egg.

Table 4: Effect of larval competition on oviposition, adult emergence and weight of *Callosobruchus maculatus*

Treatment	Adult emergence (F1)	Oviposition	Adult Weight (mg)	Adult emergence (F2)
Non-fed 1 Egg	2.02c	3.67c	0.44a	2.12c
Non-fed 3-4 Eggs	1.72c	9.02ab	0.26a	3.87b
Non-fed 6-8 Eggs	4.89ab	15.0ab	0.25a	6.10a
Non-fed 10-12 Eggs	3.27b	6.83b	0.20a	4.26ab
Sugar 1 Egg	2.42b	6.73b	0.57a	2.85b
Sugar 3-4 Eggs	3.47ab	9.65ab	0.29a	4.79ab
Sugar 6-8 Eggs	2.66bc	11.6ab	0.25a	5.92ab
Sugar 10-12 Eggs	5.79a	16.78a	0.20a	5.49ab

Means followed by the same letter in column are not different at 5% using Tukey's Test.

4. Discussion

The present investigation showed that the non-fed populations of *Callosobruchus maculatus* have shorter longevity than the fed populations. The result of present this study corroborated reports of previous workers [18, 14, 16] that the adult are short lived and do not feed although they will drink if offered water or sucrose and this lengthen the adult lifespan. Developmental period was shorter in fed population while it was prolonged in the non-fed population of the insects.

On daily emergence of *Callosobruchus maculatus*, it was noted that the highest emergence at day 1 were Coconut 15ml, Distilled water and Sugar 5g. Insect fed with sugar solution Sugar and containing 10-12 eggs (F_1 generation) recorded highest number of emerged adults but was not significantly different p<0.05 from the other treatments. It has been reported by [19] that adult emergence decline with time of emergence. He also concluded that most of insect laid most in their first 3days of egg laying. Effects of larval competition revealed that when seeds were loaded with eggs, the emergence of the adult of F_2 was affected. In F_2 generation, highest and lowest number of emerged adults was observed in non-fed (6-8 eggs) and non-fed (1 egg) respectively. This result was similar to the results obtained by [16] when he fed *C. maculatus* with several sugar sources. Though several factors have been suggested to affect the performance of *C. maculatus*; host size [20], larval competition [21] and host species [22] affect larval survival, development and fecundity of the emerging adults. Weight loss in seeds was substantial in seeds infested with fed insects and showed statistical significant from those of the non-fed insects. This could be as a result of prolonged survival time caused by the feeding of the insect. Fed insects had highest value for the weight of

adults while it was least in the non-fed. However, when number of eggs contained on the seeds was large, the subsequent weight of the adult is reduced even when the insect were fed. Feeding generally seems to improve the vigor of the adult insect especially with the sugar sources. This was also observed by [15] who opined that the feeding replenishes the energy of the fed insect and [16] who observed that feeding enhanced the performance of the *C. maculatus* when provided with sugar solutions.

5. Conclusion and recommendation

The present study showed that feeding of *Callosobruchus maculatus* with sugar and coconut solutions will affect its survival, developmental period, oviposition and adult emergence. Also larval competition (number of eggs laid) will affect number of emerged adult and its weight. For the purpose of rearing *Callosobruchus maculatus*, it is recommended that if oviposition (egg laid) is to be considered, 10% coconut solution should be provided. However when premium is on adult emergence 15% is recommended.

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