

**Pupation Sites of the Pepper Fruitfly,  
*Atherigona orientalis* Schiner (Diptera: Muscidae)**

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**ABSTRACT**

Fruits of five local pepper varieties popularly known in the eastern States as Nsukka yellow, atarugu, Tatashi (all of *Capsicum annum*), Bird's eye chilli and Local medium red (Ogoni pepper) both of *C. frutescens* were evaluated for their choice as pupation substrates/sites by the pepper fruitfly, *Atherigona orientalis* Schiner, a dipterous pest of pepper fruits in Nigeria. Observations revealed that pupation occurred both within and outside pepper fruits both in the laboratory and in the field. High significant differences existed in the number of third instar larvae that pupated within the fruits of different pepper varieties in 1995 and 1996. There was no significant difference in the number of pupae within Nsukka yellow (the variety that recorded the highest number of pupae both in the laboratory and in the field). Bird's eye chilli variety which recorded no pupa in both laboratory and field conditions. Further analysis using t-test also revealed high significant differences between the larvae that pupated within fruits and those that pupated outside fruits in both laboratory and field conditions in 1995 and 1996. A conclusion was drawn that the pupation sites of *A. orientalis* occurs mostly within pepper fruits in both laboratory and field conditions.

## INTRODUCTION

Pepper (*Capsicum* species) is susceptible to a number of insect pests notably *Atherigona orientalis* Schiner, *Megaselia* species and *Caratitidis capitata*. These insects attack pepper fruits of different ages especially during rainy season. Other pests of pepper fruits include *Cryptophlebia leucotreta* (Meyrick), *Acrae eponina* (Cramer) which are occasional pests of pepper fruits. Iheagwam and Nwankiti (1977) reported *A. orientalis* and *Megaselia* species as dipterous pests of pepper and tomato in the Eastern States of Nigeria. Other pests of pepper include the larvae of *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae) which attack the leaves of two species of pepper in Nigeria, and *Aphis craccivora* (Koch). Maduwesi (1967) also listed aphids and whiteflies as possible vectors of the pepper mosaic virus in Nigeria. In USA, the pepper weevil, *Anthonomous eugenii* (Cano) infests and lays eggs in the buds of young pods where the white larvae feed and develop rendering the pepper fruits unmarketable (Anon, 1963). The pepper maggot, *Zonosemata elata* (Say), a larva of a Tephritid fly also causes serious injury to pepper fruits and pupates in the soil after completing larval development in the fruits (Anon. 1959). More recently in Sri Lanka, Wijeratne (1996) reported the presence of thrips on pepper leaves. The thrips identified include *Thrips palmi* Karny, *Scitrothrips dorsalis* (Hood), *Frakliniella schultzei* (Trybom.) and *Megalurothrips usitatis* (Bagnall) are known to be responsible for transmitting leafcurl disease in chilli peppers. In Nigeria, Alao and Misari (1992) observed that some Thrips species are responsible for the transmission of leafcurl diseases. Other authors, Nour-Edin et al. (1969) reported that pepper, *C. annum* amongst other crops of economic importance are known to be susceptible to leafcurl disease in Nigeria. On pepper, Ogbalu (1989) established that *A. orientalis* is a rainfall pest. It is the most destructive pest of pepper fruits in Nigeria in that larvae bore through pepper fruits and feed on the mesocarp, ovules, placenta and seeds (Ogbalu and Okwakpam, 1996).

Presently, there is little or no literature on the pupation sites of *A. orientalis* in pepper. Skidmore (1985) only reported that the puparium of *A. orientalis* is usually short and broad. Other recent works include those of Daubeze et al. (1995) on the resistance of *Leveillula taurica* in pepper and tyhose of Ferrarese et al. (1995) on the

differential ethylene-inducible expression of cellulase in pepper plants.

## **MATERIALS AND METHODS**

Two experiments were conducted during 1995 and 1996 at the Agricultural Research Farm of the Rivers State College of Arts and Science, Port Harcourt, Nigeria. Five local varieties of pepper namely: Nsukka yellow, Atarugu, Tatashi, Local medium red (Ogoni pepper) and the Bird's eye chilli were used.

### **(a) Laboratory Experiment**

Thirty fresh and mature pepper fruits were plucked from each of the pepper plots of the five local pepper varieties taken to the laboratory, washed under a running laboratory tap water for about three minutes and later introduced into sample bottle that was lined with moist filter paper. Into each bottle was introduced 20 first instar larvae and the open end of the sample bottle was closed with cotton gauze and held by rubber band and left at room temperature 26 C - 28 C and rh 82 - 88% until pupation. The sample bottles were arranged on the laboratory table in a randomized complete design of five replicates. Daily observations were made on the pre-pupal behaviour for those larvae that were found outside the pepper fruits.

Pupation Sites of *Atherigona orientalis* Some first instar larvae were also introduced on sliced pepper fruits in petri dishes primarily to study their pre-pupal behaviour in the laboratory.

### **(b) Field Experiment**

During the rainy season (May - September) 1995 and 1996, pepper plants of the five local varieties were transplanted to well-prepared beds made on unploughed portions of the farm 14 days after planting. The beds each of 4.2m x 4.5m containing 5 rows of 7 plants (each row) per variety was randomized completely in five replicates. Each experimental plot contained 35 plants and 30 infested fruits were screened per experimental plot using fine cotton mesh bags (10 cm x 5 cm). The open end of the fine cotton mesh bag was tied to the branch bearing the infested fruit and

left till pupation had occurred. At the end of 13 days just prior to adult emergence when pupation would have been completed each branch bearing the cotton mesh bag was cut off from the main pepper plant and taken to the laboratory for dissection of fruits and counting of pupae within and outside pepper fruits (i.e. those in the bags) for all the varieties used. Statistical Analysis Data from the laboratory and field experiments for the two years 1995 and 1996 were analysed separately. Analysis of variance according to the conventional randomized complete design, was used to test treatment effects. In the field experiment, a randomized complete block design was used. In both laboratory and field experiments the varietal effects were compared for the pupation sites (i.e. within/outside fruits in laboratory/field and also for 1995/96).

## RESULTS

### (a) Pre-pupal Behaviour

Prior to pupation, the third instar larvae become sluggish in action and except when disturbed, they remained motionless on a spot. In the laboratory, it was observed that some of the third instar larvae which were bred in sliced pepper fruits and kept in Petri-dishes lined with black cotton material preferred 'hiding' under the black cotton material while others remained on sliced pepper fruits. The third instar larvae of *A. orientalis* secreted a gelatinous sticky substance which served as an adhesive to the substratum. A reduction in body length and an increase in body width (effected by the contraction of the body segments) also occurred. A gradual withdrawal of the cephalopharyngeal skeleton through the first three anterior segment resulted in the retaining of the cephalopharyngeal skeleton in the fourth segment. At the end of this event an opening was left at the anterior end. Later the first three segments joined to the fourth segment following contraction. This results in the 'loss' of three segments in the pre-pupal stage and consequently nine segments were noticeable in the pupa.

### (b) Pupation

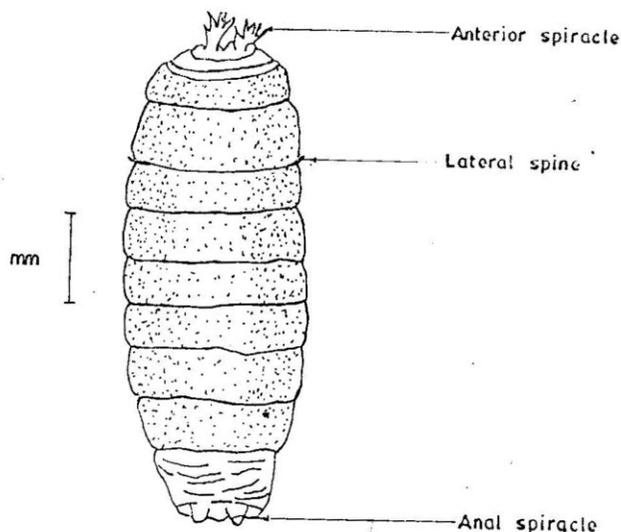
Pupation in *A. orientalis* was completed within 2 to 3 hours, shortly after pupation, the pupa assumed a light yellow coloration (a two-day old pupa is reddish

### Pupation sites of *Atherigona orientalis*

111

brown in colour). The pupa is of coarctate form. The entire surface of the pupa is covered with granular spots. The caudal segments has strong folds which encircle the periphery of the posterior spiracles. The topmost section of the first anterior segment accommodates a pair of anterior spiracles which is of palmate type. At the base of the second anterior segment is a pair of lateral spine (Fig. 1).

Fig. 1.



### 1995 Experiments

#### (a) Laboratory Experiment

Observations revealed that pupation of third instar larvae of *A. orientalis* occurred both within and outside pepper fruits in the laboratory. Table 1 (a) shows the number of third instar larvae of the pest that pupated within/outside the fruits of five pepper varieties in the laboratory. In the Bird's eye chilli variety, (*C. frutescens*) there was no pupation both within and outside fruits of this variety and this was significantly different from those that pupated within the fruits of other four varieties and significantly similar with the number of larvae that pupated outside the fruits of Tatashi variety. In the Nsukka yellow variety, the number of larvae that pupated within fruits was significantly higher than in the other varieties followed by those of the Local medium red pepper (Ogoni pepper).

**TABLE 1a : The Mean Number of Third Instar Larvae of *A. orientalis* that Pupated within/outside Fruits of five Pepper Varieties.**

(a) Laboratory Experiments (1995)

Pepper Varieties	Mean larval pupation per fruit (within)	Mean larval pupation per fruit (outside)
<i>C. annum</i>		
Nsukka yellow	17.68 e	3.90 c
Atarugu	11.30 c	1.84 b
Tatashi	4.36 b	0.0 a
<i>C. frutescens</i>		
Local medium red (Ogoni pepper)	14.10 d	6.32 d
Bird's eye chilli	0.0 a	0.0 a

Means in the same column followed by the same letter are not significantly different at 5% level of significance (DMRT)

(b) Field Experiment

In the field, the trend was almost the same as in the laboratory with those that pupated within the fruits of Nsukka yellow variety retaining a high significant difference from those that pupated within the fruits of the other four varieties ( $P < 0.05$ , DMRT). No pupation was recorded within the fruits of Bird's eye chilli variety even in the field. In Tatashi variety, no larvae pupated outside the fruits hence significant similarities existed between this variety and Bird's eye chilli at 5% level (DMRT) (Table 1(b)).

**TABLE 1(b): The Mean Number of Third Instar Larvae of *A. orientalis* that Pupated within/outside Fruits of Five Pepper Varieties.****(a) Field Experiments (1995)**

Pepper varieties	Mean larval pupation per fruit (within)	Mean larval pupation per fruit (outside)
<i>C. annum</i>		
Nsukka yellow	21.52 d	6.16 d
Atarugu	14.64 c	2.28 b
Tatashi	5.74 b	0.0 a
<i>C. frutescens</i>		
Local medium red (Ogoni pepper)	6.46 c	4.74 c
Bird's eye chilli	0.0 a	0.0 a

Means in the same column followed by the same letter are not significantly different at 5% level of significance (DMRT).

**1996 Experiment****(a) Laboratory Experiment**

Table 2(a) shows that the larvae that pupated within the fruits of Nsukka yellow variety was significantly higher than those of the other four varieties. For the Bird's eye chilli and tatashi varieties, the trend was the same as in the 1995 laboratory experiment and both were significantly similar from the rest (i.e. for pupation outside the fruits).

**TABLE 2(a): The Mean Number of Third Instar Larvae of *A. orientalis* that Pupated within/outside Fruits of Five Pepper Varieties (1996).**

(a) Laboratory Experiments (1996)

Pepper varieties	Mean larval pupation per fruit (within)	Mean larval pupation per fruit (outside)
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*C. annum*

Nsukka yellow	20.96 d	4.12 c
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Atarugu	16.02 c	1.82 b
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Tatashi	5.12 b	0.0 a
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*C. frutescens*

Local medium red	15.52 c	5.34 c
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(Ogoni pepper)

Bird's eye chilli	0.0 a	0.0 a
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Means in the same column followed by the same letter are not significantly different at 5% level of Significance (DMRT)

(b) Field Experiment

In 1996, the trend was similar to the situation in 1995 with those larvae that pupated within the fruits of Nsukka yellow variety being significantly higher than those that pupated within the fruits of the other varieties (Table 2b).

**TABLE 2(b): The Mean Number of Third Instar Larvae of *A. orientalis* that Pupated within/outside Fruits of Five Pepper Varieties.**

(a) Field Experiments (1996)		
Pepper varieties	Mean larval pupation per fruit (within)	Mean larval pupation per fruit (outside)
<i>C. annum</i>		
Nsukka yellow	23.38 d	6.68 d
Atarugu	15.04 c	2.20 b
Tatashi	6.56 b	0.0 a
<i>C. frutescens</i>		
Local medium red (Ogoni pepper)	15.60 c	5.02 c
Bird's eye chilli	0.0 a	0.0 a

Means in the same column followed by the same letter are not significantly different at 5% level of Significance (DMRT)

Table 3 reveals a highly significant relationship in the comparison between the number of larvae that pupated within the fruits of pepper varieties and those that pupated outside in the 1995 laboratory experiments. The comparison of these variables (i.e. those that pupated within and outside in the 1996 laboratory experiments still revealed highly significant relationship (Table 4). In the field trials of 1996 a high significant difference was also revealed between those larvae that pupated within fruits and those that pupated outside fruits. However, the comparison of pupation within fruits in the laboratory for both 1995 and 1996 was a highly significant relationship (Table 5). The t-test analysis also showed a non-significant relationship between the number of pupae outside the fruits in the laboratory for 1995 and 1996 (Table 6). Pupation within the fruits in both laboratory and field conditions showed a non-significant relationship. Table 7a shows confirmatory results of high

significant difference for within pupation in both field and laboratory conditions in 1995, although a non-significant result was obtained for the analysis between the larvae that pupated within the fruits in 1996 (in both laboratory and field experiments) (Table 7b).

**TABLE 3: Paired t-test analysis on the Number of Pupae within/outside Pepper Fruits in the laboratory in 1995/1996.**

1995		1996			
Variable	x + s. e.	t-value	Variable	x + s. e.	t-value
Pupation within fruits	9.488 + 1.34	7.12**	Pupation within fruits	11.520 + 1.61	7.23**
Pupation outside fruits	2.412 + 0.53		Pupation outside fruits	2.260 + 0.48	

\*\* = Highly significant relationship

**TABLE 4: Paired t-test analysis on the Number of Pupae within/outside Pepper Fruits in the Field for 1995/96.**

1995		1996			
Variable	x + s. e.	t-value	Variable	x + s. e.	t-value
Pupation within fruits	11.67 + 1.61	7.65**	Pupation within fruits	12.12 + 1.68	7.42**
Pupation outside fruits	2.64 + 0.53		Pupation outside fruits	2.78 + 0.59	

\*\* = Highly significant relationship

**Pupation sites of *Atherigona orientalis***

**TABLE 5: Comparative Analysis between Pupation within Pepper Fruits in 1995 and Pupation Within Pepper Fruits in 1996.**

(Laboratory Experiments)		
Variable	x + s.e.	t-value
Pupation within fruits 1995	9.48 + 1.34	- 3.82 **
Pupation within fruits 1996	11.52 + 1.61	

\*\* = Highly significant relationship

**TABLE 6: Comparative Analysis Between Pupation Outside Pepper Fruits in the Laboratory in 1995 and 1996**

(Laboratory Experiments)		
Variable	x + s. e.	t-value
Pupation outside fruits in 1995	2.41 + 0.53	0.58 N.S
Pupation outside fruits in 1996	2.25 + 0.48	

N.S = Non-significant relationship

**TABLE 7a: Comparative Analysis of Pupation within Fruits in both Laboratory and Field in 1995**

Variable	1995 x + s.e.	t-value
Pupation within fruits in 1995 (Laboratory)	9.48 + 1.34	-4.40 **
Pupation within fruits in 1995 (Field)	11.67 + 1.61	

\*\* = Highly significant relationship

TABLE 7b: Comparative Analysis of Pupation Within Fruits in both Laboratory and Field in 1996

Variable	1996		t-value
	x	s.e.	
Pupation within fruits in 1996 (Laboratory)	11.52	1.61	-1.06 NS
Pupation within fruits in 1996 (Field)	12.12	1.68	

NS = Non-significant relationship

## DISCUSSION

Although the eggs deposited by the females of *A. orientalis* on fruits of pepper varieties hatched in most varieties, the survival and development of larvae was different (Ogbalu and Okwakpam, 1996). However, in most susceptible pepper fruits, *A. orientalis* larval survival progressively increased as the fruits increased in maturity (especially at the ripening stage). Substantial number of larvae pupated within the fruits of most pepper varieties than they did outside in both laboratory and field conditions. More larvae pupated in pepper fruits of *C. annum* taxa than those of *C. frutescens*, and development in Nsukka yellow, atarugu and tatashi varieties (all *C. annum*) is faster and more conducive because of some morphological attributes such as the possession of fleshy mesocarp, placenta and high aromatic content. In the aforementioned varieties the high significant difference in the number of larvae that pupated within fruits in both laboratory and field situations may be due to nutritional adequacy apart from possible changes (especially under laboratory conditions). The differences may also be due to variation in larval survival reported earlier by Ogbalu (1986) among varieties where morphological factors (which include size, presence or absence of fleshy mesocarp, number of seeds, weight of fruits, etc.) are known to

affect development. The claims of Dean and Chapman (1973) and Nielson (1976) that flesh texture and firmness affect the survival of larvae in various apple cultivars corroborate this finding. Also where the third instar larvae obtained less food within fruits (nutritional inadequacy) early migration in search of food could result. Depending on the age/time of migration of the larvae, pupation may occur outside the fruits.

The interactive effects of the developing larvae (i.e. in the unpicked pepper fruits) in the pepper fruits in the field as well as age of pepper fruits and those of the picked pepper fruits in the laboratory may be responsible for the varietal differences in pupation sites in these two locations. This also confirms the report of Reissig (1979) that the variations in larval survival in the apple maggot *Rhagoletis pomonella* (Diptera: Tephritidae) in picked and unpicked apple were due to the interaction between the larvae and the chemical differences in the immature host.

In pepper possibly the existence of chemical differences in the picked fruits (used in laboratory experiments) and in the unpicked fruits (used in field experiments) may have caused the variation in the number that pupated within/outside fruits in both laboratory and field. In *A. orientalis* pupation occurs mostly within fruits than outside pepper fruits in both laboratory and field conditions. The results of the experiment indicate clearly that the choice for pupation site(s) by *A. orientalis* larva is influenced by adequate availability of food source prior to pupation.

In conclusion the field results of both 1995 and 1996 corroborate the laboratory findings and confirm that pupation of *A. orientalis* larvae occurs mostly within pepper fruits.

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- WIJERATNE, P.M. 1996.** Some aspects of chilli leaf curl control in Sri Lanka. *TVIS Newsletter*. No. 1: 17-18. Fig. 1. Pupa of *A. orientalis* (4 - days old)