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THE EFFECT OF SEASONAL VARIATION ON REPRODUCTION AND SURVIVAL OF *EPHESTIA CAUTELLA* WALKER (LEPIDOPTERA: PYRALIDAE) IN COCOA BEANS

J.O. AKINNEYE
Department of Biology, The Federal University of Technology, P.M.B. 704, Akure, Nigeria.
Corresponding author's email: josephakinneye@yahoo.co.uk

ABSTRACT

The effect of seasonal variation on the development of *Ephestia cautella* Walker (Lepidoptera: Pyralidae) was investigated in the laboratory at ambient temperature of 28±2^{o}C and 75±5% relative humidity during wet set season and ambient temperature of 34±2^{0}C and 65±5% relative humidity during dry season. Fecundity, egg viability, number of generations and longevity of *E. cautella* were determined in both the dry and wet season of the year. Wet seasons describe April-September 2006 and April to September 2008 while Dry seasons describe October 2005-March 2006 and October 2007-March 2008. The *E. cautella* females laid more eggs in the wet seasons than in the dry seasons as they recorded 137.30 and 170.16 eggs in the two wet seasons respectively while they recorded 73.41 and 100.50 eggs in the two dry seasons respectively. The wet seasons recorded the longest egg-laying duration of 1 – 9 days and 1 – 15 days respectively while the egg-laying duration for the two dry seasons was 1 – 6 days. The wet seasons recorded the highest egg viability of 85 and 81% respectively while the dry seasons recorded the lowest egg viability. The highest developmental period of 45.60 and 45.50days was recorded for the two wet seasons respectively. The number of generation obtained in wet and dry seasons was 4 and 5 respectively. Isolated virgin adult male and female lived longer in wet season (25.0 and 12.0 days) than those isolated during dry seasons (12.0 and 6.0 days). Male in group of 20males in one vial lived an average of 7 days in dry season and an average of 15 days in wet season. Unmated male and female live longer than their mated counterpart. Moreover, it was noted that all the live stages of *E. cautella* was effervescent during wet season while dry season could enfeeble them. Hence the development of the insect was altered by seasons.

Keyword: Season, fecundity, generation, longevity, *Ephestia cautella.*

INTRODUCTION

Ephestia cautella is a cosmopolitan pest infesting a wide variety of hosts, such as cereals, dried fruits, cocoa beans, chocolates, candies and confectionery (Burges and Haskin, 1965, Levinson and Levinson, 1978). It also infest dates, nuts, groundnut, banana chips (Hill, 1993). *E. cautella* caused 60% weight loss of wheat and no seed germinate after 7 days post-infestation periods (Madrid and Sinha, 1982). Larvae of this insect cause direct damage to store product by making the product unattractive to consumers and as well contaminate food and produce silken thread that is webbing the products together (Wood et *al*., 1987). *E. cautella* is a major pest of dried cocoa beans in storage (Akinneye *et al*., 2006). Dried cocoa bean is the principal raw material for chocolate, cocoa powder which served as a major host for *E. cautella* (Murpy *et al*., 2003). The nutrition and health benefits of cocoa beans include the provision of adequate proteins and vitamins and rich source of antioxidant such as phenol. Cocoa product when added to food are said to inhibit plasma lipid oxidation, lowered cholesterol, reduced high density lipoprotein, enhance blood flow, facilitate nitric oxide synthesis and inhibited platelet activation (Murpy *et al.*, 2003). As a result of the numerous advantages derived from this produce, protecting the product against the agents of deterioration becomes imperative. The major agents of deterioration of cocoa beans in Nigeria are the insect and vertebrate pests. The major insect pest of stored cocoa beans in Nigeria include *E. cautella* , *Corcyra cephalonica* (Stainton) and *Lasioderma serricorne* (Fabricius) (Owolabi,1972). Mejule (1983) reported that the effect of insect infestation on quality of cocoa include the boring of holes, and the consumption of food content and forming frass which renders the cocoa beans unacceptable to man. Since the pest is a major nuisance infesting cocoa beans in storage, studying the effect of season on their development becomes imperatives since production of dried cocoa beans runs through both wet and dry seasons in Nigeria and it will pave way for a better way of controlling the insect. This research sought to determine the effect of seasonal variation on development and survival of *E. cautella* in cocoa beans.

MATERIALS AND METHODS

Insect Culture

Naturally infested cocoa beans were collected from Coop Cocoa Nigeria Limited, Akure, Ondo State and placed in a two litres plastic container containing 300g of uninfested cocoa powder obtained from Ile-Oluji Cocoa Product Company, Ondo State to start *E.cautella* culture. The culture was maintained by continually replacing consumed powder and sieving out frass, fragment and larvae of the moth. The plastic containers were covered with muslin cloth, fastened with rubber bands, and placed inside wire mesh cage of dimension 75cm×50cm and 60cm (L×W×H) with its four stands dipped in water-kerosene mixture contained

in the plastic container to prevent entry of predatory ants into the cages. The whole set-up was left inside the storage research laboratory of the Department of Biology, Federal University of Technology, Akure, Ondo State, Nigeria. The culture was maintained at laboratory temperature of 28±2^{0}C and 75±5% relative humidity in wet season and laboratory temperature of 34±2^{0}C and 65±5% relative humidity in dry season. The temperature variation during insect culture was due to difference in season.

Determination of Fecundity of Ephestia cautella in Dry and Wet Seasons

Fecundity of *E. cautella* was studied on standard diet (cocoa powder) in dry and wet season for two seasons each. Wet seasons describe April-September 2006 and April-September 2008. Dry season describes October 2005-March 2006 and October 2007-March 2008. Twenty replicates were prepared in dry and wet season. Each replication consisted of 20 newly laid eggs of *E. cautella* in 15g of cocoa powder per plastic Petri-dish. Larvae at 4th instar were sexed just before pupation by examination of dorsal integument. Males were easily discernible by the dark patch formed by the testis, the patch being visible through the integument in the medium plane of the mid-dorsal abdomen (Jourbert, 1967). The larvae were transferred into different plastic container according to sex, and were allowed to pupate and observed daily for adult emergence. Newly- emerged unmated adults were immediately paired and the numbers of eggs laid per female per day were recorded daily until the female died. The total number of eggs laid in their life span was recorded and the average determined.

Determination of Egg Viability of E. cautella in Dry and Wet Season

Twenty newly laid eggs of about 24 hours old were placed in plastic Petri-dishes containing fine cocoa powder and replicated three times. Newly-emerged larvae usually moved around in search of food and in doing so they feed on other unhatched eggs, therefore, finely sifted cocoa powder was introduced into the Petri-dishes to provide source of food for the newly hatched larvae in order to avoid unhatched eggs being eaten. The contents of the Petri-dishes were examined daily under a stereomicroscope (Olympus N.22103) for hatchability and newly emerged larvae were counted and taken out with a camel-hair brush into another culture for adult emergence. This procedure was carried out for both dry and wet season. The number of hatched eggs was observed every day and percentage viability was calculated using the formula below

$$\%Viability = \frac{number\ of\ larvae\ emerged}{total\ number\ of\ eggs\ laid} x \frac{100}{1}\%$$

Determination of the Number of Generation per Season (Dry and Wet Season)

Immediately after adult emergence, male and female in ratio 5:5 were paired and placed on cocoa powder diet to enable fertile eggs to be laid and the setups were kept inside insect breeding cage pending adult emergence. After the emergence of F_1 generation, the same procedure was repeated till the end of each season and the number of generations per season was observed.

Determination of Longevity of Virgin Adult Male and Female E.cautella

The virgin male and female *E. cautella* were individually isolated inside a plastic container of dimension 12.50 cm diameter and 13.50 cm deep and were kept inside insect cage. To ensure virginity, male and female pupae were placed in different plastic containers and moth that emerged was used for the experiment. Each sex was replicated twenty times. The plastic containers were taken out of the insect breeding cage daily to count the number of dead adult moths and this processes continued till all the insects in the plastic containers were dead and their longevity in days was observed and the average was determined.

Determination of Longevity of Adult in Group

Twenty newly emerged adults female and male of 0 – 24h old were separately introduced into plastic container of dimension 12.50cm diameter and 13.50cm deep and were replicated three times. The plastic containers were taken out of the insect breeding cage daily to count the number of dead moth and this processes continued till all the moth in the plastic containers were dead. The longevity of the insect in days was observed and the average was determined.

Longevity of Mated Male and Female E. cautella

Twenty males and females of the same age (0-24h old) were kept together in one plastic container (12.50 cm diameter and 13.50 cm deep) and were allowed to mate. This was replicated three times. The same procedure was repeated for one male and one female *E. cautalla* (0 – 24h old). The plastic containers were opened daily to count the number of dead moth and longevity in days was calculated and average determined. This continued until all the insects were dead.

Data Analysis

Data were subjected to analysis of variance and where significant differences existed means were compared at 0.05 significant levels with Duncan's New Multiple Range Test using SPSS version 17.

RESULTS

Fecundity, Egg-laying Duration, Egg Viability, Developmental Period and Number of Generations per Season

The fecundity, egg-laying duration, egg viability, developmental period and number of generation per year are presented in Table 1. Generally, mean number of eggs laid in the wet seasons were significantly higher than in the dry season as average egg of 137.30 and 170.16 were laid during the two wet seasons respectively while only 73.41

and 100.50 eggs were laid during the two dry seasons respectively.

The wet seasons recorded the longest egg-laying duration of 1 – 9 days in April 2006 and 1–15 days in April 2008 while 1-6 day egg laying duration was observed in both dry seasons. The wet seasons recorded the higher egg viability of 85% and 81 % in April 2006 and April 2008 respectively (Table 1). The dry season of October 2005 to March 2006 recorded the lowest egg viability and the lowest developmental period (32.50± 0.5 days) while dry season of October 2007 to March 2008 recorded 35.50±6.0 days (ranged 34 – 40 days). The wet seasons (April – September 2006 and 2008) recorded the highest developmental periods (45.50±0.5days and 45.60±7.42 respectively). The numbers of generations obtained in wet and dry seasons were 4 and 5 respectively.

Seasonal Variation in Longevity of E. cuatella in Dry Season (October 2005 -March 2006) and Wet Season (April – September 2006)

The seasonal variation in longevity of *E. cautella* in dry season (October 2005 – March 2006) and wet season (April – September 2006) is presented in Table 2. Isolated virgin adult male (25.0 days) and female (12.0 days) lived longer in wet season (2006) than the individual isolated virgin adult male (12.0days) and female (6.0 days) in dry season. Individual isolated virgin adult males lived longer than group of mated pairs or adults in group of 20 males in one vial in wet and dry seasons. Males in group of 20 in one vial lived an average of 7 days in dry season and an average of 15 days in wet season (Table 2).

Table 1: **Fecundity, egg-laying duration, egg-viability, developmental period and number of generations per session in *Ephestia cautella* Mean±SE**

Parameter	Number of egg laid /season (Mean±SE)	Egg laying duration (range in days)	% Egg-Hatchability	Development al periods (days) (Mean±SE)	Number of generations per season
Dry season Oct 2005 – March 2006	$73.41^{a} \pm 4.8$	1 – 6	60.00	$32.50^{a} \pm 0.5$ (30 -38)	5
Wet season April 2006 – Sept 2006	$137.30^{c} \pm 9.01$	1 – 9	85.00	$45.50^{b} \pm 0.5$ (40 – 54)	4
Dry season Oct. 2007 – March 2008	$100.50^{b} \pm 10.11$	1 – 6	65.00	$35.50^{a} \pm 6.0$ (34 – 40)	5
Wet season April 2008 – Sept. 2008	$170.16^{d} \pm 10.42$	1 – 15	81.00	$45.60^{b} \pm 7.42$ (48-54)	4

Mean followed by the same letter (s) are not significantly different (p >0.05) by New Duncan's Multiple Range Test

Table 2: **Seasonal variation in longevity (Mean±SE) of *E. cautella* in dry season of Oct - March 2005/2006 and wet season of April – Sept, 2006.**

Sex	Parameter	Longevity in Dry season Oct 2005 – March 2006 (Days)	Longevity in Wet season April 2005 –Sept 2006 (Days)
Male	Virgin male adult	12.00^{c}±0.58	25.00^{f}±0.58
	Group of 20 male adult	7.00^{a}±0.00	15.00^{d}±0.58
	Group of 20 mated male and 20 mated female	7.00^{a}± 0.00	14.00^{d}±0.58
	One male and one female paired	9.00^{b}± 0.58	18.00^{e} ± 0.58
Female	Virgin female adult	6.00^{a}±0.00	12.00^{c}±0.58
	Group of 20 female	6.00^{a}±0.00	10.00^{ab}±0.58
	Group of 20 mated female and 20 mated male	6.00^{a}±0.00	9.00^{a}±0.58
	One female and one male	6.00^{a}±0.00	11.00^{bc}±0.58

Mean followed by the same letter (s) are not significantly different (p >0.05) by New Duncan's Multiple Range Test

Females in group of 20 per vials lived an average of 6 days in dry season and an average of 10 days in wet season. Mated adult *E. cautella* in group of 20 males and females in one vial recorded an average of 7 days and 14 days lifespan in dry and wet seasons respectively while group of 20 mated females and males in one vial have an average lifespan of 6 days and 9 days in dry and wet seasons respectively. One male paired with one female have an average lifespan of 9 days and 18 days in dry and wet season respectively. One female paired with one male recorded 6 days and 11 days lifespan in dry and wet season respectively. In the foregoing, the *E. cautella* bred in wet season lived longer than the one bred in the dry season.

Seasonal Variation in Longevity of E. cautella in Dry Season (October 2007 –March 2008) and Wet Season (April – September 2008)

The seasonal variation in longevity of *E. cautella* in dry season (October 2007 – March 2008) and wet season (April – September 2008) is presented in Table 3. Isolated virgin adult males and females in wet season (2008) lived longer (17.67 and 12.67 days) than the individual isolated virgin adult males

and females (12.33 and 6.33 days) in dry season respectively. Group of 20 males and females in one vial lived an average of 15.00 days and 7.67 days in wet season and an average lifespan of 10.33 days and 4.67 days respectively in dry season lived (October 2007 -March 2008). Group of 20 mated males and females in one vial recorded an average lifespan of 12.67 days and 7.67 days in wet and dry seasons respectively. While group of 20 mated females and males lived and average of 4.67 days and 5.0 days in wet and dry seasons respectively (Table 3). One male and one female in one vial recorded an average lifespan of 15.67 days and

12.60 days in wet and dry season while one male and one female paired recorded an average lifespan of 12.60 and 5.0 days respectively in dry season and 15.67 and 11.67days in wet season respectively (Table 3). Generally, wet season supports adult longevity more than the dry season and isolated male and female lived longer than male and female in groups.

Table3: **Seasonal variation in longevity (Mean±SE) of *E. cautella* in dry season Oct - March 2007/2008 and wet season April – Sept. 2008.**

Sex	**Parameter**	**Longevity Dry season Oct 2007 – Mar 2008**	**Longevity Wet season Apr 2008 –Sept 2008**
Male	Virgin male adult kept	12.33^{e}±0.33	17.67^{f}±0.33
	Group of 20 male adult	10.33^{d}±0.33	15.00^{e}±0.58
	Group of 20 mated male and 20 mated female	7.67^{c}± 0.33	12.67^{d}±0.33
	One male and one female paired	12.60^{e}± 0.33	15.67^{e} ± 0.89
Female	Virgin female adult	6.33^{b}±0.33	12.67^{d}±0.33

Group of 20 female	$4.67^{a}\pm0.33$	$7.67^{b}\pm0.33$
Group of 20 mated female and 20 mated male	$5.00^{a}\pm0.58$	$4.67^{a}\pm0.33$
One female and one male	$5.67^{ab}\pm0.33$	$11.67^{c}\pm033$

Mean followed by the same letter (s) are not significantly different ($p > 0.05$) by New Duncan's Multiple Range Test

DISCUSSION

Fecundity, Egg-Laying Duration, Egg-Viability, Developmental Period and Number of Generations per Season

Ephestia cautella laid more in wet season at a temperature of 28±2°C and mean humidity of 85±5% but had low eggs count in dry season eggs count in dry season at a mean temperature of 34±2°C and mean relative humidity of 65±5%. The high egg count in the wet season could be due to low temperature and high relative humidity in the environment and low egg count may be attributed to evapotranspiration of water from the insect body since water is needed for ovarian development (Ashamo, 2000). This observation could be due to higher rate of dehydration in the dry season by reducing the water available in the insect body resulting to reduction in the number of egg laid. Burges and Haskin (1964) also observed that high temperature of 34°C resulted in male impotence which lowers the egg production and reduced egg viability of the female *E. cautella*. Higher percentage egg viability was recorded for *E. cautella* bred in wet season and this is above the minimum egg viability (75%) proposed for insect (Singh 1983). The lowest percentage egg-viability was obtained in *E. cautella* bred in dry season at a mean temperature of 34±2°C and mean relative humidity of 65±5% and this is below the minimum egg viability proposed by Singh (1983). This finding was similar to the result obtained by Ashamo (2000) that high temperature was a major cause of reduction in egg viability in *Euzopherodes vapidella* Mann (Lepidoptera: Pyralidae) and eggs are viable at low temperature. Low temperature might have contributed immensely to higher egg viability in wet season as opposed to low egg viability in dry season. The higher percentage egg viability obtained in the wet season could be attributed to moderate temperature and relative humidity obtained during the wet season. Arbogast and Chini (2005) reported that highest population of *Ephestia cautella* was recorded at low temperature. Since insect egg have pores that allowed oxygen to pass into the egg content and through this pores water evapotranspiration from the egg into the external environment; this might have reduced the viability of the egg during the dry season. Low temperature seems to have been responsible for lesser generations in wet season which resulted in

extended lifecycle duration. The insect go into quiescence as a result of high relative humidity (85±5%) and low temperature (Akinneye, 2011).

Seasonal Variation in Longevity of E. cautella in Dry Season and Wet Season.

The male *E. cautella* had the longest lifespan in all male groups and in mixed – sex groups in both season; female lifespan was extremely lower in mixed –sex group and in all female group in the dry season while the lifespan of female in all female groups and mixed sex group were longer in the wet season than in the dry season .The persistence of this pattern suggests a seasonal regulatory

mechanism with the onset of high temperature (dry season) as a major cause of population collapse (Arbogast and Chini., 2005). This suggests that high rate of dehydration from their body in the dry season might be responsible for energy reduction thereby resulting to death. The result obtained in this study was in contrast to the finding of (Spratt, 1980) that males of *Cryptolestes ferrugineus* (Stephens) (Coleoptera: Cucujidae) have the shortest lifespan in mixed-sex groups and in all male groups. Spratt (1980) suggested that in the presence of a number of females, other males are strongly stimulated to compete for sexual partners and may cause injury to themselves or to other adult beetles during copulation attempts thereby reducing their longevity. Population density and congestion affect group of mated pairs since one male with one female lived longer than 20 males paired with 20 females in one vial in the two seasons. This observation agreed with the findings of Spratt (1980) that aggressive male sexual behaviour has been identified as an important factor in reducing the lifespan of *Tribolium castaneum* (Herbst) (Coleoptera:Tenebrionidae) and *Tribolium confusum* (J.du Val.) (Coleoptera:Tenebrionidae) adults kept in groups or in crowd. Females in groups of 20 had reduced lifespan than isolated individual females in both seasons. This result corroborates with the result obtained by Rivary and Meisner (1965) that isolated female lived longer than female in groups or crowd. Males in group of 20 in one vial had short lifespan and this is

consistent with the report of Taylor and Sokoloff (1971) that males have been observed attempting to mate with other males, dead beetles, or small objects that resemble other beetles, leading to expenditure of energy when attempting to copulate with other males, thereby resulting to death of the males in the group. Prevailing temperature and atmospheric relative humidity have serious effects on the lifespan of *E. cautella* during the prevailing seasons, this findings is in agreement with the report of Powell (1931) that life is shortened by high temperature and low relative humidity in *Lasioderma serricorne* (Fabricius) (Coleoptera:Anobiidae). Ashamo (2000) revealed that insects reared at 20^{o}C lived longer than those reared at higher temperature. Short lifespan was recorded for *E. cautella* paired while long lifespan was recorded for isolated virgin adult *E. cautella.*

This result was similar to the report of Ragland and Sohal (1973) who observed that survival period of mated adults are consistently shorter than those of virgin adults. This is to be expected because the extension of adult life by the prevention of mating is a common phenomenon among insects with short-live span and non-feeding adults. Short lifespans were recorded in individually isolated virgin males and females, male and female in groups, mixed-sex in groups and male and female with one partner in dry season while long lifespans were recorded for individually isolated males and females, male and female in group, mixed-sexes in groups and males and females with one partner in one vial in the wet season. The behaviour of these insects may be different when not in confinement. The result obtained in this study was similar to the findings of Ashamo (2000) that low temperature and high relative humidity enhanced the lifespan of *Euzopherodes vapidella* (Mann) (Lepidoptera:Pyralidae). The activity of these insect can be modulated by season because temperature, relative humidity, available space within the culture media (confinement) and mating contribute to the rearing of *E. cautella* in laboratory.

Conclusion

The biology of this insect is favoured by wet season which include high fecundity, long oviposition duration, high egg viability and long lifespan as opposed to dry season. Therefore, large population of this insect can be produced in wet season than in dry season. Wet season appeared to be more favourable for the survival of the insect and the biology of this insect can be regulated by season.

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