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The effects of artificial diets on the oviposition and development of *Acraea acerata* Hew - A Lepidopterous pest of sweet potato (*Ipomoea batatas* L. Lam.).

O. K. Ogbalu [1]

Abstract
Studies were undertaken to investigate the effects of different artificial diets of Dry Baker's Yeast (DBY) + Sugar + Water; 10% Sugar solution and 10% Honey solution) on the oviposition and development of Acraea acerata on sweet potato. Females fed on DBY + Sugar + H_2O diet laid significantly higher number of eggs than those exposed to the other two diets. Development was also faster for the larvae which parental stocks were fed on the DBY + Sugar + H_2O diet ($P< 0.05$, DMRT). Data on consumption, digestion and utilization indices were significantly higher for larvae that the parents were fed on DBY + Sugar + H_2O.
Feeding of larvae on follage affected yield depending on the number of larvae and larval age. The feeding effects of younger larvae induced lateral outgrowths and branchings.

1 Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam) is an important root crop in tropical Africa that accounts for 4.4% of world production (OKIGBO, 1986). In Nigeria sweet potato production is becoming popular replacing yams in the North and supplementing yam consumption in the eastern states. The importance of sweet potato has increasingly been tremendous within the last two decades because of the global food crisis and the realization if its Potential as food, animals fodder and industrial raw materials (NUMFOR and LYONGA, 1986). In Nigeria the tender vines, leaves and tubers of sweet potato are enjoyed as stews, soup and porridges. The main constraint that affects potato production and its commercialization is the array of insect pest complex that attack the plants. Notable among them is *Acraea acerata* which ANIOKE *et al.* (1995) studied its biology on potato. In their study rearing of adults of *A. acerala* was with 10% sugar solution. This pest has become and risen to a primary pest in the Niger especially at and wet seasons.

Eggs of this pest were collected from potato plots as well as their larvae. Damage symptoms were also observed on the foliage. Since it is of primary importance to know the number of larval instars it was decided to determine the effects of diets on the

1 Department of Biological Sciences, Rivers State University of Science And Technology, Port Harcourt, Nigeria.

larval parental stock in relation to oviposition and also on the feeding performance of the larvae. The larvae of *A. acerata* being the destructive stage of the pest will be evaluated for their damage on the foliage which happens to be the centre for photosynthesis of the crop, fodder for livestock, and a source of vitamins for many families in the developing world.

2 Materials and Methods

2.1 Effects of diets on oviposition

Adult insects of *A. acerata* (males and females) were collected from potato field in the department of Biological Sciences, Rivers State University of Science and Technology, Port Harcourt, with the aid of a sweep net and taken to the laboratory for oviposition studies. In the laboratory the insects were paired (1:1) and kept in gauzed Kliner jars (n=30). Small glass vials (n=30) each containing 10ml of water and potato leaf were introduced in the Kliner jar. Each pair of A. acerata adults was fed with 10% sugar solution (ANIOKE *et al.* 1995), 10% Honey solution and a diet mixture of dry bakers yeast, sugar and water (DBY + Sugar + H_2O) in the ratio of 1:1:5 respectively. Each of these three diets which was absorbed in cotton wools was constantly available in each of the jars. Each diet was resupplied every 24 hours. Each diet was offered to each pair of insects in 10 cages concurrently and replicated 3 times so that altogether n=30 insects for each diet. Potato leaves were observed in order to record pre-oviposition and incubation periods. Observations were also made on the developmental changes of the larvae.

2.2 Feeding performance of the 2nd instar larvae

Fresh vines of sweet potato (*Ipomoea batatas* cv. TIS-844 1) of 10cm length were collected from 1 month old potato being grown at the Department of Biological Sciences, Rivers State University of Science and Technology, Port Harcourt, Nigeria. The vines were planted in 2 litre capacity plastic buckets and were allowed to grow for another 4 weeks when they were offered to 3 sets of 2nd instar larvae (each set of larvae was reared from eggs deposited by female parents that were fed on the three different diets listed above). Only the fresh apical leaves were offered to the larvae as food although their feeding period. Thirty (4th instar) larvae each from three different parental stock were reared individually in 30 sterilized Kliner jars. Each jar was lined with Whattnan's filter paper for the collection of faecal matters of the larvae. Fresh leaves and filter papers were replaced at 24hrs intervals the jars were arranged in a completely randomized block design with three treatments (3 diets) replicated 3 times at a laboratory temperature range and relative humidity range of 28°C – 30°C and 78% - 83% respectively. Larval development was monitored at 24 hrs intervals. Food was not offered at the prepupal and pupal periods but the pupae were still kept in rearing jars to account for adult emergence. Larval and pupal weights were recorded using a sensitive balance (AE 163). All leaves offered to the larvae were weighed as well as unconsumed food and faecal materials. The total fresh weights of food consumed by each larva was determined at the end of the instar stage until adult stage. The larval and pupal weights as well as the developmental periods of the different stages and percentage mortality were recorded. Other parameters such as consumption, growth and utilization indices were calculated using the formulae of WALDBAUER (1964, 1968) which ANIOKE & BOAKYE (1992) and OGBALU (1999) also used.

2.3 Damage studies

The feeding effects of the larvae of *A. acerata* larvae on the foliage and root yields of sweet potato was studied under field conditions using four population levels of 2nd instar and 4th instar larvae and a non-infested control as treatments.

2nd instar larvae of A. acerata which parental stocks were fed with three different diets were used to inoculate sweet potato plants at 4 weeks after planting (WAP). The potatoes were grown on a Typic Paleuduit soil in ridges of 50cm height and at a distance of 100cm apart from each other. Screened wooden cages of 60 x 60cm were placed over the inoculated plants. This was done to avoid cross infestation and infestation by other pests of potato and to ensure correct damage assessment. Damage caused by the larvae at the end of the larval cycle was assessed visually using the following scoring scale of ANIOKE *et al.* (1995):

0: no damage,	3: 41-60% damage,
1: 1 - 20% damage,	4: 61-80% damage
2: 21-40% damage,	5: > 80% damage.

Plants were harvested at 8 WAP and 12 WAP when foliage and root yield assessments were recorded for all larvae introduced as 2nd and 4th instars had pupated and pupae were isolated from underside of foliage at 8 WAP. 4th instar larvae of *A. acerala* were introduced on separate plots as another set of larvae to be used for damage assessment and were allowed to feed for 21 days. Percentage defoliation was calculated at the end of this period (at 12 WAP).
Analysis of variance was used for the statistical computation of the data.

3 Results

Eggs of *A. acerata* which were collected from infested sweet potato leaves in the field were laid in batches and ranged from 48 to 120. In the laboratory females fed on different diets laid more eggs than those laid in the field. *A. acerata* laid eggs on the adaxial surface of sweet potato leaves both in the field and under laboratory conditions. When freshly laid, eggs are light-yellow in colour and eggs darken with time to deep yellow. Significantly fewer eggs were laid by females fed on a diet of 10% sugar solution with a mean range of 75.4 - 120.1 eggs (Table 1).
The highest number of eggs was recorded for females fed on a diet mixture of dry baker's yeast, sugar and water in all replicates with a mean range of 176.4 to 192.4. Females fed on this diet significantly laid highest eggs than those fed in other diets (Table 1). Also adult gravid females had 203 to 350 ova when dissected. Females fed on 10% Honey solution, performed better and had 270 to 310 ova than those fed with 10% sugar solution (Table 1) and had 200 - 310 ova. Females fed on the diet mixture (DBY, Sugar and H_2O) had shorter incubation and larval durations. Subsequently, emerging adults also showed higher longevity (Table 2). The data on the consumption, digestion and utilization indices are presented in Table 3. High significant differences were observed between C.I. of different nutritional diets (P = 0.05, DMRT), the highest

index was recorded for larvae that the parental stock fed on the diet mixture of DBY + Sugar + H_2O and larvae reared from eggs of parental stock that was fed on 10% sugar solution had the lowest. Also larval insects which parental females were fed with the diet mixture of DBY + Sugar + H_2O showed the highest significant approximate digestibility (A.D) when compared with those of 10% Sugar and Honey solutions. The same trend was observed in E.C.I. analysis (Table 4). The effect of feeding of the insects with different nutritional diets showed that the larvae and subsequent pupae reared on the mixture diet had significantly highest weights and shortest developmental periods than the rest (Table 4).

Table 1: Effect of different diets on the number of eggs deposited by females of *A. acerata*

Parents stock diet	mean number of eggs/female (n = 30/replicate)				
	I	II	III	IV	V
10% Sugar solution	75.4a	88.4a	120.1b	96.7 a	80.5a
Dry Baker's Yeast + Sugar + H_2O	176.4c	181.3c	192.4c	168.4c	128.4c
10% Honey Solution	101.2b	123.1b	98.4 a	121.2 b	104.6b

Figures in the same column followed by different letters are significantly different from each other at P<0.05 (DMRT).

Table 2: Effects of different nutritional diets on the developmental periods of *A. acerata*

Developmental stage of *A. acerata*	10% Sugar Solution	Dry Baker's yeast + Sugar + H_2O	10% Honey Solution
Egg	6.0	5.4	5.8
1st instar	3.6 + 0.1	3.2 ± 0.1	3.5 ± 0.2
2nd instar	2.6 ± 0.1	2.6 + 0.1	2.6 ± 0.1
3rd instar	3.0 + 0.2	2.8 ± 0.1	2.8 + 0.2
4th instar	2.7 ± 0.2	2.5 ± 0.1	2.6 ± 0.2
5th instar	4.8 + 0.3	3.2 ± 0.2	4.5 ± 0.3
6th instar	4.0 + 0.3	3.6 ± 0.2	3.8 ± 0.3
7th instar	5.1 + 1.4	4.8 ± 0.3	5.0 ± 1.2
Pre-pupa	1.1 ± 0.0	0.08 ± 0.0	1.1 ± 0.0
Pupa	6.0 ± 0.05	5.5 ± 0.04	5.9 ± 0.05
Adult	9.6 ± 0.05	15.4 ± 0.06	9.3 ± 0.05

Table 3: Damage Assessment on Larvae with 10% Honey solution parental stock 8 WAP, Yield/Damage Assessment.

2nd instar level	Foliage yield	Root yield (g/plant)	Damage score (0 - 5)
0	56.28 c	10.81 a	0.80
5	68.4 a	10.21 b	1.21
10	58.36 a	9.48 c	1.36
15	48.41 d	8.31 d	2.48
20	31.33 e	5.67 e	3.17

Figures in the same column followed by different letters are significantly different from each other ($P< 0.05$; DMRT).

Table 4: Effect of different diets on the development of *A. acerala*

Parental Stock Diets	Larval wt. (mg)	$\overline{X}$ pupae wt (mg)	Dev. Period (days)	Mortality (%)
10% Sugar solution	185 c	484 c	47.2 c	43.4
DBY + Sugar + H_2O	308 a	988 a	42.3 a	0.2
10% Honey Solution	206 b	725 a	44.6 b	12.8

Figures in the same column followed by different letters are significantly different from each other ($P< 0.05$; DMRT),

Observations on the feeding pattern of the larvae of *A. acerata* showed that the 1st, 2nd and 3rd instars most often feed unidirectionally and move as a group while feeding facing a particular direction. Their feeding pattern is by browsing which results in skeletonization of potato leaves. The older instars feed voraciously creating holes and eventually leaving only the major veins on the petiole.

Table 5 shows that five 2nd instar larvae from DBY + Sugar + H_2O parental stock in foliage damage assessment had the highest foliage yield compared to plants that were not inoculated at all and the five 2nd instar larval population significantly induced higher foliage yields compared to other population levels. On the root yield assessment, five 2nd instar level due to their feeding activities significantly affected root yields in both years compared to the rest. This population also had the lowest damage score (Table 5) compared to other levels. Larvae from 10% honey solution parental stock generally had higher foliage and root yields (Table 5) even though damage was higher.

Table 5: Effect of the diet on *A. acerata* larval feeding on sweet potato yield at 8 WAP

Damage Assessment on larvae of DBY + Sugar + H_2O parental stock			
2nd instar population level	Foliage yield (g / plant)	Root yield (g / plant)	damage score (0 – 5)
0	52.41 d	10.72 e	0.70 a
5	58.32 e	9.13 d	0.88 a
10	47.63 c	6.48 c	1.25 b
15	38.41 b	2.41 a	3.77 c
20	26.27 a	3.56 b	4.08 d

Figures in the same column followed by different letters are significantly different from each other at 5% level (DMRT)

Table 6: Effect of Diets on *A. acerata* larval feeding on sweet potato yield at 12 WAP

4th instar population levels	Foliage yield (g / plant)	Tuber yield (g / plant 1)	Damage score (0-5)
0	84.26 e	3.81 d	0.32 e
5	15.41 d	1.03 c	1.25 d
10	8.71 c	0.88 b	2.31 c
15	3.42 b	0.72 b	4.83 b
20	0.71 a	0.21 a	5.92 a

Figures in the same column followed by the same letters are not significantly different from each other ($P< 0.05$, DMRT).

4 Discussion

Food ingested and digested by any insect is expected to fulfil its nutritional requirements for normal growth and development. Apart from carbohydrates, which are required for energy, amino acids required for tissue and enzyme production, a direct source of sterols is necessary in all insects especially as they lack the ability to synthesize these compounds. Also various vitamins are needed in their diet including a source of inorganic salts.

The preoviposition period of *A. acerata* females was 2 to 4 days for those, fed on the mixture diet of DBY + Sugar + H_2O, 3 - 5 days for those fed on 10% honey solution and 3 to 6 days was recorded for those fed with 10% sugar solution. These facts conformed with the observations on *A. eponina* Cramer made by Bawo and Ogbalu, (Unpublished) indicating differential preoviposition periods of females fed on different leaf forms of *Corchorus olitorius* (the range being 3 - 7 days). Incubation periods were shorter on the diet mixture and those fed with 10% sugar solution had the same incubation period with *A. acerala* larvae which parental female stock Anioke *et al.* (1995) bred on 10% sugar solution. The protein content of the bakers yeast mixture diet of the parental stock induced and accelerated the development of both eggs and larvae.

The larvae also derived vitamins from the diet mixture. Although all the larvae were fed on the same potato leaves the protein diet of the parent must have affected the consumption ability of the larvae hence the larval and pupal weights of those which parental stock were fed on the diet mixture of DBY + Sugar + H_2O were higher, the larvae of parental stocks of insects exposed to DBY + Sugar + H_2O diet consumed more potato leaves than others and consequently had significantly higher C.I. than others.

The larvae were initially reared in groups of thirty larvae per jar prior to isolation and some authors are of the opinion that insects reared together in group grow faster than those reared in isolation (LANDOWSKI, 1938; CHAUVIN, 1958; IWAO, 1959 and WALTER 1982). Also *A. acerata* females fed on the DBY + Sugar + H_2O diet must have been nutritionally adequate as they laid higher number of eggs, had shorter incubation periods, larger and heavier larvae and pupae. Also the suitability of a particular diet for any insect is reflected in a low mortality among larvae and pupae and also in large size of insects hence *A. acerata* larvae which parental stocks were fed with the diet mixture were heavier and the females were more fecund than others. Differences in consumption indices (C.I.) may be due to differences in the chemical composition of the diets. WALDBAUER (1964, 1968) opined that the C.I. (food intake per unit body weight per day) could be reduced due to nutritional characteristics of the food. Again the approximate digestibility (A.D.) of phytophagous insects (which *A. acerala* belongs to) is generally poor and SINGH (1975) identified three factors which might influence the A.D. of insects in *Odontotermes* spp as follows: (i) time taken by the food to pass through the gut (ii) the hydrogen ion concentration of the gut and (iii) the presence or absence of corresponding enzymes. A mean 100% A.D. of insects which parental stock was fed with the DBY + Sugar + H_2O diet implied complete digestibility of materials consumed. The larvae used for this study were all of the same age and therefore had the same digestive physiology as they were of the same instar. Digestive physiology is usually different in different instars.

Consequently larvae with parental stock background of DBY + Sugar + H_2O diet had higher efficiency of conversion of ingested food to body matter (ECI) along with others. This is not surprising as protease, lipase, amylase, invertase and maltase are mid-gut enzymes present in phytophagous lepidopterous larvae (WIGGLEWORTH, 1965). There is no doubt that with what was inherited physiologically from the parental stock that those larvae which parents were bred on the DBY + Sugar + H_2O derived higher nutrients hence higher E.C.I. (higher assimilation) of higher quality nutrients and consequently higher weights, faster development and lowest mortality.

OGBALU *et al.* (1998) established that dipterous pests of pepper reared on the DBY + Sugar + H_2O diets more fecund than those reared on 3% honey solution. Also OGBALU and AMACHREE (1998a, 1998b) showed that diets have effects on size, growth and oviposition rates of Atherigona orientalis in the laboratory. *A. acerata* larvae cause damage on potato leaves. Damage by both, early and later instars of this pest affect the photosynthetic activities of the plant as they cause skeletonization and defoliation of leaves. Skeletonizational feeding by the early instars creates and causes transparency in leaves and defoliation (apart from large irregular holes) also causes loss of all green matter of the leaf, leaving only major leaf veins at rainy seasons.

Under higher infestation, yield is affected, with the early instar infestation at 4 WAP, foliage yield could be affected depending on the number of insects present. Skeletonization results in yellowness of leaves, which implies loss of chlorophyll. In some cases older larval feeding results in death of affected plant tissues. Damage by fewer insects does not significantly affect yield however under high population pressure yield is affected. ANIOKE *et al.* (1995) reported that plants infested with five and ten 2nd instars larvae at 6 WAP resulted in significantly higher yield than plants infested with higher population levels.

KOGAN (1984) attributed the general increase in foliage yield from five or ten 2nd instar larvae to compensatory response by the plants to damage caused by insects. Older instars (e.g. 4th to 7th instar larvae) are solitary and in nature a range of 3 to 7 larvae are found per potato plant attacking different parts of the foliage (e.g. vines, leaves and apical meristems). Damage on the apical meristems by younger instars induced and stimulated lateral outgrowths which caused increase in yield. (MILTHORPE and MOORBY, 1974; HAHN and HOZYO, 1984). Increase in larval population levels resulted in reduction in foliage yields as their feeding suppressed lateral outgrowths (ANIOKE *et al.*, 1995).

On the introduction of the 4th instar larvae at 8 WAP foliage, yield was very low. 20.3% defoliation was observed at five 4th instar population level and foliage yield was much lower than when 2nd instar of the same population was introduced. Population levels of five 4th instar larvae did not affect both foliage and tuber yield and damage was less than 15% at 12 WAP. 15 and 20 fourth instar larvae populations caused more than 80% damage and 100% defoliation of sweet potato in the field at 12 WAP. It is believed that if all the eggs deposited by one female exposed to DBY + Sugar +H_2O diet were allowed to hatch on even five potato plants, that everything that will be left will be just a stamp of potato plant. This pest is a serious pest in the Niger Delta of Nigeria and the next study will cover its control as many farmers are embarking on its commercialisation especially with the early maturing variety (TIS 8441) which is high yielding in the absence of pest infestation.
Increasing the population of A. acerata by using the DBY + Sugar + H_2O diet enhances the breeding and growth of Praying mantis (Pseudocrebotra sp) which feed on the pest. This is very useful for biocontrol strategies.

Those larvae from DBY + Sugar + H_2O parental stock fed less than those fed with honey solution due to inherited nutrient adequacy transferred from parent to offsprings, hence feeding did not cause higher increase in foliage and root yields unlike the situation in the larvae of 10% honey parental stock with nutrient inadequacy that fed voraciously inducing higher foliage and root yields. This according to MC CAFFERY (1975) indicated that high consumption compensates for dietary inadequacy. Some insects consume more food in order to compensate for low nutrient level in their diet.

As they consumed more potato leaves their feeding induced extra branchings foliage offering a compensatory role.

Higher yields can also be affected by the type of nutrient used in treating the soil. Depending on the source of nutrient, higher relative protection value against damage could be achieved. OGBALU (1999) established that some pepper cultivars received higher relative protection values against A. orientalis damage under some traditional and chemical nutrient applications. This according to MC CAFFERY (1975) indicated that high consumption compensates for dietary inadequacy. Some insects consume more food in order to compensate for low nutrient level in their diet. As they consumed more potato leaves their feeding induced extra branchings of foliage offering a compensatory role.

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