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Adebayo RA
Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, Federal University of Technology, P. M. B. 704, Akure, Nigeria

Oke TF
Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, Federal University of Technology, P. M. B. 704, Akure, Nigeria

Correspondence
Adebayo RA
Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, Federal University of Technology, P. M. B. 704, Akure, Nigeria

Effects of honey and glucose solutions feeding and larval competition on the development of *Callosobruchus maculatus* (F.) [Coleoptera: Chrysomelidae]

Adebayo RA and Oke TF

Abstract

Experiments were conducted in the Department of Crop, Soil and Pest Management, the Federal University of Technology Akure, to evaluate the effects of honey and glucose solutions feeding and larval competition on *Callosobruchus maculatus* (F.). Cotton wool soaked with honey and glucose solutions were presented in plastic containers with cowpea seeds to *C. maculatus* at 5%, 10%, 15% and 20% concentrations while distilled water and non- fed were included as the controls. The results showed that feeding influenced the oviposition, adult emergence, longevity and developmental period of *Callosobruchus maculatus*. There were significant differences ($p<0.05$) among glucose and honey at 5% and 10%. Results of larval competition showed that significant highest number of F_1 adults emerged from seeds infested with insects fed with honey at 15% and contained 10-12 eggs. *C. maculatus* whether fed or not will reproduce, multiply and survive. However, feeding indicated enhanced performance in parameters that were observed.

Keywords: *Callosobruchus maculatus,* honey, glucose, larval competition

1. Introduction

Bean beetles, *Callosobruchus maculatus* (F). (Coleoptera: Chrysomelidae) is an important pest of stored cowpea (*Vigna unguiculata* L. Walp) with ample distribution in tropical and subtropical regions where this crop represents one of the main sources of protein in human diet [1]. In Nigeria, *C. maculatus* is a major pest of stored cowpea, pigeon pea and African yam bean [2]. It also infests soya bean and bambara groundnuts. In other parts of the tropics and subtropics it may be found infesting *Cicer arietinum, Lablab purpureus, Lens ciihnaris, V. acoriiflolia, Pisum sativum* and *V. angularis* [3]. Like the other members of the genus *Callosobruchus, C. maculatus* has a pair of parallel ridges on the ventral side of each hind femur, each of which bears a tooth near the apical end. The teeth are roughly equal in size; the antennae of both sexes are slightly serrate. Females often have strong markings on the elytra consisting of 2-4 large marginal dark patches mid-way along the elytra and smaller patches at the anterior and posterior ends, leaving a light grey-brown cross-shaped area covering the rest [4]. *C. maculatus* infestation normally starts with females laying eggs on the nearly maturing cowpea on the field [5, 2]. The larvae burrow through the chorion of the eggs directly into the pod wall, and then into the seed, where the larval develop and pupate [6]. This insect infests the cowpea before harvest and causes both quantitative and qualitative loss to seeds in storage facilities [7, 8]. Under traditional storage conditions 100% infestation of cowpea occurs within 3-5 months of storage [9]. *C. maculatus* also causes reduction in market value and germination of seeds [2]. Though, adults of *C. maculatus* require no food and water for its development [10, 11]. Some researchers have shown they benefit from artificial feeding [12, 13].

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 [14]. The females with access to sugar lived longer and laid more eggs than those without that access. The conditions organism experience during development could have profound effects on adult fitness and behavior [15, 16, 13]. This could happen through nutritional effects and the impact of juvenile feeding on subsequent fitness of the adults. One group of insects in which the effects of developmental conditions on adult trait has been studied particularly well is bruchid beetles. As these beetles do not feed as adults, their reproductive potential, longevity and growth are determined entirely by resources accumulated during development. The differences in bean (host) quality are likely to be especially important. Indeed, previous studies on *C. maculatus* have shown that host size [17], host species [18] and larval competition [15, 13] can all affect larval survival and development time, and also the fecundity of emerging adults. Therefore, the present study seeks to investigate provision of honey and glucose solutions and larval competition on performance of *C. maculatus* infesting cowpea seeds.

2. Materials and Methods

2.1 Study Area

The experiment was carried out at the Pest Management Laboratory of the Department Crop, Soil and Pest Management, the Federal University of Technology Akure under laboratory conditions of 28±2 ^{0}C temperature and 55-75% relative humidity.

2.2 Sources of materials

The two cowpea varieties used for the study were Ife- brown and Oloyin. Oloyin seeds were obtained from Oba Adesida market in Akure, Ondo State were used mainly for culturing of *C. maculatus* while Ife-brown was used for the investigations. Pure honey used was purchased from Sunshine Honey and Agro-Industrial Ltd., Alagbaka Akure, Ondo State and glucose was purchased from Oyinda Supermarket, F.U.T.A south gate Akure. Initial populations of *C. maculatus* were derived from freshly emerged adults from infested Oloyin cowpea seeds.

2.3 Culturing of *Callosobruchus maculatus*

Two hundred and fifty grams (250 g) of cowpea seeds (Oloyin) was weighed into three plastic containers covered with net at an ambient temperature of 28±2^{0}C and relative humidity ranging from 55 to 75% and were infested with adults of *Callosobruchus maculatus*. The adults of *C. maculatus* were sieved out after 7 days of oviposition. Freshly emerged adults of *C. maculatus* (1-2 days old) from the laboratory culture were used for the experiments. Prior to infestation, clean uninfested beans were heat-sterilized to eliminate possible contaminations thereby maintaining pure culture (Adebayo and Eyo, 2014).

2.4 Preparation of treatments

In this study, adults of *Callosobruchus maculatus* were offered honey, glucose, while no feeding and distilled water served as controls. Honey at 5 ml, 10 ml, 15 ml and 20 ml dissolved in 100 ml of water were the concentrations used while 5 g, 10 g 15 g and 20 g of glucose were dissolved in 100 ml of water. These gave concentration of 5%, 10%, 15% and 20% of both honey and glucose.

2.5 Experiments procedure on feeding and larval competition

The freshly emerged adults (10 males and 10 females of 1-2 days old) were used to infest 100 g of cowpea (Ife-brown) in 1litre plastic containers and were fed with different concentrations of glucose and honey while distilled water and non-fed cultures were included as controls up to the fourth generation. Feeding was done by placing cotton wool soaked in the solution of glucose and honey in small bottle covers placed in the plastic containers. To test for the effect of feeding on the adult *Callosobruchus maculatus*, a petri dish culture of three replicates per concentration of the treatments was set up whereby 20 seeds of Ife-brown were infested with three pairs of freshly emerged fed *C. maculatus*. Prior to setting the experiment, the initial weight of the seeds were determined while at the 14th day of oviposition, number of eggs laid and seed with and without eggs were counted, at about 21 days (3 weeks after oviposition) number of emerged adults, the developmental period and final weight of seeds was counted and recorded. The daily number of adults that emerged was counted and recorded for 7 days.

Another experiment was set up to test for the effects of larval competition on the number of eggs laid, adults that emerged and weight of adults in *C. maculatus*. Cultures were set up in this regard for fed and non-fed adults of *C. maculatus*. The adults were fed with Honey (15%) 15 ml in 100 ml 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

The experiments were laid in Completely Randomized Design (CRD). Square root transformation was performed on the data obtained in counts. Data were analyzed using SPSS while Analysis of variance (ANOVA) was performed to detect possible differences in the means and means separated using Tukey's test at 5% level of probability.

3. Results

3.1 Effects of feeding on longevity and development period of *C. maculatus*

Results of honey and glucose feeding on longevity and development period are presented in Table 1. It was revealed that the fed population have shorter developmental period compared with the non-fed population.

The non-fed population of *C. maculatus* lived for a shorter period than the fed population. The population of *C. maculatus* fed with glucose lived longer and had short development period compared with the population of *C. maculatus* offered other foods and those that were not provided with food.

Table 1: Longevity and development period of fed and non-fed adult's *C. maculatus.*

Treatments	Longevity (days)	Developmental period (days)
Glucose	13±1	22±2
Honey	12±1	24±2
Distilled Water	12±1	26±2
Non Fed	10±1	28±2

3.2 Effects of honey and glucose feeding on the *Callosobruchus maculatus*

From Table 2 below, it was observed that feeding had effects on the egg laying in *Callosobruchus maculatus* and was statistically significant (p<0.05) in glucose and honey at 5%. Highest number of eggs was obtained from insects fed with honey at 10% while least was recorded on insects fed with 5% of glucose. Results also showed that both glucose and honey at 10% gave better oviposition compared to other treatments but were not significantly different at p>0.05. Insects with no food and those provided with distilled water laid eggs that were not significantly different from the other treatments. The results of oviposition clearly showed that *C. maculatus* offered 10% of honey or glucose performed better. Similar trend occurred in seed with eggs, though no significant difference exists among the treatments.

Seeds from insects fed with 10% of glucose or honey recorded the highest no of eggs (Table 2). However, different trend was observed in weight loss where highest weight loss was recorded in seeds obtained from insects fed with 5% of honey. The 0.84 g weight loss was significantly different from weight loss of 0.16 g recorded for insects fed with 15% of glucose. Though weight loss from other treatments were not significantly different at $p>0.05$ (Table 2).

Table 2: The number of eggs laid, number of seeds with egg and the weight loss at fourth generation.

Treatments	Oviposition	Seed with egg	Weight loss (g)
Glucose 5%	5.82^{b}	3.43^{a}	0.27^{ab}
Glucose 10%	11.18^{ab}	4.53^{a}	0.51^{ab}
Glucose 15%	8.33^{ab}	4.45^{a}	0.16^{b}
Glucose 20%	10.06^{ab}	4.53^{a}	0.47^{ab}
Honey 5%	13.27^{a}	4.49^{a}	0.84^{a}
Honey 10%	13.30^{a}	4.53^{a}	0.52^{ab}
Honey 15%	8.63^{ab}	4.45^{a}	0.29^{ab}
Honey 20%	7.76^{ab}	4.53^{a}	0.26^{ab}
Distilled water	8.42^{ab}	4.37^{a}	0.28^{ab}
Non-fed	9.07^{ab}	4.49^{a}	0.26^{ab}

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

3.3 Daily emergence in fifth generation adult's *C. maculatus* provided with honey and glucose

The results of daily emergence of *C. maculatus* were presented in Table 3. Observations revealed that highest number of adults of *C. maculatus* emerged within first three days of emergence. Highest number of emerged adults occurred with insects fed with 20% of glucose at day 1 and was significantly different ($p<0.05$) from that of the non-fed insects.

Similar trend was observed at day 2 except that highest emerged adults were recorded in insects fed with honey at 5% which showed no significant different from the other treatments at $p>0.05$. On the 3rd day, similar trend to day 2 was observed with least number of emerged adults recorded from insects fed with 15% of glucose. This was however not different significantly at $p>0.05$ from the other treatments. It was also indicated in the results that emergence of adults declined with the day of emergence with insects fed with 10% glucose and 5% honey having 2.69 and 3.13 number of emerged adults and were significantly different $p>0.05$ from the adults that emerged from the seeds infested with non-fed insects.

Table 3: Effects of feeding on daily emergence of fifth generation adults *C. maculatus*.

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Glucose 5%	3.05^{ab}	2.87^{a}	3.03^{a}	1.91^{a}	1.73^{a}	1.33^{a}	1.47^{bc}
Glucose 10%	3.90^{ab}	3.72^{a}	4.37^{a}	3.31^{a}	2.43^{a}	2.19^{a}	2.69^{ab}
Glucose 15%	1.66^{b}	2.67^{a}	2.27^{a}	1.79^{a}	1.58^{a}	1.69^{a}	1.55^{bc}
Glucose 20%	4.99^{a}	4.27^{a}	4.34^{a}	2.05^{a}	2.13^{a}	1.62^{a}	1.82^{b}
Honey 5%	4.34^{ab}	4.51^{a}	4.51^{a}	3.36^{a}	2.22^{a}	1.80^{a}	3.13^{a}
Honey 10%	4.38^{ab}	3.69^{a}	3.96^{a}	2.24^{a}	1.75^{a}	1.38^{a}	1.58^{bc}
Honey 15%	3.35^{ab}	3.39^{a}	4.25^{a}	2.48^{a}	1.71^{a}	1.55^{a}	1.38^{bc}
Honey 20%	3.67^{ab}	3.24^{a}	4.15^{a}	2.05^{a}	1.80^{a}	1.00^{a}	1.48^{bc}
Distilled water	2.64^{ab}	3.88^{a}	4.15^{a}	2.40^{a}	1.47^{a}	1.75^{a}	1.52^{bc}
Non-fed	1.77^{b}	2.53^{a}	2.54^{a}	2.17^{a}	2.36^{a}	1.71^{a}	1.14^{c}

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

3.4 Effects of larval competition on the development *C. maculatus*

Results from Table 4 showed that highest number of emerged adults was from seeds infested with insects fed with honey and loaded with (10-12 eggs) and was significantly different ($p<0.05$) from those fed with honey (1 egg), non-fed (1 egg) and non-fed (10-12 eggs). Highest number of eggs was laid by adults fed with honey and from seeds containing 10-12 eggs and was significantly different ($p<0.05$) from all other combinations of the non-fed. The observation also showed that higher number of adults emerged from seeds with higher number of eggs. The effects of larval competition were observed on the emerged adults at F_2. No significant differences exist except for the non-fed (1 egg) where least number of adults emerged. Other treatments were not statistically different $p<0.05$. It was also noted that where egg load was much, larval competition affects number of subsequent adults that emerged. More adults emerged from both non-fed (3-4 eggs) and honey (3-4 eggs) compared to where higher number of eggs was available on the seeds (Table 4).

Table 4: Effects of larval competition on the oviposition, adult emergence and weight of *C. maculatus*.

Treatments	Adult emergence (F_1)	Oviposition	Adult emergence(F_2)	Adult Weight(g)
Non-fed (1 egg)	2.20^{c}	4.33^{c}	1.72^{b}	0.02^{b}
Non-fed (3-4 eggs)	3.09^{bc}	11.94^{b}	5.89^{a}	0.09^{a}
Non-fed (6-8 eggs)	3.80^{ab}	12.10^{b}	5.72^{a}	0.10^{a}
Non-fed (10-12 eggs)	3.73^{b}	12.89^{b}	5.99^{a}	0.10^{a}
Honey (1 egg)	2.20^{c}	8.90^{bc}	4.57^{ab}	0.06^{ab}
Honey (3-4 eggs)	3.27^{bc}	13.95^{ab}	5.63^{a}	0.08^{a}
Honey (6-8 eggs)	4.27^{ab}	12.46^{b}	5.47^{a}	0.09^{a}
Honey (10-12 eggs)	5.01^{a}	20.60^{a}	5.42^{a}	0.09^{a}

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

4. Discussion

This investigation showed that the adults of *C. maculatus* that were fed with glucose and honey have shorter development period compared with the non-fed populations of *C. maculatus*. The non-fed population survived for a shorter period compared with the fed populations. This result agreed with the report that the adult are short lived and do not feed although they will drink if offered water or sucrose [19] and this lengthen adult lifespan [13]. Similarly, the result revealed that the highest number of eggs and seeds with eggs was obtained from the fed populations of *C. maculatus* when compared with the non-fed and the highest weight loss in cowpea seeds occurred with the infestation of populations provided with food. This result is in agreement with the report that when *C. maculatus* are fed with water or sucrose, fecundity can be increased by as much as 50% [12]. It also confirmed previous report that despite the beetle not requiring food, if offered sugar water, yeast or plain water, adults will eat. This eating seems to replenish spent resources and affects how many eggs the females will lay [14]. The results of investigation on larval competition showed that the highest number of emerged adults of F_1 generation was recorded from the seeds infested with populations fed with honey and contained 10-12 eggs. This shows that the higher the number of eggs, the higher the number of emerged adults. But in F_2 generation, it was noted that where egg load was much (insect fed with honey and seeds with 10-12 eggs) it affected the number of emerged adults negatively. The higher number of emerged adults was observed both in non-fed with (3-4 eggs) and insect fed with honey (3-4 eggs) compared to where higher number of eggs was available on the seeds. This supported the observation that host size [17], host species [18] and larval competition [15] can affect larval survival, development and fecundity of emerging adults [20]. Also, non-fed (1 egg) has the lowest number of emerged adults; eggs laid and weight adults both in F_1 and F_2 generations. There have been reports that even low levels of larval crowding can cause delayed development, smaller adult size and reduced fecundity [16, 13].

5. Conclusion and recommendation

The results from this study confirmed that *C. maculatus* will feed if offered food and this will affect the longevity or survival, developmental period, oviposition and adult emergence. Larval competition also affects the weight and number of emerged adults. Based on the findings of this study, it is thus recommended that; for the rearing of *C. maculatus* for experimental purpose 10% of honey should be used as the most effective sugar source. This concentration gave the best performance in the parameters observed.

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