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Research Article

Effect of Temperature and Humidity on the Biology and Morphometric Measurement of Groundnut Bruchid (*Caryedon serratus* Olivier) [Coleoptera: Bruchidae] in Groundnut Seed

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ABSTRACT

The experiment determined the effects of varying temperatures and relative humidity on the biology and morphometrics of *Caryedon serratus*. The temperatures were 30, 35, and 40°C and relative humidity differences were 60, 65, and 70%. The results show that eggs hatched in 3-4 days at 30°C and 60% RH, 4-5 days at 35°C and 65% RH, 6-7 days at 40°C and 70% RH respectively. Larval period ranges from 19-23 days at 30°C and 60% RH, 14-18 days at 35°C and 65% RH, 14-18 days at 40°C and 70% RH respectively. The morphometric measurements showed that the average length and breadth of eggs were 0.58 mm and 0.15 mm. The mean length and breadth of larval stages were 0.69, 1.27, 2.52, 3.58 mm and 0.35, 0.86, 1.35, and 2.10 mm respectively. The average length and breadth of the pupa were 4.60 mm and 3.00 mm. The mean length and breadth of adults were 4.10 mm and 3.40 mm. The life cycle of bruchid took 33-40, 14-18, and 16-20 days to complete at temperature degrees of 30, 35, 40°C and relative humidity ranges of 60, 65, and 70%. Therefore, this work has recommended that the standard optimum temperature and humidity for the best performance of *C. serratus* particularly on stored groundnut seeds ranges between 30-35°C and 60-65% RH. Farmers and all those involved in the storage of groundnut are admonished to be cautious of this period.

Keywords: Temperature, Humidity, Groundnut, Biology, Morphometric, Measurement, *Caryedon serratus*, Seed

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INTRODUCTION

The groundnut bruchid (*Caryedon serratus* Olivier) [Coleoptera: Bruchidae] is known to infest groundnut seeds, especially from the field and massively in the store (Oaya, 2020). This insect pest is more often than not found in groundnut-growing areas of the Tropical and Subtropical parts of the world particularly in West Africa (Beghnin and Sewadah, 2003; FAOSTAT 2017). *C. serratus* is also a major and economically important insect pest of tamarind, locust bean and shea butter (FAOSTAT, 2014). Groundnut bruchid is among the most cosmopolitan insect pests of groundnut seeds (*Arachis hypogea*) that cause economic damage to groundnut seeds in the store (Sharma *et al.,* 2017). The insect multiplies rapidly in storage due to its ability to have many generations within a short period. Groundnut seeds are significantly affected by the bruchid causing weight losses of up to 70 % (Mohammed *et al.,* 2020; Abdullah *et al.,* 2016). The larval and pupal stage of *C. serratus* which is holometabolic in nature is domicile inside the

groundnut grain or seed and thereafter eats up the endosperms. This scenario not only reduces the viability of the seeds for sprouting and sowing but also renders it unfit for consumption (Oaya *et al.,* 2012). Synthetic insecticide has been used to manage or control the bruchid in storage with positive and promising results and effects on the insect pest. However, these positive developments come with associated health hazards to man, the livestock and devastating effects on the environment (Alewu and Nosiri, 2011). The bruchid can effectively be controlled by analyzing the life cycle, temperature degrees, and moisture preferences for the insect oviposition and development of different life stages (Sundria and Kumar, 2004). This type of Laboratory evaluation has not been done previously and adequately especially in the study area and related kinds of literature was also very limited. Therefore, the present study was conducted on groundnut seed or grain under Laboratory experimental conditions to determine the biology and morphometric measurement of different developmental stages of the insect pest such as the egg, larva, pupa, and adult stages to recommend or suggest suitable control measures of the bruchid (*C. serratus*) in storage.

MATERIALS AND METHODS

The study was carried out in the laboratory of the Department of Crop Science (Crop Protection Division), Faculty of Agriculture, Adamawa State University, Mubi. Mubi is located in the Northern Guinea Savanna Agro-ecological Zone of Nigeria. It is situated between latitude 10°10' and 10° 30' North of the Equator and between longitude 13° 10' and 13° 30' East of Greenwich meridian and at an altitude of 696m above sea level. The annual mean rainfall of Mubi is 965mm, and a minimum temperature of 12.48^{+-0}C during the harmatan period and 38.27^{o+-}C maximum in June (Adebayo *et al.,* 2020). The work commenced from March to June 2022 under the effect of three different temperature degrees (30, 35, and 40˚C) and relative humidity (60, 65, and 70% RH) respectively. Groundnut seed commonly grown in the study area was obtained from the Mubi Main Market and selected for the insect culture and sample preparation study as reported by Abdullah *et al.* (2016). The insect culture was prepared and grown in the Laboratory at a temperature of 32 ± 2˚C, 12: 12 L: D and 70% RH kept in plastic jar of 1kg.

Maintenance of Experimental Insects in the Laboratory

The groundnut bruchid (*C. serratus*) was the experimental insect used. Cleaned groundnut seeds were sterilized by heating at 70˚C for an hour which was subsequently placed in a glass jar to reabsorb moisture. 300g of groundnut seeds were transferred to a separately sterilized culture jar. A small population of the bruchid with the same sexual ratio was released from the previous culture under Laboratory conditions on groundnut seeds in the growth chamber at 32 ± 2˚C, 12:12 L: D and with 70 ± 5.0% RH following the method of Abdullah *et al.* (2016). The growth chambers were sealed with muslin cloth and the bruchids were allowed for mating and oviposition. After a week, the parental insects were transferred to another jar and the infested groundnut seed containing the eggs was also transferred to another fresh groundnut seed in the breeding jars that were covered with muslin cloth sealed with a rubber band to allow for aeration and also prevent the bruchids from escaping.

Test Insects and Sample Preparation

The groundnut bruchids (*C. serratus*) were cultured on groundnut seeds in a petri dish of 9 cm in size; and contained 100 seeds of groundnut. The equal sex ratio of freshly emerged adults (1-2 days old) were reared into a petri dish for egg laying and allowed for 24 hours to lay eggs on groundnut seeds. The samples were placed in the incubator at three varying temperatures (30, 35, and 40˚C) and ranges of relative humidity (60, 65, and 70%) separately. A pin was used as leverage at the areas where the eggs were laid and a pill cutter was used to make an initial cut adjacent to the groundnut seed. The initial incision creating a two-sided cross-section into the cowpea seed was done by using a scalpel. The dissected portion was examined under the plate Microscope (Nikon SMZ-2B/japan) to see and find the larvae. The remaining seeds were deposited for observing the other developmental stages of the insect. Then the petri dish containing groundnut seeds was closed and kept in an incubator as the earlier one for testing and observing the next stages of development. The observation was conducted in 2 day intervals to confirm the different stages of development. The observation was recorded daily on development, and carefully observed for the size of different stages (egg, larva, pupa and adult). A digital caliper was used for the measurement of breadth and

length of the different developmental stages. The experiment was conducted using standard mean deviation with four replications. The data was analyzed statistically.

Development-Hatching

The eggs were tested from the day the infested groundnut seeds were cultured in petri dishes and exposing same to the incubator for hatching. The time taken by the eggs to hatch was calculated and recorded.

Larval and Pupal Development

The hatching period of eggs they were calculated and recorded thereby allowing for subsequent development of the eggs. The larva of bruchids bores its way out directly from the developing egg into the seed groundnut and develops inside the seed, since the larva moults within the seed. The interval between the various larval instar or stages was recorded and calculated separately. At the end of the larval period, the larva drills a minute circular hole near the seed coat until just a thin layer of the seed coat is left intact and at this time the larva metamorphosized. Incision creating a two sided cross section in to the seed was carried out by using scalpel to observe the pupal stage.

Adult Emergence

The adult emergence was indicated as pupation stage using scalpel for the incision creating a two sided cross section in to the seed and observing the adult stage of the bruchid. The emergence of adult bruchid was determined by emergence hole on the seed which was taken at the final stage of the growth phase.

RESULTS AND DISCUSSION

The biological parameters and morphometric details of the developmental stages of *C. serratus* fed on groundnut seed under the effect of different temperature degrees (30, 35, and 40˚C) and relative humidity (60, 65, and 70%) are presented in Table 1. The different stages of development from egg to adult of *C. serratus* from egg to adult are shown in plate 2. From the laboratory experimental data, the life cycle of *C. serratus* was studied.

Table 1: Biological and morphological measurement of *C. serratus* developmental stages

Stages of Life	**Duration (Days) under the effect of Temperature degrees and Humidity Ranges**			**Length (mean±SE) (mm)**	**Breadth (mean±SE) (mm)**
	30˚C/60%RH	35˚C/65%RH	40˚C/65%RH		
Gg	3-4	4-5	6-7	0.58 ± 0.01	0.15±0.01
1st Larval Instar	6-7	6-6	5-6	0.69±0.03	0.35±0.02
2nd Larval Instar	4-5	3-4	4-5	1.27±0.04	0.86±0.04
3th Larval Instar	4-5	3-4	3-4	2.52±0.05	1.35±0,05
4th Larval Instar	5-6	3-4	4-5	3.58±0.06	2.10±0.08
Pupal Stage	6-7	5-6	4-5	4.60±0.07	3.00±0.09
Adult Stage	5-6	3-4	4-5	4.10±0.09	3.40±0.07
Total life spam (days)	33-40	26-33	28-35		

Egg

The egg was small oval or spindle shaped, and firmly glued to the groundnut seeds and many eggs could be seen on a single seed. The freshly laid eggs were clear, translucent smooth and shining, which later become white yellow. The duration of egg at different temperature degrees (30, 35 and 40 ˚C) and humidity of 60, 65 and 70% RH respectively was ranged from 3-4, 4-5 and 6-7 days respectively. The average length of egg was 0.58± 0.01 mm and breadth was 0.15± 0.01 mm. Abdullah *et al.* (2016) reported that egg was 0.54 mm in length. The size of egg was reported by Bhubaneshwari *et al.* (2014) that it was 0.47 mm in length and 0.12 mm in breadth. The differences here could be attributed to characteristic genetic differences of the strains themselves and age of the bruchids during oviposition.

First instar larva

1st instar larva was formed inside the eggs out of groundnut seed coat and after the formation of pigmented larval head capsule they bored from the bases of the egg by biting through the seed coat and entered into the groundnut seed endosperm without

moving outside the protection of the egg. The remaining egg shell become opaque white or mottled as it was filled with frass from the larva. The larva was curve, white in color and had a small head. The larval period ranged from 6-7, 5-6 and 5-6 days at 30, 35 and 40 ˚C and humidity of 60, 65 and 70% RH respectively. This agrees with the finding by Abdullah *et al.* (2016) and Raina (2007) who both reported that, the larvae hatched out of egg and burrowed directly into the groundnut about 4-8 days after oviposition. The 1st instar larva measured 0.69± 0.03 mm in length and 0.35± 0.02mm in breadth. Bhubaneshwari *et al.* (2014) reported that the average length of larva was 0.60 mm and breadth was 0.22 mm.

Second instar larva

The 2nd instar larva developed from first instar larva, they burrowed and fed on the groundnut endosperm. The duration of larval period at 30, 35 and 40˚C and humidity of 60, 65 and 70% RH respectively ranged from 4-5, 3-4 and 4-5 days respectively. The length of larva was ranged from 1.27 to 1.35 mm with an average 0.86± 0.03 mm and the breadth was 0.10 to 0.12 mm with an average 0.9± 0.04 mm respectively.

Third instar larva

The duration of the larva at mentioned three incubated degree of temperature was similar to the 2nd instar larva except for temperature degree of 40˚C and humidity of 70% RH which was 3-4 days. The average body length of the 3rd instar larva was 2.52± 0.04 mm and the breadth was 1.35± 0.04 mm. This work is in consonant with Abdullah *et al.* (2016) who reported that, the duration of 3rd larval period at 25, 30 and 35˚C and constant humidity of 65% RH respectively ranged from 3-4, 2-3 and 2-3 days respectively. The 3rd instar larvae were most active and fed on the entire endosperm of groundnut seeds.

Fourth instar larva

The duration of 4th larval period at 30, 35 and 40˚C and humidity of 60, 65 and 70% RH respectively ranged from 5-6, 3-4 and 4-5 days respectively which were similar to 3rd instar larval stage except for the temperature degree of 30˚C and humidity of 60% RH. The length of the 4th instar larva was in average of 3.58± 0.05 mm and the breadth was in average of 2.10± 0.05 mm respectively. The present study show that the total larva period range from 19-23 days in a 30˚C which was higher than at both temperature degrees 35˚C and 40˚C (14-16; 15-18) days respectively. The larva was white and yellow in colour and somewhat C-shaped with small and pigmented head. This instar larva seemed to become larger and fed on the entire groundnut endosperm voraciously and burrowed into a position just underneath the seed coat prior to pupation.

Pupa

The pupation stage developed from 4th instar larva. During this stage adult structures developed; the rudiments of the wings appeared at first, then appendages such as legs, antenna and proboscis developed freely followed by eyes, mouth part, forewing, hind wing and legs with cuticular hair developed but inter-segmental region of the abdomen and remained colourless. Forewing was looked as light green in colour. At the end of this stage forewings changed into dark brown with black patches. The pupal period ranged from 6-7, 5-6 and 4-5 days at 30, 35 and 40˚C respectively while the length and breadth of pupa was measured 4.60± 0.06 mm and 3.00± 0.06 mm respectively both at 30, 35 and 40˚C and humidity of 60, 65 and 70% RH respectively.

Adult

The adult of the bruchid results from pupation remained in the groundnut seed for several days before pushing or biting out the window with its mandibles. The adult emerged from the groundnut seed by chewing and removing a circular piece of the seed coat to form a round hole. Adult were small in size than pupa with typical rounded appearance and reddish brown in colour. The head of the bruchid was hypognathous in type with biting type of mouthparts, which are best used during the larval stages. Head of adult was provided with a pair of segmented antennae, which were serrate in type comparatively longer in males than in females. The hind wings ware membranous and longer than forewings and protected by the elytra. The adult male was smaller in size and possessed a more round shape than the female whereas female adult bruchids had dark stripes on each side of dorsal abdomen. The adult periods of bruchid inside groundnut seed up to emergence out of the seed were 5-6, 3-4 and 4-5 days at temperature degrees of 30, 35 and 40˚C and humidity of 60, 65, and 70% RH respectively.

The lifespan of an adult after emergence from the seed was 7-10 days. This agrees with Raina (2007) who reported that adult bruchids have a mean life span of 7 days in Laboratory conditions, but some have been able to live up to 14 days. The average

male and female length and breadth were 4.10± 0.07 and 3.40± 0.09 mm respectively. This is in accordance to the findings by Beck and Blumer (2007) who stated that, the average body length of adult bruchid was 4-6 mm and the average length of male was 3.21± 0.06 mm and breadth was 1.91± 0.05 mm whereas the average length and breadth of female beetle was 3.70± 0.1 mm and 2.17± 0.05 mm respectively. The results of the present study shows that, the developmental period from the egg to when the adult emerged from the seed was longer at temperature degrees of 30˚C and relative humidity of 60%RH (33-40) followed by 40˚C and 70%RM (28-35 days) and the shorter was period was observed at 35˚C and 65%RH (26-33 days). The optimum temperature for rapid growth of *C. serratus* lies between 30 and 35^{o}C at a relative high humidity rang of 60-65%RH. Bhubaneshwari *et al.* (2014) reported that, the developmental period of the egg to adult was 45-48 days. It took one and half month to complete its life cycle, which could take longer time under unfavorable conditions depending on the different strain of bruchids, food supply, temperature and humidity.

CONCLUSION

The results of the study revealed that, the standard optimum temperature for *C. serratus* fitness lie between the range of 30-35^{o}C and a relatively humidity range of 60-65 percent. This standard is valid only to the bruchids reared on a standard feed. The period of life cycle stage of the bruchids could be increased at temperature lesser than 30 and higher than 35^{o}C. Similarly, the life cycle could also be increased at relative humidity lesser than 60 and greater than 65 percent. The pupa is incidentally not affected by high temperature for its period of pupation but increase in temperature and humidity greater than 30^{o}C and 65% respectively may reduce the pupal period.

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