Sexual Variations in Nutritive Value of Adult Variegated Grasshopper, *Zonocerus variegatus* (Linnaeus, 1758) (Orthoptera: Pyrgomorphidae)

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Nig. J. Entomol. 33: 17-21 (2017)

ABSTRACT: The act of eating insects (entomophagy) has been on the increase due to their medicinal and nutritional importance. This study examined the sexual differences in the nutritive value of adult variegated grasshopper, *Zonocerus variegatus*. The proximate composition (crude protein, carbohydrate, fat, crude fibre, and ash), mineral profile (Na^+ , Ca^{2+} , Mg^{2+} , and Fe^{2+}), vitamin (A, B₁, B₂, and C), anti-nutrient (alkaloid, anthraquinone, flavonoid, saponin, and tannin) and heavy metal contents (Cd^{2+} , Cu^{2+} , Ni^{2+} , Pb^{2+} , and Zn^{2+}) of 5-day old adult male and female *Zonocerus* were analysed by standard methods. Female *Z. variegatus* had significantly higher ($t_u = 0.05$) crude protein, ash, fibre and carbohydrate than the male. Anti-nutrients and heavy metal contents of the adult *Zonocerus* varied from 0.210-8.82% and 0.113-1.264mg/100g, respectively, with the female having higher values. Adult female *Z. variegatus* is thus more nutritious than the male.

Keywords: *Zonocerus variegatus*, nutrients, sexual differences, minerals, heavy metals.

INTRODUCTION

The eating of insects by humans (entomophagy) is on the increase as knowledge on their nutritional and medicinal benefits becomes more global (Banjo *et al.*, 2006). Few years back, Idowu and Modder (1996) reported the practice of eating variegated grasshopper, *Zonocerus variegatus*, by the people of Ikare, Owo and Oka-Akoko of Ondo State, Nigeria. Insects are consumed at different life stages including eggs, larvae, pupae or adults and their consumption is highly influenced by cultural, social, and religious factors (Jongema, 2017).

Insects commonly consumed include ants, bees, beetles, cicadas, corn borer, crickets, flies,

grasshoppers and grubs. Insect proteins possess nutritional advantages in total protein levels and essential amino acid profiles over plant proteins such as cereals, beans or soybean (Rumpold and Schluter, 2014). Insects also have higher levels of quality proteins (50-85%) and significant amounts of other nutrients like lipids, vitamins, and minerals (Bukkens, 2005).

The variegated grasshopper is a polyphagous insect found in the forest and savanna zones of Central and West Africa (Chiffaud and Nestre, 1990). It consumes both food and cash crops in the tropics, namely, banana, cassava, cocoa, citrus, cowpea and yam (Toye, 1982).

The life cycle of *Z. variegatus* is usually a calendar year with two populations: a dry season population (November–March) and a wet season population (April–October) (Toye, 1982).

However, the average life span of *Z. variegatus* from nymph to adult is 9-10 months

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(Anyia, 1973). A breakdown of the life cycle showed that nymphal developmental stages spread over 111.1 ± 0.02 days, while the life spans of male and female adults were 101.2 ± 0.32 and 127.9 ± 0.22 days, respectively (Ademolu *et al.*, 2013). Morphometric analyses showed a progressive increase in size of all the body parts of *Z. variegatus* during post embryonic development. Sexual dimorphism is a common phenomenon in insects; it arises from natural selection of each gender. Muse (2003) observed that female *Z. variegatus* lived longer than their male congeners either in group or isolation. Ademolu (2013) similarly reported sexual dimorphism in the somatic tissue responses of *Zonocerus* to copulation. Based on their different mating behaviour and tissue (femoral muscles, haemolymph, and antennae) composition, it is hypothesized that there will be sexual differences in the nutritive value of *Z. variegatus*. This study determined the sexual differences in the nutritive value of *Z. variegatus*.

MATERIALS AND METHODS

Collection and Maintenance of Insects

Nymphs in the penultimate (6th) instar stage of development of *Z. variegatus* were collected with a sweep net from uncultivated farm land opposite the gate of Federal University of Agriculture, Abeokuta, Nigeria (FUNAAB), brought to the insectary in the Department of Pure and Applied Zoology, FUNAAB, and sorted into sexes. The insects were maintained on *Manihot esculenta* (cassava) leaves in a wire mesh cage (30x30x45cm) (Idowu *et al.*, 2004). Five days after adult emergence, *Zonocerus* samples (24.35 ± 0.33 g) were taken out and asphyxiated in a deep freezer at -25°C for 15 minutes before being used for chemical analysis.

Chemical Analyses

The proximate composition (crude protein, carbohydrate, fat, crude fibre, and ash), vitamin (A, B₁, B₂, and C), anti-nutrients (alkaloid, antraquinone, flavonoid, saponin, and tannin), and heavy metal (Cd^{2+} , Cu^{2+} , Ni^{2+} , Pb^{2+} , and Zn^{2+}) contents of 5-day old adult *Z. variegatus* males and females were determined by methods of A.O.A.C. (1990). The minerals Ca^{2+} , Mg^{2+} , Fe^{2+} were analysed by atomic absorption spectrophotometry while Na⁺ was determined with a Corning 410 Flame Photometer. All the chemical analyses were carried out in triplicates.

Statistical Analyses

Data collected were subjected to student's t-test to detect significance of differences ($t_{\alpha} = 0.05$) between sexes.

RESULTS

The proximate composition of the male and female adult *Z. variegatus* is shown in Table 1. The female had significantly higher crude protein, ash, fibre, and carbohydrate than the male but both sexes had statistically comparable fat content ($1.00 - 1.18$ g/100 g). Excluding B₂, other vitamins were numerically higher in females than in males but the differences were due to random variation ($t_{\alpha} > 0.05$). The range of values for vitamin C was higher than those for other vitamins (Table 2). In decreasing order of magnitude, the mineral content of adult *Z. variegatus* was $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^{+} > \text{Fe}^{2+}$. Statistically significant sexual differences were detected with the male having higher content of Ca^{2+} and Mg^{2+} but lower contents of Na⁺ and Fe^{2+} (Table 3). Both sexes contained measurable levels of alkaloid, antraquinone, flavonoid, saponin, and tannin. With the exception of saponin, the contents were significantly higher in the female (Table 4).

Table 1: Proximate composition (g/100g) of adult male and female *Zonocerus variegatus*

Sex	Dry Matter	Crude Protein	Carbohydrate	Fat	Crude fibre	Ash
Male	33.040 ± 0.04^b	14.960 ± 0.03^b	15.140 ± 0.04^b	1.000 ± 0.10	1.030 ± 0.03^b	0.907 ± 0.01^b
Female	38.350 ± 0.05^a	17.280 ± 0.01^a	17.730 ± 0.03^a	1.180 ± 0.01	1.140 ± 0.04^a	1.050 ± 0.02^a

*Mean values ($\pm$ s.e.) in a column having different superscript are significantly different ($t_{\alpha} = 0.05$).

Table 2: Comparison of vitamin contents (mg/100g) of adult male and female *Zonocerus variegatus*

Sex	Vitamin A	Vitamin B ₁	Vitamin B ₂	Vitamin C
Male	6.920±0.02	0.104±0.00	0.066±0.00	8.140±0.04
Female	6.950±0.03	0.089±0.00	0.062±0.00	8.220±0.02

Table 3: Mineral composition (mg/100g) of adult male and female *Zonocerus variegatus*

Sex	Na ⁺	Ca ²⁺	Mg ²⁺	Fe ²⁺
Male	21.611±0.00 ^b	78.301±0.00 ^a	10.364±0.00 ^a	2.169±0.00 ^b
Female	21.684±0.00 ^a	72.458±0.00 ^b	9.873±0.00 ^b	2.361±0.00 ^a

*Mean values (± s.e.) in a column having different superscript are significantly different ($t_a = 0.05$).

Table 4: Anti-nutrient composition (%) of adult male and female *Zonocerus variegatus*

Sex	Tannin	Saponin	Alkaloid	Flavonoid	Antraquinone
Male	2.410±0.01 ^b	6.740±0.04 ^a	1.770±0.02 ^b	7.670±0.02 ^b	0.210±0.01 ^b
Female	2.510±0.01 ^a	6.110±0.01 ^b	1.820±0.02 ^a	8.820±0.02 ^a	0.280±0.01 ^a

*Mean values (± s.e.) in the same column having different superscript are significantly different ($t_a = 0.05$).

Table 5: Heavy metal composition (mg/100g) of adult male and female *Zonocerus variegatus*

Sex	Pb ²⁺	Zn ²⁺	Cu ²⁺	Cd ²⁺	Ni ²⁺
Male	1.006±0.00 ^b	1.071±0.00 ^b	0.861±0.00 ^b	0.286±0.00 ^b	0.113±0.00 ^b
Female	1.104±0.00 ^a	1.264±0.00 ^a	0.884±0.00 ^a	0.341±0.00 ^a	0.124±0.00 ^a

*Mean values (± s.e.) in the same column having different superscript are significantly different ($t_a = 0.05$).

Table 5 compares heavy metal content of adult male and female *Z. variegatus*. The content of Cu²⁺, Pb²⁺, Ni²⁺, Zn²⁺, and Cd²⁺ in females were 1.03-, 1.10-, 1.10-, 1.18-, and 1.19-fold greater ($t_a > 0.05$) than in the males (Table 5).

DISCUSSION

Zonocerus variegatus had always been an item in the diet of the Yorubas in southwestern Nigeria (Banjo *et al.*, 2006; Idowu and Modder, 1996). This fact is probably not unconnected to the high nutritional value of this species. Alegbeleye *et al.* (2011) incorporated varying levels of *Zonocerus* adults in the diets of *Clarias gariepinus* to replace fish meal and concluded that the insect could replace up to 25% of the fishmeal without adverse effect on fish growth and nutrient utilization.

Adult female *Z. variegatus* had significantly higher protein, carbohydrate, and ash contents than the male. Female insect generally invest more in reproductive process than males, mobilizing resources and nutrients in the early somatic stage for this energy demanding process (Ademolu *et al.*, 2011). Chapman (1990) had shown that protein is important and highly needed during egg maturation and vitellogenesis.

The crude fat content was in the range 0.907- 1.05

g/100g. This low fat content makes *Z. variegatus* an ideal diet for Nigerians, particularly those with heart-related ailments.

Vitamins A, B₁, B₂, and C were detected at higher levels in the adults than reported for the early nymphal instars (1st-3rd) by Ademolu *et al.* (2010). The numerically higher values in females also relate to greater investment in reproductive process. The high value of Ca²⁺ in the adult female in particular, is expected given that the mineral is an important constituent of egg shell and chorion and an essential requirement in embryo development (Kaneuchi *et al.*, 2015). The anti-nutrient and heavy metal content of both sexes were lower than World Health Organization's critical limits (WHO, 2009) thus making *Z. variegatus* safe for consumption. In general, the higher values of nutrients in the adult female *Z. variegatus* could be the result of higher food consumption by this sex (Ademolu *et al.*, 2016).

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Nigerian Journal of Entomology

Published by the Entomological Society of Nigeria

www.esn.org.ng

ISSN: 0331-0094

Volume 33, 2017

pp 17-21

DOI: 10.36108/NJE/7102/33(0130)