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Geographical variation of the pyrgomorphid grasshopper, *Zonocerus variegatus* L. (Orthoptera: Pyrgomorphidae) in southern Nigeria

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ABSTRACT
Mean body weights of male and female *Zonocerus variegatus* varied with location. In the male, the mean body weight vary significantly between Owerri specimens (0.598±0.032 g) and Ado-Ekiti specimens (0.868±0.031 g). The mean weights of ovary with eggs, the mean number of the eggs in the ovary and the mean number of eggs from pods deposited by the female *Z. variegatus* fluatuated significantly among the locations. There was a positive correlation between the weight of ovary with eggs and the body weight of females in all the locations. The weight of accessory reproductive glands-seminal vesicle bundles were dependent on the weights of the testes for males in all locations. Body size, seems to determine the reproductive potential of *Z. variegatus* since larger females possessed bigger ovaries with higher egg number and of larger size in the pods. Mean number of eggs from pods vary significantly with location indicating differential fecundity with locality. The study showed that females from Ile-Ife, Ado-Ekiti, Owerri, and Port-Harcourt were more fecund than those from Asaba and Abakaliki. Aspect of the biology of *Z. variegatus* from parts of southern Nigeria.

Keywords: Pyrgomorphid grasshopper, *Z. variegatus*, variation, south Nigeria.

1. Introduction
Zonocerus variegatus L. (Orthoptera Pyrgomorphidae) is a short horned grasshopper with an aposematic colouration and found predominantly in south Nigeria. It sequesters toxic chemical from plants and commonly lives in dense group [1] The dry season population, commonly found in the field between November and April constitutes serious pest problem for farmers, damaging crops, especially cassava.
The entire lives of insects depend on efficient reproductive capacities of the species, which is mostly regulated by the accessory reproductive glands [2]. The male accessory glands secretion of some species of insects is responsible for the elevation of oviposition and repression of sexual receptivity in female insects [3]. Vahed [4] recorded an average of 62.0±9.6 mature eggs for female *Steropleurus stali* when sexually receptive. Oocyte resorption bodies in *Romalea microptera* was used as an alternative for egg pod collection and counting of eggs to assess fecundity [5]. Muse [6] showed that the mean body weight of female *Z. variegatus* positively correlated with the mean ovary weight, egg weight and egg number and suggested the contribution of various organs in the determination of insect body weight, for an unmated female at all ages of the adult. The enormity of devastation of cassava farms and plantations is not uniform in parts of south Nigeria and devastation is possibly associated with differential rate of reproduction of the species. The Federal Government of Nigeria policy on mass cultivation of cassava, *Manihot esculanta*, which is intended to reduce foreign exchange on importation of wheat and encourage the baking and consumption of cassava bread, will ultimately lead to increase in population of *Z.variegatus*. The study of variations within population and among populations of *Z. variegatus* from different geographical regions of south Nigeria has been ignored in the biology and ecology the variegated grasshopper [7]. In this invstigation, body weights and certain reproductive structures of male and female *Z. variegatus* were used to determine geographical variations of the variegated grasshopper in southern Nigeria.

2. Materials and Methods

The dry season population of *Z. variegatus* was used for this investigation. Adults were collected from the field from six locations in south Nigeria, particularly from University campuses in Ile-Ife, Ado-Ekiti, Asaba, Abakaliki, Owerri and Port-Harcourt. The insects were collected with sweep net, kept in cages (10x10x10 cm) and used for experiment within 72 hrs.

Twenty five males and females of *Z. variegatus* were killed at temp. -10 ^{o}C. The wings and limbs were removed and weights of male and female samples were taken. The females were dissected under dissecting microscope (x2 mag.) to remove the ovary. The weights were recorded and immediately put in 30% ethanol for 30days in order to facilitate the separation of individual eggs from the tissues. The eggs were removed, dried and counted. Males were similarly dissected to remove the testes and the accessory gland-seminal vesicle bundles and their weights were recorded using Mettler's balance. Complete guts from each of the twenty five males and females were also isolated and weighed appropriately. Data were subjected to Analysis of variance test and Regression Analysis and T-test. Means that were significant were separated using Duncan Multiple Range test.

3. Results

Table 1 is the mean body weights of male and female *Z. variegatus* collected from Ile-Ife, Ado-Ekiti, Asaba, Owerri, Abakaliki and Port-Harcourt. Mean weights of male vary from one location to the other with the highest weight of 0.87±0.03 g obtained for Ado-Ekiti samples, followed by Port-Harcourt with 0.82±0.02 g. Mean value of 0.63±0.03 g was obtained for Owerri samples. There was significant difference in the mean weights of male *Z. variegatus* collected from the six locations (df=5, F=12.14, p<0.0001). Female from Ado-Ekiti had the heighest mean weight of 1.40±0.06 g. The mean weights of female from Ile-Ife, Owerri, Asaba and Port-Harcourt ranged between 1.24±0.006 for Asaba and 1.32±0.4 g for Owerri. Females collected from Abakaliki had the lowest weight of 1.11±0.05 g. Mean weights of females from the six location were significantly different from each other (df=5, F=3.52, p<0.0001). Mean gut weights of males vary between 0.165±0.05g for Owerri and 0.300±0.07 g for Port-Harcourt males (Table 2). There was significant difference in the gut weight of males from all the locations (df=5, F=13.51, p<0.001). There was significant difference in the mean gut weight of females (df=5, F=9.30, p<0.001) with the lowest and highest weights of 0.305±0.10 g and 0.51±0.10 g for Owerri and Port-Harcourt respectively. Gut weight of females was higher than those of males. At every location, there was significant difference between the gut weights of males and females (p<0.00). Increase in body weight weights of males and females was accompanied by corresponding and significant increase in the gut weights of male and female *Z. variegatus* in all the locations (Figs. 1 and 2).

Table 1: Mean body weights of males and females *Z. variregatus* from six locations.

Location	Male	Female
Ado-Ekiti	0.87^{a}	1.40^{a}
Port-Harcourt	0.82^{a}	1.29^{a}
Ile-Ife	0.74^{b}	1.28^{a}
Asaba	0.74^{b}	1.24^{ab}
Abakaliki	0.68^{bc}	1.11^{b}
Owerri	0.63^{c}	1.32^{a}

Means with the same letter are not significantly different according to Duncan Multiple Range test.

Table 2: Gut weight of male and female *Z. variegatus* from the six different locations.

Location	Male	Female	T-test (p<0.05)
Ado-Ekiti	0.240±0.06^{c}	0.422±0.12^{e}	0.000
Port-Harcourt	0.300±0.07^{f}	0.514±0.10^{f}	0.000
Ile-Ife	0.250±0.07^{d}	0.408±0.13^{d}	0.000
Asaba	0.261±0.05^{e}	0.398±0.10^{c}	0.000
Abakaliki	0.228±0.06^{b}	0.359±0.13^{b}	0.000
Owerri	0.165±0.05^{a}	0.305±0.10^{a}	0.000

Mean with the same letter are not significantly different according to Duncan Multiple Range Test.

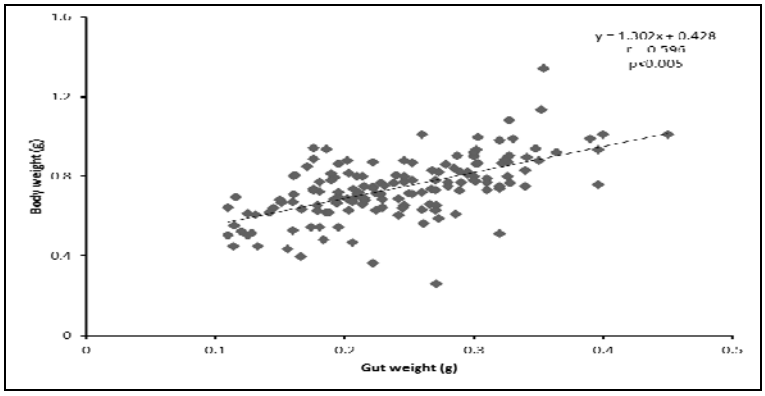

Fig 1: Regression analysis of body weight on gut weight of male *Z. variegatus* across the six locations

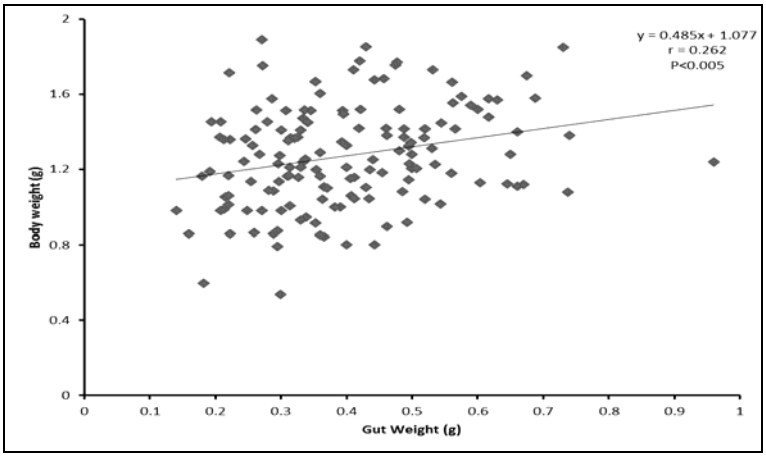

Fig 2: Regression analysis of body weight on gut weight of female *Z. variegatus* across the six locations

Mean weight of ovary and the mean number of eggs in female *Z. variegatus* collected from the six locations vary from one location to the other (Table 3). There was no significant difference in the mean weights of ovary from Ile-Ife, Abakaliki, Owerri and Asaba. Mean weight of ovary was highest for Port-Harcourt samples. There was significant difference in the mean weight of ovary of females from the six locations (df=5, F=2.94, p<0.001). The regression coefficient of the body weight on ovary weight of females from the six locations were significantly positive for each of the locations (p<0.001). There was also a weak but significant correlation between the mean weight of testes and ARG-SV bundle (r=0.45) (p<0.05) Mean number of eggs fluctuated significantly from one location to the other (p<0.001). Ile-Ife recorded the highest mean number of eggs (59.04±1.21 g) while Asaba recorded the lowest with 42.48±2.00 g among the six locations. There was no significant difference in the mean number of eggs deposited by females from Ado-Ekiti, Owerri and Port-Harcourt (p>0.001).

Table 3: Mean weight of ovary and mean number of eggs of female *Z. variegatus* collected from the six locations

Location	Mean ovary weight (g)	Mean number of eggs
Ado-Ekiti	0.37^{c}	52.72^{cb}
Port-Harcourt	0.51^{a}	54.28^{b}
Ile-Ife	0.43^{b}	59.04^{a}
Asaba	0.46^{b}	42.48^{d}
Abakaliki	0.40^{b}	47.64^{c}
Owerri	0.42^{b}	53.44^{b}

Mean with the same letter are not significantly different according to Duncan Multiple Range Test.

Table 4: Mean weights of Testes and Accessory Reproductive Gland-Seminal Vesicle bundle (ARG-SV) of male *Z.variegatus* collected from the six locations.

Location	Mean weight of testes (g)	Mean weight of ARG-SV (g)
Ado-Ekiti	0.016^{c}	0.013^{b}
Port-Harcourt	0.039^{a}	0.023^{a}
Ile-Ife	0.026^{b}	0.013^{b}
Asaba	0.027^{b}	0.015^{b}
Abakaliki	0.025^{b}	0.012^{b}
Owerri	0.026^{b}	0.015^{b}

Mean weights of testes from male samples collected from Ile-Ife, Abakaliki, Owerri and Asaba ranged between 0.025±0.001 g and 0.027±0.002 g but not significantly different from each other (Table 4). Mean weight was lowest for Ado-Ekiti samples, 0.016±0.001 g and highest for Port-Harcourt with 0.039±0.002 g. There was significant difference in the mean weight of testes of males collected from the six locations (df=5, F=32.07, p<0.0001). Mean weight of accessory reproductive gland-seminal vesicle bundles (ARG-SV) was the highest for male samples from Port-Harcourt with 0.023±0.002 g. There was no difference in weights of ARG-SV isolated from males collected from Ado-Ekiti, Ile-Ife, Asaba, Abakaliki and Owerri but there was significant difference in the weights of ARG-SV of males collected from the six locations (df=5, F=17.07, p<0.0001).

4. Discussion

Male and female *Z. variegatus* had dissimilar body weights with location. This may be caused by factors such as temperature, humidity and nature of soils which vary from one location to the other and which ultimately determine richness of cassava crop and vegetation. The body weights are consistent with the gut weights which also vary with location, indicating that body weight is

dependent on the gut weight. It seems therefore that, the grasshoppers from the different locations are in different physiological conditions owing to type and quality of food consumed. Female body weights, as well as gut weights were significantly higher than the body and gut weights of males in all the locations. Biologists often use body size to estimate other characteristics [8] which justifies the measurement of some reproductive structures of males and females *Z. variegatus* in this study. Larger females often possess more ovarioles, more eggs, larger eggs and reproduce earlier than smaller females [9, 10, 11]. In this investigation, there was absence of significant difference in the weights of ovary from four locations which is an indication of equal potential for egg production in females from all the locations as reflected in the number of eggs recovered from the ovaries. Muse [12] reported that the mean body weight of *Z. variegatus* was positively correlated with the mean ovary weight, egg weight and egg number, indicating their contribution in the determination of insect body weight. A maximum number of 59.04±1.210 eggs was reported in the ovary of female *Z. variegatus*. Vahed [4] recorded 62.0±9.6 mature eggs for female *Steropleurus stali* when sexually receptive. An average of between 29 and 51 eggs in pods was reported by [13] and insect fed with cut cassava plant had 29.2 - 65.9 eggs in their pods [14]. It is possible that male testes has capacity for fixed quantity of sperms owing to the constant weight of testes from obtained from the six locations. It is the same situation for the seminal vesicle-accessory reproductive gland (SV-ARG) whose weights were not significantly different from five of the six locations. It is observed here that the male reproductive organs are essentially the same in *Z. variegatus* in spite of the fact that they were collected from different parts of southern Nigeria. It is obvious that the local environment did not affect the size and structure of the organs. The quantity of sperm and accessory gland secretions transfered to the female can be assumed to be constant but the frequency transfer may be different owing to the significant difference in the sizes of the organs in the six locations. Accessory gland substance enhanced the fecundity of female *M. sanguinipes* [2]. Many traits of *Drosophila melanogaster* including body size, development time, egg size and ovariole number have been reported to vary clinally with latitude on multiple continents [15]. Geographically varying traits such as the body size is largely dependent on the gut weight. However, the reproductive structures of males and females are largely similar in *Z. variegatus* from different geographical locations in southern Nigeria.

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