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Morphology, Development and Reproduction of *Zonocerus variegatus* (L.) (Pyrgomorphidae) Feeding on *Vernonia amygdalina* (Asteraceae) and *Manihot esculenta* (Euphorbiaceae) in the Laboratory

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Abstract.- *Vernonia amygdalina* (Asteraceae) and *Manihot esculenta* (Euphorbiaceae) are food sources for human and hosts plant of the African pest *Zonocerus variegatus* (L.) (Orthoptera : Pyrgomorphidae). In this study, survival, larval development, morphology and reproduction of *Z. variegatus* on *M. esculenta* and *V. amygdalina* were investigated in the laboratory. The experiments were conducted in 180 cages and in each, a couple of stage 4, 5 or 6 larvae were introduced. Larvae and adults were nourished with leaves of *M. esculenta* or *V. amygdalina*. The experiments were monitored every two days, from November 2010 to September 2011, until the death of all the individuals. The results revealed that *Z. variegatus* survivorship was more than 83% and was not affected by diet change. The development proceeded normally and no supernumerary larval stage was noticed. Adult lifespan and the number of ootheca per female were higher on *M. esculenta* than on *V. amygdalina*. When the breeding started with the stage 4 and 5 larvae, the dimensions of the eggs were not affected by the diet variation; but when breeding started with stage 6 larvae, eggs were larger on *V. amygdalina* than on *M. esculenta*. The diet variation did not affect the body dimensions of *Z. variegatus*, except for the abdomen of adults derived from the larvae which were monitored since stages 5 or 6. The sexual dimorphism was noticed on the two diets. This work has provided an important data on the advancement of ecological knowledge on *Z. variegatus*.

Keys words: *Zonocerus variegatus*, survival, development, egg, dimorphism, *Manihot esculenta* and *Vernonia amygdalina*.

INTRODUCTION

The African variegated grasshopper, *Zonocerus variegatus* (L.) (Orthoptera: Pyrgomorphidae), is the main grasshopper crop pest in more than twenty countries, including the extensive forest and savannah areas in West and Central Africa (Modder, 1994). In Cameroon, this arthropod is ranked as the third most economically important agricultural insect pest (Kekeunou *et al*., 2006). *Z. variegatus* has seven post-embryonic stages (adult and six larval stages) (Chiffaud and Mestre, 1990); stages 1 to 3 larvae are gregarious while stages 4 to 6 and adults are solitary. In the areas of Cameroon with an equatorial climate, *Z. variegatus* is present throughout the year in two univoltine populations which have unequal abundance and duration (Messi *et al*., 2006; Kekeunou *et al*., 2014). In the natural habitats, *Z. variegatus* lives and feeds on about 318 host plant species, including a wide range of plantation and subsistence crops (Kekeunou, 2007). *Manihot esculenta* Crantz and *Vernonia amygdalina* Delile; the leaves are consumed by humans and *Z. variegatus*, while tubers are only eaten by humans. Numerous grasshoppers are known to feed on cassava in Africa and in America, but only in Africa, *Z. variegatus* and its congeneric species *Z. elegans* are major cassava pests (Modder, 1994). Damages to cassava stand in the form of defoliation and debarking. It is noteworthy that in the Ibadan area (Southern Nigeria), Page *et al*. (1980) found that experimental defoliation of cassava caused a significant reduction in tuber yield and delayed the natural leaf regeneration which occurs during the rainy season, following a dry season during which cassava plants are normally defoliated (Toye-Afolabi, 1982). Damages by *Z. variegatus* to crops, in particular to cassava, have increased in the recent years; the attacks on crops threaten the livelihood of the many poor subsistence farmers. In the Southern

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Nigeria, over 50% of the cassava crop is lost during years of *Z. variegatus* high abundance (Modder, 1994); the attacks are higher during the dry season thus, *Z. variegatus* is considered as a seasonal pest (De Gregorio, 1989).

In the laboratory, the number of larval stages varies from 6 to 8 according to diet, six larval stages being most frequent (Kekeunou *et al.*, 2010). The highest growth rate, the great amount of haemolymph and fat body, and the greatest food value in these tissues, are generally found in those grasshoppers that are fed on the mixed diet and those that are fed on *M. esculenta* (Modder and Tamu, 1996). The time of nymphal instar appearance is shorter on *M. esculenta* than on legumes or Asteraceae (Kekeunou *et al.*, 2010). Caged *Z. variegatus* individuals which are fed on cassava show rapid post-embryonic development (Bernays *et al.*, 1975) and high fecundity, cassava being efficiently converted into body tissue (Mc Caffery *et al.*, 1978). For the single diet, the lifespan is longest on *Synedrella nodiflora* (11.5 months) and *M. esculenta* (11–11.5 months); while the shortest duration is noticed on *Lablab purpurea* (7–7.5 months) and *Cajanus cajan* (8.5 months) (Kekeunou *et al.*, 2010). The effect of mixed diet on the lifespan of *Z. variegatus* is variable (Kekeunou *et al.*, 2010). The best somatic growth is manifested by adult females feeding on *M. esculenta* and *Acalypha wilkesiana*, and the poorest on *Chromolaena odorata*; the pre-oviposition period is shortest on *M. esculenta* and longest on *S. nodiflora* (Modder and Tamu, 1996). The ovaries did not develop on *C. odorata* and *P. pinnata*; in late vitellogenesis, the largest ovarioles, containing the largest reserves is found in adult females feeding on *M. esculenta* and the smallest on *S. nodiflora*; also most eggs of *Z. variegatus* are produced on *M. esculenta* (Modder and Tamu, 1996). *V. amygdalina* supports the growth and development of *Z. variegatus* (Tamu, 1990). *Z. variegatus* fed on leaves of cassava and *V. amygdalia*, or a mixture of *M. esculenta* and *Acalypha wilkesiana* gave good volume of secretion while *C. odorata*, *Elaeis guinensis*, *A. africana* and *Citrus sinensis* did not favour secretion production (Idowu and Idowu, 2001). It is clear that, a lot of works exist in literature on the effect of *M. esculenta* on the biology and ecology of *Z. variegatus*, but few are known about *V. amygdalina*.

The objective of this study was to comparatively assess the effect of *M. esculenta* and *V. amygdalina* on the survival, developmental duration, courtship, mating, oviposition and adult morphology of *Z. variegatus*.

MATERIALS AND METHODS

Study site

This study was carried out in the Zoology laboratory of the Faculty of Science of the University of Yaounde I. The larvae and adults of *Z. variegatus* were collected from Zamakoé (3° 34’ 43°.6’’N et 11°30’ 32°.9’E), a village that is 6 km away from the Centre of Mbalmayo town. Zamakoé is located in the semi-deciduous forest of the humid forest zone of Southern Cameroon, which is characterized by an abundance of Sterculiaceae and Ulmaceae (Holland *et al.*, 1992). In Zamakoé, the rainfall pattern is bimodal and characteristic of an equatorial climate. The short rainy season (mid-March–June) is followed by the short dry season (July–August), and the long rainy season (September–mid-November) is followed by the long dry season (mid-November to mid-March). In this area, rainfall is 1800-2000 mm per year and the temperature fluctuates between 22 and 29°C (Santoir and Bopda, 1995). Individuals of *Z. variegatus* were captured in natural herbaceous vegetation.

Experimental design, parameters measured and observations

The breeding was carried out from November 2010 to September 2011 in 180 cylindrical plastic cages (height, 9 cm, diameter, 13 cm) in the Zoology laboratory under an ambient temperature (21.25 to 26.15°C) and hygrometry of 60 to 95%. In each cage, one dry stem of *C. odorata* (used as the support for insect individuals) and one couple of stage 4, 5 or 6 larvae were introduced with fresh leaves of *M. esculenta* or *V. amygdalina*. Ninety cages received *M. esculenta*, while 90 others received *V. amygdalina*. For each type of diet, 30 cages received stage 4 larvae, 30 received stage 5 larvae and 30 received stage 6 larvae. Observations began when the individuals and diet were introduced in the cages and were carried out every two days until the death of all *Z. variegatus*. During each observation day, food was changed, ecdysis was noticed, the number of live insects was assessed and the cage was well cleaned. After each moult, we noticed the insect post-embryonic stage. At the adult stage, the pre-mating behaviour and the date of mating were recorded. At the death of each adult, some morphological characteristics (adult colour, femur, tibia, pronotum, wings, cephalic capsule, head, pronotum, body, abdomen, antenna and genital valve lengths and width) were noticed; eyes diameter were measured and the number of antenna articles counted. The measurements of body parts were done using an electronic slide calliper and they are herein expressed in mm.

Data analysis

We calculated the survival rate (S); the duration of each larval stage [$(D_i) = d_1 - d_0$, where d_0 = date when stage i_{-1} moved to stage i and d_1 = date when stage i moved to stage i_{+1}], adult lifespan [$(D'_i) = d'_1 - d'_0$, where d'_0 = date when stage 6 larvae moved to adult stage and d'_1 = date of the death of the adult]. The number of ootheca (egg pod) deposited per female and the number of eggs per ootheca were also counted. All statistical analyses were done using Statistical Analysis Systems (version 9.1) software (SAS Inc, Carey, NJ, USA). Each mean or percentage was calculated with the confidence limit. The Pearson Chi-square test was used to compare the survival frequency of *Zonocerus variegatus* between sexes and between larval stages. Means for continuous variables and counting were subjected to ANOVA and Student–Newman–Keuls tests (GLM procedure). In the case of normal distribution and absence of homogeneity of variance, Welch test was used while in the absence of normal distribution, Kruskal–Wallis (for k-samples) and Wilcoxon two sample tests were used. Differences were deemed to be significant when $p < 0.05$.

RESULTS

Survivorship of Zonocerus variegatus *on* Manihot esculenta *and* Vernonia amygdalina

In the laboratory, the survivorship of *Z. variegatus* varied from 83 to 97% for the breeding that started at stages 4, 5 or 6 larvae. The variation of the diet and of the initial larval stage did not affect the survival and even the sex of the larvae and adult of *Z. variegatus* ($p > 0.05$) (Table I).

Larval developmental duration and adult lifespan of Zonocerus variegatus *on* Manihot esculenta *and* Vernonia amygdalina

In each diet, the development proceeded normally and no supernumerary larval stage was observed. On *M. esculenta* and *V. amygdalina*, the difference between stage 5 and stage 6 larvae developmental durations was non-significant ($p > 0.05$), while the difference between each larval developmental type duration and the adult lifespan was significant ($p < 0.05$) (Table II). In fact, on *M. esculenta*, stage 5 and stage 6 larvae developmental durations were 28.70±1.69 and 27.92±1.02 days, respectively, and almost 4 times less than that of the adult lifespan (127±10.58 days), while on *V. amygdalina*, stage 5 and stage 6 larvae developmental durations were 27.72±1.72 and 29.22±1.10 days, respectively and almost 3.5 times less than that of the adult lifespan (100.26±3.85 days).

For each type of initial larval stage bred (stages 4, 5 or 6 larvae), the developmental duration was not affected by the variation of the diet; however, the adult lifespan was longer on *M. esculenta* than on *V. amygdalina* (Table II).

In general, the larval developmental duration and the adult lifespan were not affected by the variation of the initial larvae breeding stage, except on *M. esculenta*, where the developmental duration of stage 6 larvae derived from stage 5 larvae (emanating from the natural habitat) was longer than that derived at stage 5 larvae which were monitored since stage 4 larvae ($p < 0.05$). Considering the diet and the initial breeding larvae stages, no significant difference was observed in the larval developmental duration and adult lifespan between the males and females (Data not shown).

Numbers of eggs and ootheca produced by each female

Averagely, each female deposited 1.82±0.17 ootheca (1 to 6). The initial stage of larva bred didn't affect this number, except on *V. amygdalina*

Table I.- Survival rate (%) of *Zonocerus variegatus* on *Manihot esculenta* and *Vernonia amygdalina* in the laboratory.

Obtained stages		Initial larval stage breed			X^2-value	p-value
		Stage 4	Stage 5	Stage 6		
Stage 5 larva	*M.esculenta*	91.67±0.05% (55)				
	V.amygdalina	83.33±0.07% (50)				
	X^2-value	0.2381				
	p-value	0.6256				
Stage 6 larva	*M. esculenta*	91.67±0.05% (55)	91.67±0.05% (55)		0.0000	1.0000
	V. amygdalina	83.33±0.07% (50)	93.33±0.05%(56)		0.3396	0.5600
	X^2-value	0.2381	0.0090			
	p-value	0.6256	0.9244			
Adult	*M. esculenta*	86.67±0.07%(52)	91.67±0.05%(55)	96.67±0.05%(58)	0.3273	0.8491
	V. amygdalina	83.33±0.07%(50)	93.33±0.05%(56)	93.33±0.05%(56)	0.4444	0.8007
	X^2-value	0.0392	0.0090	0.0351		
	p-value	0.8430	0.9244	0.8514		

p-value is the significant level of the Chi-square test (X^2). In bracket, the number of alive individuals.

Table II.- Developmental duration and Life span (in days) of solitary stages of *Zonocerus variegatus* according to the diet (*Manihot esculenta* and *Vernonia amygdalina*).

Obtained stages		Initial larval stage breed			H* or Z-value	p-value
		Stage 4	Stage 5	Stage 6		
Stage 5 larva (which molting and give stage 6 larvae)	*M. esculenta*	28.70±1.69 (18-44) (53)				
	V. amygdalina	27. 72±1.72 (18-50)(50)				
	Z-value	-0.97				
	p-value	0.33				
Stage 6 larva (which molting and give adult)	*M. esculenta*	27.92±1.02 (18-38) (53)	29.38±0.97 (20-38) (55)		-2.10	0.04
	V. amygdalina	29.22±1.10 (18-38)(50)	30.20±1.01 (22-42) (56)		-1.67	0.09
	Z-value	1.57	-1.02			
	p-value	0.12	0.31			
Adult (evolving to death)	*M. esculenta*	127.00±10.58 (14-220) (52)	135.20±11.31 (10-232) (55)	124.02±12.65 (0-220) (58)	1.70*	0.43
	V. amygdalina	100.26±13.46 (2-192) (50)	105.48±10.96 (4-180) (56)	83.00±13.58 (4-162) (56)	4.36*	0.11
	Z-value	-3.09	3.63	-4.05		
	p-value	0.0020	0.0003	<0.0001		

p-value is the significant level of the H value of Kruskal Wallis test (or Z-value of the Wilcoxon two samples test). In bracket: minimum, maximum and number of alive individuals.

where the females (derived from the larvae that were monitored since the 4th stage) deposited less ootheca than those derived from larvae monitored since stages 5 or 6 ($p<0.05$). For each initial breeding larval stage type, the mean number of ootheca deposited by each female was higher on *M. esculenta* than on *V. amygdalina* (Table III).

The mean number of eggs per ootheca was 18.69±1.96 (0 to 61). This number was not affected by the type of initial breeding larval stage, except on

Table III.- Number of ootheca per female, number of eggs per ootheca, eggs and ootheca dimensions on *Manihot esculenta* and *Vernonia amygdalina*.

Initial breeding larvae	Diet	Ootheca			Egg		
		Number	Length (mm)	Width (mm)	Number	Length (mm)	Width (mm)
Stage 4 larvae	*Manihot esculenta*	2.14 ±0.56a (1-6)(21)	20.84 ±2.91a (7.68-42) (45)	8.96 ±0.94a (4.4-16.27) (45)	15.79±3.07a (0-39) (39)	6.51±0.06a(5.3-7.4)(166)	1.41±0.02a (1-1.98) (167)
	Vernonia amygdalina	1.21 ±0.25b (1-2)(14)	24.42±6.35a (7.5-44.5) (17)	9.35±1.42a (4-14)(17)	15.63±5.33a (0-35)(16)	6.40±0.11a(5.4-7.08)(61)	1.39±0.04a (1.1-1.71) (61)
Stage 5 larvae	*Manihot esculenta*	2.72±0.74a (1-6)(22)	17.53±2.41a (4.81-43.2) (60)	8.82±0.96a (3-18.96) (60)	15.13± 4.08a (0-55) (52)	6.60±0.04a (5.8-7.52) (213)	1.43±0.02a (1.1-1.89) (217)
	Vernonia amygdalina	1.63±0.37b (1-3)(19)	21.42±3.52a (8.29-39)(31)	9.95±1.14a (4.5-16.3)(31)	19.70±4.58a (0-46)(30)	6.54±0.05a(5.6-7.13)(162)	1.41 ±0.07a (1.1-1.9)(165)
Stage 6 larvae	*Manihot esculenta*	2.22±0.47a (1-4) (23)	22.97±3.08a (5-56.71) (51)	9.79±3.35a (3.1-17) (51)	23.31±5.07a (0-61) (49)	6.39±0.05a (5.1-7.48) (348)	1.38±0.02a (0.87-1.94) (349)
	Vernonia amygdalina	1.50±0.34b (1-3) (16)	25.76±5.5a (7.84-44.73) (23)	9.87±3.69a (4-15.5) (23)	20.08±5.23a (0-38) (24)	6.58±0.07b (5.2-7.23) (109)	1.43±0.03b (1.1-1.9) (110)

For each column, means±SD with the same letter are not significantly different for SNK test. In bracket: minimum, maximum and number of alive individuals.

cassava where the eggs that were laid by female that were derived from larvae monitored since stage 6 were numerous than those laid by female derived from larvae monitored since stages 4 or 5 (p < 0.02). Diet variation had no effect on the egg number deposited by each female (Table III).

Morphometry of Zonocerus variegatus *on* Manihot esculenta *and* Vernonia amygdalina

Ootheca

The length of ootheca varied from 4.81 to 56.71 mm (average 22.60±1.51 mm) and the width from 3.10 to 28 mm (average 9.76±0.50 mm). The type of initial breeding larval stage did not significantly affect the length and the width of the ootheca (p<0.05) (Table III). Likewise, no significant difference was observed on the length and width of the ootheca between the two diets (p<0.05).

Egg

The length of eggs varied from 5.10 to 7.52 mm (average 6.50±0.02 mm) and the width from 0.87 to 1.98 mm (average 1.41±0.01 mm). On *M. esculenta*, the *Z. variegatus* egg dimensions varied according to the type of initial breeding larval stage, the values being higher for the females derived from larvae monitored since stages 4 or 5 than those derived from larvae monitored since stage 6 (Table III). No significant differences were observed on the length and the width of eggs between the two diets, except for the female derived from larvae monitored since stage 6 and fed on *V. amygdalina*, these eggs were larger than those of *M. esculenta* (Table III).

Adult

In general, the adults derived from the larvae monitored since stages 5 or 6 were significantly larger (p < 0.05) than those derived from larvae monitored as from stage 4. By considering individually each diet, we observed that for the number of articles and total length of antenna, there were no significant effects of the initial breeding larval stage on the adults feeding on *M. esculenta* or *V. amygdalina*; the diet variation did not affect significantly the different parts of *Z. variegatus* body, except the abdominal length which was significantly larger (P<0.05) for adults derived from larvae monitored since stage 5 and feed on *M. esculenta* than those which fed on *V. amygdalina*.

The abdominal length of the adults derived from larvae monitored since stages 6 and fed on *V. amygdalina* was larger than that which fed on *M. esculenta* (Table IV).

Sexual dimorphism in adults of Zonocerus variegatus

On *Manihot esculenta* and *Vernonia amygdalina*, females were significantly (P<0.05) larger than males, for the length of the body, abdomen and pronotum. The number of antenna articles, the length and the width of the head capsule varied with non-significant difference on each plant (data not published)

DISCUSSION

In the laboratory, the breeding of *Zonocerus variegatus* started from old larvae (stages 4, 5 or 6 larvae), on *Manihot esculenta* and *Vernonia amygdalina* showed high rates of survival (between 83 and 97%). The results obtained on *M. esculenta* were almost two times higher than that obtained by Kekeunou *et al.* (2010). In fact, these authors have obtained 54% of survivorship until the adult stage. The difference between these results might be due to the fact that, in Kekeunou *et al.* (2010), breeding started at stage 1 larvae (20 larvae per cage). Therefore, cassava leaves seem to be most appropriate for the development of solitary larvae of *Z. variegatus* than that of the young larvae. This could explain why young larvae of *Z. variegatus* are rare on cassava leaves in the natural conditions (Chiffaud and Mestre, 1990).

Compared to *V. amygdalina*, cassava consumption extends the lifespan of adults of *Z. variegatus* in the laboratory, but the developmental duration of stage 5 or 6 larvae was almost the same between *M. esculenta* and *V. amygdalina*. This result suggests that, we can therefore choose indifferently one of the two plants to follow the stages 5 and 6 larval development in the laboratory. However, using the plants different from *V. amygdalina*, Kekeunou *et al.* (2010) and Ahmad and Nabi (2012) showed that, the type of food consumed by the larvae of *Z. variegatus* affects the developmental duration of larvae. The results also showed that no supernumerary larvae (stages 7 and

Table IV.- Variation of the dimensions of the body parts of *Zonocerus variegatus* adult according to the diet (*Manihot esculenta* and *Vernonia amygdalina*)

Initial Breeding larvae	Diet	No. of Antenna articles	Length											
			Aantenna	Pronotum	Body	Posterior Wing	Anterior Wing	Thorax	Abdomen	Posterior femur	Posterior Tibia	Anterior Femur	Anterior Tibia	Median Femur
Stage 4 larvae	*M. esculenta*	15.37± 0.49a (35)	15.33± 1.40a (35)	6.99± 0.80a (41)	33.87± 4.05a (41)	16.70± 2.39a (40)	19.92± 2.57a (40)	11.87± 1.30a (41)	18.89± 2.83a (41)	16.34± 1.31a (40)	15.64± 1.37a(39)	5.52± 0.48a(41)	5.33± 0.39a(40)	5.46± 0.47a(41)
	V. amygdalina	15.34± 0.54a (35)	15.12± 1.28a (34)	6.94± 0.71a (36)	33.69± 3.16a (36)	17.91± 3.07a (33)	20.95± 3.07a (34)	12.01± 1.25a (36)	18.74± 2.2a5 (36)	16.42± 1.21a (36)	15.84± 1.03a(36)	5.53± 0.78a(36)	5.35± 0.44a(36)	5.43± 0.75a(36)
Stage 5 larvae	*M. esculenta*	15.31± 0.47a (42)	16.26± 1.42a (42)	7.47± 0.52a (51)	36.52± 3.48a (51)	18.99± 2.55a (49)	22.30± 2.27a(48)	12.91± 1.53a(51)	20.80± 3.35a(51)	17.45± 1.03a(51)	16.83± 0.96a(51)	5.86± 0.42a(49)	5.60± 0.43a(49)	5.79± 0.43a(50)
	V. amygdalina	15.41± 0.55a (41)	15.88± 1.59a (40)	7.46± 0.63a (42)	35.62± 2.58a (43)	18.59± 1.72a (40)	21.59± 2.47a(41)	12.75± 1.22a(44)	19.06± 2.33b(44)	17.21± 1.36a(44)	16.59± 1.11a(44)	6.05± 1.71a(44)	5.53± 0.41a(44)	5.70± 0.45a44)
Stage 6 larvae	*M. esculenta*	15.44± 0.59a (45)	15.62± 1.05a (46)	7.49± 0.70a (50)	36.89± 3.81a (50)	17.98± 2.12a (46)	21.33± 2.32a(46)	12.76± 1.29a(50)	20.78± 3.07a(50)	17.28± 1.10a(50)	16.61± 1.23a(50)	5.78± 0.45a(50)	5.55± 0.38a(50)	5.68± 0.38a(49)
	V. amygdalina	15.53± 0.51a (40)	15.61± 1.33a (40)	7.47± 0.79a (46)	35.71± 3.27a (46)	17.87± 2.59a (46)	20.87± 2.67a(46)	12.80± 1.92a(46)	19.07± 3.41b(46)	17.61± 1.95a(46)	16.23± 1.68a(46)	5.83± 0.48a(46)	5.49± 0.39a(45)	5.81± 0.49a(46)

For each column, means±SD with the same letter are not significantly different for SNK test.

8 larvae) were observed on *Manihot esculenta* and *Vernonia amygdalina*. These results suggest that, the influence of diet on the appearance of supernumerary larvae come into action in young larvae and not in the old larvae. In fact, based on the work of Kekeunou *et al.* (2010), the stage 7 and 8 larvae were obtained in the laboratory when breeding on cassava started with a grouped stage 1 larvae.

As in *Hieroglyphus perpolita*, *H. perpolita*, *H. oryzivorus* (Sultana and Wagan, 2007), each female of *Z. variegatus* laid only one egg-pod in each oviposition. The number of ootheca per female of *Z. variegatus*, varied from 1 to 6 (almost 1.82±0.17) as it was stated in Benin by Douro Kpindou *et al.* (2000) who observed a deposit of 2-6 egg pods (ootheca) per female. These results are much higher than those of Page (Chiffaud and Mestre, 1990) who recorded 2-3 ootheca per female. The fact that the number of ootheca increases on *M. esculenta* than on *V. amygdalina* suggests that in a monospecific diet, *M. esculenta* would increase the fecundity rate of *Z. variegatus*. The egg number deposit per female (per ootheca) was the same between *M. esculenta* and *V. amygdalina*. The contrasting result has been obtained by Modder and Tamu (1996) who showed that, the number of eggs per ootheca were almost two times more in *M. esculenta* (43.6±2.27) than in *Acalypha wilkesiana* (22.8±1.73), *Synedrella nodiflora* (22.4±0.71) and mixed diet (21.4±0.75). In our work, the number of eggs per ootheca increases with the length of ootheca ($r = 0.5$; $p<0.0001$) and the number of eggs per ootheca and ootheca length obtained in *M. esculenta* was less than that of Modder and Tamu (1996) in the same plant. This suggests that the bigger ootheca might contain the biggest egg. The fact that, on cassava, the eggs derived from females come from larvae monitored from stage 6 are numerous than those derived from the female coming from larvae monitored since stages 4 or 5 suggest that, increasing the duration of the supply of the *Z. variegatus* by cassava would reduce the fertility of the female.

The fact that, the body length of the adults derived from larvae monitored since stages 5 or 6 were significantly larger ($p< 0.05$) than those derived from larvae monitored since stage 4 (Table IV) suggest that, increasing the duration of the supply of the *Z. variegatus* by cassava or *V. amygdalina* would reduce the size of the individuals.

Sexual dimorphism that is noticed in this study amongst the adults is a frequent phenomenon in the animal world (Arnett, 1997). As in *Z. variegatus*, females are generally larger than the males (Dajoz, 2000). This is probably due to the different gender roles, including the energy that the females need to store for egg maturation and deposition of egg capsules (Arnett, 1997).

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