African Journal of Biotechnology Vol. 2 (10), pp. 350-355, October 2003
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 

*Full Length Research Paper*

# The Contribution of food plants to the growth, development and fecundity of *Zonocerus variegatus* (L)

**Idowu A.B.* and Sonde O.A.**

Department of Biological Sciences University of Agriculture, Abeokuta, Nigeria.

Accepted 22 September 2003

**The performance of the variegated grasshopper, *Zonocerus variegatus* (L) fed on different food plants namely cassava (*Manihot esculenta),* pawpaw *(Carica papaya)* and acalypha *(Acalypha wilkesiana)* and a mixture of these plants (mixed diets) from 5th nymphal instar to adult was investigated. Survivor and longevity of nymphs and as well as the reproductive performance of adult *Zonocerus* was greater and better for insect fed on cassava and mixed diets, as compared to those fed only on *Acalypha* and pawpaw. Adults emerged between the 5th to 16th week in cages containing 5th instars fed on cassava and mixed diets, while it took between 7-23 weeks for those fed on acalypha and pawpaw to emerge as adult. There were significant differences in the measurements of the body parameters of insects fed on the four different food plants. Ranking was cassava>mixture>pawpaw>acalyhpa. Sex had no significant effect on the measurement of body parameters regardless of the food plants. Feeding assay showed that there was a significant difference between the amounts of leaves consumed by *Zonocerus* fed on the different food plants. Of all the diets, cassava was the most preferred and most consumed food plant. This had a corresponding effect on the weight gained by the insects. The results of the proximate analysis showed significant differences in the dry matter, crude protein and fat content of *Z. variegatus* fed on the different food plants. A positive correlation existed between the body weight, protein and fat content of *Z. variegatus* fed on the different food plants.**

**Key words:** *Zonocerus variegatus,* food plants, instar, growth, development.

## INTRODUCTION

The variegated grasshopper, *Zonocerus variegatus* (L) (Orthoptera: Pyrgomorphidae) is widespread in Western and Central Africa. It is primarily associated with the forest regions, but extends into the savannah, where it is restricted to riverine habitats (Chapman et al., 1986). Its polyphagous habits and typical group behaviour contribute to its status as a pest (Chapman et al., 1986).

*Z. variegatus* is a polyphagous insect and its food plants include a wild range of wide and uncultivated plants, though it exhibits preferences. However, not all the food plants eaten by *Z. variegatus* are adequate for survival and development. For example cassava, *Manihot esculcuta* (Crantz) (Bernays et al., 1975; McCaffery et al., 1978; Tamu, 1990) and *Vernonia amygdalina* (Shreb) (Tamu, 1990) have been shown to support growth and development of *Z. variegatus*. On the other hand, *Citrus spp* only support growth while *Chromolaena odorata* and *Aspilia africana* (L) do not support growth of insects (Bernays et al., 1975; McCaffery et al., 1978). *Z. variegatus* thrives very well on *C. odorata* from the 1st to the 4th nymphal instar. The early instars do not eat cassava in the field, although they may roost on it ( Bernays et al., 1975); it is the later instars that are responsible for damage. Bernays et al.

*Correspondence author:E-mail: idowuab@unaab.edu.ng.

(1975) also found that insects reared on cut leaves of cassava in the laboratory fed readily on the cut leaves, development was more rapid and the resultant insects were heavier than on other food plants.

The purpose of this study was to determine the impact of the different food plants associated with the population of *Z.variegatus* in the University of Agriculture, Abeokuta on its growth, development and fecundity.

## MATERIALS AND METHODS

### Collection and maintenance of insects

Populations of *Z. variegatus* resident in grounds of University of Agriculture, Abeokuta were studied for 3 years. Oviposition sites were marked in the previous seasons and the population was monitored from hatching until moulting to 5th nymphs instar. Newly moulted 5th nymphal instars of *Zonocerus* were collected and maintained in wire mesh cages (47 X 30 X 30 cm) in the laboratory under ambient temperature ($29\pm2^0$C) and relative humidity (79 to 85%). Four cages, each containing 150 5th instar nymphs, were fed different diets of standard food plants, namely cassava (*Manihot esculenta),* pawpaw *(Carica papaya)* and acalypha *(Acalypha wilkesiana)* and mixed diet (a mixture of pawpaw,cassava and acalypha), respectively. Insects were starved for 24 h before being fed their various diet regimens. The growth and development of nymphs were monitored until fledging. Upon fledging, adult insects from different cages were marked with indelible ink for easy identification in accordance with the experimental designs described below. Mated females were separated into oviposition cages with the different tags bearing the name of the respective food plants. The number of eggs laid per individual female were counted and recorded.

### Measurement of body parameters

The length of the body, elytron, antennae, femur and the length of the entire leg as well as the body weight of adult *Z. variegatus* were recorded 18 days after emerging as adults (n=50).

### Dissection of insects

Adult *Z. variegatus* of 18 days old (n=10) from the different cages were dissected for the reproductive structures. The right and left rows of ovarioles and testicular follicles (female and male respectively) of individual insects were counted under a dissecting microscope. The lengths of ovarioles and testicular follicles, including the median ligaments (males), terminal-filament (female), and vagina were measured.

### Haemocytes estimation

Thin smears were made from the haemolymph of the adult insects (male and female) obtained by cutting the antennae. These were air dried and treated with Leishman's stain. Identification of the cells was made as described by Chapman (1982).

### Proximate analysis

Proximate analysis for crude protein, fat, moisture and carbohydrate content of the adult *Z. variegatus* fed on different food plants was determined by standard methods (AOAC, 1980). The moisture content of food plants was also determined.

### Insect feeding assays

From the different cages, 5 adult instars (8 to 12 days old) were removed, starved for 24 h, weighed and placed in small cages with 20 g excised leaves of each of the food plants described above. The insects were observed for 3 h between 10 am to 1 pm which coincided with the peak feeding period of *Z. variegatus (*Idowu and Akinsete, 2000). Insects and plants were then re-weighed and the difference between the initial and final weight of the insects and plants was recorded as weight gained and food consumed by the insects.

## RESULTS

### Developmental period

The duration of nymphal development of *Z.variegatus* fed on the different food plants from 5th instars to adult ranged between 5 to 23 weeks. Insects fed on pawpaw and a*calypha* required significantly longer period to develop and to moult to adults than insects fed on cassava and mixed diets. Observation showed that during the period of developing from 5th to 6 h and finally to adult, mortality value of 10, 12, 46 and 50% were recorded in cages containing cassava, mixed diet, pawpaw and acalypha, respectively. Hatching into adult adult instar was first observed in the 5th week in cages containing insects fed on cassava and mixed diets. By the 7th week of feeding, 57 and 33% respectively of 5th instar fed on cassava and mixed diets, respectively, had moulted to adult. Whereas, moulting has just started with only 7 and 1% for insects fed on pawpaw and *Acalyhpa*, respectively. Moulting was completed by the 16th week for insect fed on cassava and a mixed diet, while that of pawpaw and acalypha was at the end of the 23rd week. Percentage mortality of emerged adults just before copulation was 2.2, 9.3, 24.1 and 45.7 for cages housing insects fed on cassava, mixed diets, pawpaw and acalypha, respectively. In all overall mortality of grasshopper fed on pawpaw and *Acalypha* was very high compared to those fed on cassava and mixed diets. Insects fed on excised cassava leaves had the highest percentage food consumption (14.8%) with highest weight gained (8.04%) while insects fed on pawpaw had the least (0.4% and 1.47% for food consumption and weight gained respectively). Mixed diets had 7.8% for food consumption and 7.87% for weight gained, while acalypha had 5.8% and 3.51% for food consumption and weight gained, respectively. Observation during this study also showed that cassava leaves were most preferred even among the mixture of food plants.

### Morphology

Measurement of the body parameters (body length, wing

**Table 1.** Measurement of the body parameters of adult male *Z. variegatus* fed on different plants.

| Plants | Mean wt. (g) | Mean length (cm) | | | | |
|---|---|---|---|---|---|---|
| | | Body | Leg | Femur | Wing | Antennae |
| Cassava | 1.078±0.03 | 3.8± 0.03 | 4.1± 0.03 | 1.8±0.02 | 2.6±0.06 | 1.7±0.03 |
| Mixture | 0.654±0.04 | 3.7±0.03 | 4.0±0.04 | 1.8±0.05 | 2.6±0.05 | 1.5±0.05 |
| Pawpaw | 0.924±0.04 | 3.7±0.04 | 4.0±0.03 | 1.8±0.03 | 2.5±0.09 | 1.6±0.03 |
| Acalypha | 0.542±0.05 | 2.9±0.08 | 3.5±0.11 | 1.6±0.04 | 1.8±0.04 | 1.6±0.04 |

**Table 2.** Measurement of the body parameters of adult female *Z. variegatus* fed on different plants.

| Plants | Mean Wt. (g) | Mean Length (cm) | | | | |
|---|---|---|---|---|---|---|
| | | Body | Leg | Femur | Wing | Antennae |
| Cassava | 1.051±0.06 | 3.9±0.04 | 4.1±0.02 | 1.8±0.03 | 2.5±0.08 | 1.6±0.02 |
| Mixture | 0.761±0.05 | 3.7±0.05 | 3.9±0.05 | 1.7±0.04 | 2.5±0.10 | 1.5±0.03 |
| Pawpaw | 0.988±0.04 | 3.8±0.04 | 4.1±0.03 | 1.7±0.04 | 2.4±0.10 | 1.5±0.03 |
| Acalypha | 0.590±0.03 | 3.2±0.10 | 3.6±0.06 | 1.6±0.03 | 1.8±0.04 | 1.5±0.04 |

**Table 3.** Average frequency of haemocycte, types in male and female adult *Z. variegatus* (L) fed on different food plant (cassava, pawpaw and acalypha).

| | | PRS | | | | | | PLS | | | | | | GRS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plants | Sex | NM | 8 | 18 | PRE | C | PC | NM | 8 | 18 | PRE | C | PC | NM | 8 | 18 | PRE | C | PC |
| Cassava | M | 24 | 07 | 09 | 06 | 06 | 03 | 43 | 17 | 19 | 17 | 15 | 10 | 30 | 25 | 26 | 19 | 21 | 13 |
| | F | 10 | 11 | 10 | 11 | 09 | 09 | 47 | 37 | 29 | 17 | 19 | 15 | 24 | 33 | 30 | 28 | 27 | 20 |
| Pawpaw | M | 18 | 04 | 04 | 03 | 03 | * | 50 | 11 | 10 | 08 | 06 | * | 42 | 20 | 19 | 13 | 11 | * |
| | F | 22 | 09 | 08 | 05 | 06 | * | 51 | 16 | 12 | 07 | 11 | * | 43 | 22 | 20 | 17 | 15 | * |
| Mixed diet | M | 11 | 22 | 16 | 16 | 11 | 03 | 30 | 41 | 29 | 26 | 20 | 10 | 30 | 31 | 28 | 28 | 26 | 13 |
| | F | 11 | 30 | 15 | 13 | 10 | 09 | 39 | 49 | 41 | 38 | 27 | 15 | 41 | 42 | 37 | 39 | 30 | 20 |
| Acalypha | M | 13 | 02 | 04 | 02 | * | * | 30 | 07 | 10 | 07 | * | * | 37 | 11 | 11 | 11 | * | * |
| | F | 21 | 06 | 05 | 04 | * | * | 24 | 13 | 10 | 09 | * | * | 24 | 18 | 15 | 12 | * | * |

| | | SPS | | | | | | ABS | | | | | | OES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plants | Sex | NM | 8 | 18 | PRE | C | PC | NM | 8 | 18 | PRE | C | PC | NM | 8 | 18 | PRE | C | PC |
| Cassava | M | 31 | 35 | 28 | 16 | 22 | 16 | 111 | 19 | 18 | 14 | 11 | 10 | 0 | 07 | 07 | 10 | 05 | 04 |
| | F | 23 | 47 | 38 | 35 | 26 | 17 | 09 | 27 | 27 | 18 | 21 | 15 | 0 | 13 | 10 | 12 | 09 | 05 |
| Pawpaw | M | 35 | 11 | 19 | 13 | 11 | * | 06 | 06 | 06 | 06 | 06 | * | 0 | 06 | 06 | 03 | 03 | * |
| | F | 42 | 13 | 20 | 17 | 15 | * | 16 | 13 | 11 | 09 | 09 | * | 0 | 08 | 06 | 05 | 05 | * |
| Mixed diet | M | 15 | 34 | 32 | 28 | 17 | 16 | 12 | 25 | 27 | 23 | 16 | 10 | 0 | 20 | 14 | 13 | 11 | 04 |
| | F | 20 | 56 | 43 | 36 | 25 | 17 | 13 | 37 | 32 | 28 | 23 | 15 | 0 | 24 | 20 | 15 | 09 | 05 |
| Acalypha | M | 28 | 21 | 17 | 12 | * | * | 06 | 17 | 15 | 11 | * | * | 0 | 02 | 03 | 03 | * | * |
| | F | 16 | 29 | 18 | 13 | * | * | 10 | 14 | 10 | 09 | * | * | 0 | 06 | 07 | 06 | * | * |

PRS, prohaemocyte; PLS, plasmatocyte; GRS, granulocyte; SPSs, spherulocyte; ADS, adipohaemocyte; OES, oenocyte; NM, newly moulted adult; PRE, pre-coppulating adult; C, copulating adult; PC, post-copulating adult; 8 and 18, 8th and 18th day after moulted to adult; *, not determined.

length, antennae, femur and entire leg length as well as the body weight) of adult male and female *Z. variegatus* fed on the different food plants are presented in Tables 1 and 2, respectively. The average body length, wing length, femur and legs including the body weight of adult insects followed the trend; cassava>mixed diet>pawpaw>*Acalyhpa*. No significant differences were recorded in the body length, wing length, femur and entire leg measurements of adult insects fed on the different food plants except for *Acalypha* which had significant low measurement ($P \geq 0.05$). Also, there was no significant difference in the measurements recorded for

**Table 4.** Male reproductive structures of adult *Z. variegatus* fed on different food plants.

| Plants | No of test follicles | | Length of test. follicles (cm) | | Length of vas. deff. (cm) | Test. + med. lig. (cm). |
|---|---|---|---|---|---|---|
| | Right | Left | Right | Left | | |
| Cassava | 45±0.87 | 43±1.09 | 0.18±0.010 | 0.16±0.010 | 1.07±0.01 | 2.22±0.01 |
| Mixture | 44±0.37 | 42±0.58 | 0.18±0.003 | 0.17±0.003 | 1.06±0.01 | 2.23±0.01 |
| Pawpaw | 43±1.08 | 41±1.14 | 0.13±0.010 | 0.11±0.010 | 1.03±0.01 | 2.11±0.11 |
| Acalypha | 39±0.50 | 37±0.00 | 0.12±0.000 | 0.10±0.010 | 1.02±0.01 | 2.08±0.03 |

Table 5. Female reproductive structures of Adult *Z. variegatus* fed on different food plants.

| Plants | No of ovarioles | | Ovarioles length (cm) | | Vaginal length (cm) | Ovi. + Calyx length (cm) | Length of Term. Fil. (cm) |
|---|---|---|---|---|---|---|---|
| | Right | Left | Right | Left | | | |
| Cassava | 45±0.37 | 43±0.66 | 0.20±0.010 | 0.19±0.010 | 0.27±0.01 | 1.85±0.02 | 1.73±0.07 |
| Mixture | 41±0.55 | 39±0.51 | 0.16±0.003 | 0.14±0.003 | 0.23±0.01 | 1.59±0.01 | 1.39±0.31 |
| Pawpaw | 44±0.90 | 42±1.03 | 0.18±0.010 | 0.16±0.010 | 0.24±0.01 | 1.86±0.00 | 1.55±0.11 |
| Acalypha | 39±0.58 | 37±0.33 | 0.14±0.003 | 0.12±0.030 | 0.21±0.01 | 1.57±0.01 | 1.38±0.07 |

the various body parameters of the female and male adult *Z. variegates* (P≥0.05).

## Haemocyte types

The frequency and occurence of blood cell types (haemocytes) in both sexes of adult *Z. variegatus* fed on four different food plants is given in Table 3. Only 6 types were recognised, namely prohaemocytes (PRS), plasmohaemocytes (PLS), granulocytes (GRS), spherulocytes (SPS), adipohaemocytes (ADS) and oenocytes (OES) (Chapman, 1982). There was a significant decrease in the number of haemocytes as adult age increases except for adipohaemocytes that increased with the age of the grasshopper (Table 3). The number of haemocytes found in the insects fed on cassava was significantly higher than those found in other food plants.

## Reproductive structures and fecundity

The mean count and length of the reproductive structures of adult *Z. variegatus* fed on four different food plants are presented on tables 4 and 5. Insects fed on cassava and mixed diets of the food plants had a significantly higher reproductive measurement (P≥0.05). Observation showed that ovarioles on the right ovary and right testicular follicles were higher in number than those on the left row regardless of the food plants. However, there was no significant difference in the male and female reproductive measurement of adult grasshopper fed on these food plants (P≥0.05) (Tables 4 and 5). The average number of eggs laid by the adult insects fed on cassava and mixture were 59.8±1.53 and 55.4±1.94, respectively. No copulation was observed among adults *Zonocerus* fed on pawpaw and acalypha. Those that copulated in cages containing pawpaw did not lay egg and when some of these insects were dissected, there were no developing follicles.

## Proximate analysis

Proximate analysis performed on adult *Z. variegatus* fed on four different food plants is given in Table 6. Insects fed on cassava and mixed diet had a significantly higher dry matter (37.18 and 35.72%, respectively) than insects fed on pawpaw and *Acalypha,* which had 29.98 and 26.53%, respectively. The crude protein and fat contents (27.05 and 8.67%, respectively) obtained for the insects fed on cassava food plant was significantly higher than those obtained for other food plants. However, crude protein content of grasshoppers fed on pawpaw and mixture were not significantly different (P≥0.05). The carbohydrate content of the insects fed on mixed diet was found to be higher (4.75%) while cassava had the least carbohydrate content (0.78%) (Table 6). Result of the moisture content of the different food plants showed no significant difference (Table 6).

## DISCUSSION

The present study showed varying effects of different food plants on the growth, development and fecundity of *Z. variegatus*. This agrees with the findings of Bernays et al. (1975) and McCaffery et al. (1978) that *Z. variegatus* fed on cut cassava leaves compared to other plants grow

**Table 6.** Proximate analysis of adult *Z. variegatus* fed on different food plants.

| Plants | %Moisture content | %Dry matter | %Ash content | %Fat content | %Crude protein | %Crude fibre | %Carbo-hydrate |
|---|---|---|---|---|---|---|---|
| Cassava | *81.23<br>62.82 | 37.18 | 0.49 | 8.67 | 27.05 | 0.19 | 0.78 |
| Pawpaw | *81.09<br>70.02 | 29.98 | 0.58 | 5.99 | 21.96 | 0.23 | 1.22 |
| Mixture | *79.00<br>64.28 | 35.72 | 0.60 | 8.61 | 21.29 | 0.47 | 4.75 |
| Acalypha | *79.30<br>73.47 | 26.53 | 0.84 | 5.85 | 17.26 | 0.56 | 2.02 |

*Moisture content of the food plants.

faster and resulting adults are heavier than on other food plants. The high mortality rate, prolonged developmental period, low relative food consumption, and low body weight (Tables 1 and 2) of adult grasshoppers fed on acalypha and pawpaw also agrees with the reports of Bernays et al. (1975). The observed differences among the grasshopper could be linked to the efficiency of conversion of food materials to body substances as observed by McCaffery et al. (1978). In a related study, Antonio and Silvia (1993) reported a high total mortality rate (56%), delayed nymphal development and poor reproductive performance in *Nesara viridula* (L) nymphs fed on immature fruits of radish. Recently, we (Idowu and Idowu, 2001) observed that food plants also had significant impact on the volume of secretion obtainable from the repellent gland of adult *Z. variegatus*.

In the present study, strong correlation (R=0.99) was observed between the body weight, fat content and crude protein content in the insects fed on cassava and mixed diet. Timmermann and Briegel (1996) also observed a significant positive correlation between body size, protein and fat content in the developmental stages of mosquito species fed on different diets. The result obtained from this study revealed a total of 6 haemocytes in both male and female adult *Z. variegatus* fed on different food plant. The sudden appearance of adipohaemocytes (ADS) during the reproductive phase and its increment with the age of the insects could be in order to facilitate temporary storage and mobilization of fat as well as to supply energy for both sexes especially the male for reproductive behaviour (Gupta, 1985). The relative small proportion of oenocytes (OES) observed from this study, correlate with the finding of Costin (1975), who also reported small proportion of OES in the haemolymph of *L. migratoria*.

The results of the study also agrees with the reports of Zheng et al. (1993) that food-supply was found to influence larval growth and development and adult fecundity of lacewing *(Chrysoperla carnea).* Adult female *Z. variegatus* fed on cassava and mixed diets produced an average of 59.8 and 55.4 eggs, respectively. These values are close to the 55 to 60 eggs recorded by Toye (1981) for *Z. variegatus*. Iheagwann (1979) also recorded an average of 29.2-65.9 eggs for adult *Z. variegatus* fed on diets that included cut cassava. In West Africa, most of the loss inflicted by *Z. variegates* is to the crops of subsistence farmers especially cassava, which has almost become the number one staple food in the region Toye (1981). There is therefore the need to find a substitute food plant for the insect especially during the dry-season when cassava seems to be the only available food for the insect on the field. The only plant readily available and consumed by the insect in the field during the dry season period in Ibadan and Abeokuta where the first author has done substantial work on *Zonocerus* is *A. wilkesiana*.

Adult *Zonocerus* consumed acalypha and gain weight, and report of past study showed that it supported the production of repellent secretion in adult *Zonocerus* fed solely on cassava from 1st to 6th instar (Idowu and Idowu, 2001). However, this present study has shown that the plant along with pawpaw are not siutable for raising nymphal instar of *Zonocerus* as the adult that emerged are not only small but also sterile. This has implication on the genetic make-up of emerging adult that needs to be investigated.

## ACKNOWLEDGEMENT

The study was supported by a research grant from the University of Agriculture, Abeokuta, Nigeria (RG120)

### REFERENCES

Antonio RP, Silvia, IS (1993). Performance of nymphal and adult Southern green stink bug on an overwintering host plant and impact of nymph to adult food-switch. Entomol. Exp. Appl. 68:109-115.

AOAC (1980). Official methods of Analysis. Association of Official Analytical Chemists, 12th Ed.

Bernays EA, Chapman RF, Cook AG, Mcveigh LJ, Page WW (1975). Food plants in the survival and development of *Zonocerus variegatus* (L). Acrida 4:33-46.

Chapman RF, Page WW, McCaffery AR (1986). Bionomics of the variegated grasshopper *(Zonocerus variegatus)* in West & Central Africa. Annu. Rev. Entomol. 33:479-505.

Chapman RF (1982). The Insects: Structure and Function 4th Ed. 819 p. English Universities Press Ltd. London.

Costin NM (1975). Histochemical observations of the haemocytes of Locusta migratoria. Histochem J. 7:21-43.
Gupta AP (1985). Cellular Elements in the Haemolymph. In: Kerkut GA, Gilbert LI (Eds) Comprehensive insect physiology. Biochem. Pharmacol. 3: 401-451.
Idowu AB, Akinsete A (2000) . The attraction of *Zonocerus variegatus* (L) (Orthoptera: Pyrgomorphidae) to different types of Lure. Rev. Biol. Trop. 49: 673-689.
Idowu AB, Idowu OA (2001). Effect of food plants on the volume of repellent secretion obtained in adult *Zonocerus variegatus* (L) (Orthoptera: Pyrgormorphidae). Rev. Biol. Trop. 49: 679-684.
Iheagwann EU (1979). Host plant effects on fecundity and adult survival of *Zonocerus variegatus* (L) Rev. Zool. Afr. 93: 760-765.
Mccaffery AR, Cook AG, Page WW, Perfect TJ (1978). Utilization of Food by *Zonocerus variegatus* (L) (Orthoptera: Acrididea). Bull. Entomol. Res. 58: 589-606.
McCaffery AR (1982). A difference in the acceptability of excised and growing Cassava leaves to *Zonocerus variegatus* (L). J. Entomol. Exp. Appl. 32: 111-115.
Tamu G (1990). Studies on feeding and food selection and oviposition in the African pest grasshopper, *Zonocerus variegatus* (L) and possible strategies for its control Ph. D. Thesis, University of Ibadan.
Timmermann SE, Briegel H (1996). Effects of plant, fungal and animal diets on mosquito development. J. Entomol. Exp. Appl. 80: 173-176.
Zheng Y, Hagen KM, Daane KM, Mittler TE (1993). Influence of larval dietary supply on the food consumption, food utilization efficiency, growth & development of the lacewing *(Chrysoperla carnea)*. J. Entomol. Exp. Appl. 67: 9-14.