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Effect of food plant sterilization on growth and nutritional value of adult variegated grasshopper *Zonocerus variegatus* (Linnaeus, 1758) (Orthoptera: Pyrgomorphidae)

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Abstract. The variegated grasshopper *Zonocerus variegatus* (Linnaeus, 1758) (Orthoptera: Pyrgomorphidae), like other insects, harbors microorganisms in its alimentary canal and these microorganisms gotten from their food plants, play a symbiotic role in the insect host. In this study, the effect of food plant sterilization on the growth and nutritional value of *Z. variegatus* was investigated. The insects were grouped into two groups of twenty insects each (A and B). Group A was fed with sterilized cassava (*Manihot esculenta* Crantz) leaves while group B was fed with unsterilized cassava leaves. The body weight and the feed intake of the insects were measured every week using sensitive weighing scale. The nutritional value of the insects in the two groups was evaluated by proximate analysis. It was observed that grasshoppers fed with unsterilized food plant had a significantly higher weight gain (0.42 g) than those fed with sterilized food plant (0.20 g), although the feed intake was not significantly ($p < 0.05$) different. The fat content, ash content, crude fibre, crude protein and carbohydrate content were also significantly higher ($p < 0.05$) in the grasshoppers fed with unsterilized food plant (5.82%, 1.67%, 12.29%, 15.85%, and 8.81%, respectively) than grasshoppers fed with sterilized food plant.

Keywords: Food plant, Nutritive value, Sterilization, *Zonocerus variegatus*.

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Introduction

Zonocerus variegatus (Linnaeus, 1758) (Orthoptera: Pyrgomorphidae) is a polyphagous insect and its food plants include several wild and uncultivated plants (Chapman et al., 1986). It begins feeding in the morning when the temperature reaches about 23° C to 26° C with a decrease at temperature over 35° C (Kaufman, 1965). Not all food plants eaten by *Z. variegatus* are adequate for survival and development. For example, leaves of cassava *Manihot esculenta* Crantz and *Vernonina amygdelina* Delile (Shreb) have been discovered to support growth and development in *Z. variegatus.* On the other hand, *Chromolaena odorata* (L.) King & H. E. Robins and *Aspilia africana* C. D. Adams do not support the growth of the insect (Tamu, 1990).

The transmission of gut microbes can either be by vertical transmission, that is, from mother to egg or horizontal transmission (uptake by the host via a food source). Idowu and Edema (2003) reported

that gut sections of *Z. variegatus* (fore-, mid- and hind gut) harbored a variety of microorganisms, mainly bacteria, yeast and moulds, and that the microbial load was highest in adults, followed by 6th, 4th and 3rd instars in that order. The report made by Ademolu and Idowu (2011) indicated that the microorganisms are actually from the food plants eaten due to the similarity in the species of microorganisms isolated from the food plants and those isolated from the gut regions of *Z. variegatus* that consumed them. Also, freshly hatched 1st instar nymphs were found to be sterile.

One of the strategies advanced for the control of *Z. variegatus* is biological control which is environmentally friendly and cheaper than other control methods. Okoye et al. (2007) reported that *Z. variegatus* is a nutritious insect that can be included in the diet of animals. Idowu and Modder (1996) had earlier observed that *Z. variegatus* formed an item in the diets of people from three towns (Oka, Ikare and Owo) in Ondo State, Nigeria, and thus human consumption was a potential means of controlling them in these areas. This practice is a result of the good nutritional value of adults *Z. variegatus*. Idowu et al. (2004) observed that the adult stage of *Z. variegatus* had high protein content (27.05%) as well as a high mineral value. Elsewhere, Cherry (1993) observed that insect consumption as food was the most important use of insect to the Australian Aborigines. If fully harnessed, the human consumption of *Z. variegatus* will actually reduce the amount spent on the purchase of insecticides and even makes the environment safer (Kekeunou et al., 2006).

Many benefits have been adduced for the symbiotic relationship between the microbes and their host - *Z. variegatus* (Chapman, 1990). It includes better growth, vitamin production, production of enzymes and alcohol. However there were little or no empirical data to substantiate this fact in literature.

The thrust for this work is to determine the impact of sterilization of food plants (thereby removing the microbes) on the performance and nutritional qualities of Z. *variegatus*.

Materials and methods

Collection and maintenance of *Z. variegatus*

Z. variegatus were collected from uncultivated farmland on the *Campus* of the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria (7° 10’ N, 3° 2’ E). The samples of *Z. variegatus* used for this study were collected very early in the morning (6:30 am - 7:30 am). In this area the dominant plant on which the instar stages were found roosting was the common composite weed *C. odorata*.

They were reared in wire cages (30 x 30 x 45 cm) at the Insectary of the Department of Biological Sciences, FUNAAB. The first-third instars were fed daily on fresh leaves of *C. odorata*, while the later instars were given cassava leaves *M. esculenta*. Newly emerged adult males and females were removed from the cages and put in different cages (30 x 30 x 45 cm) according to sex; however, only male grasshoppers were used for this study.

Experimental procedure

Adult males were separated into two groups of 20 individuals each (A and B), group A was fed with sterilized food plant (*M. esculenta* leaves) while insects in group B were on unsterilized food plant, that is, feeding them with cassava leaves directly without pre-sterilization. Both groups were fed *ad-libitum* with their different diets.

Sterilization of the feed. The food plant was sterilized using absolute ethanol by placing the leaves on a clean flat surface and using cotton wool soaked in absolute ethanol to clean both the front and back of the leaves and allow to air dried for two minutes. However, the grasshoppers that were given unsterilized feed were presented with the cassava leaves directly without pre-sterilizing the leaves.

Data collection. The body weight of the insects was measured every week using the sensitive electronic weighing balance (Mettler-PM 11-K, UK). The daily

feed intake was also measured by subtracting leftover food from the food given.

Proximate analysis of *Z. variegatus*

The proximate analysis of the grasshoppers from the two groups was carried out by the methods described by Hormitz (1990). The moisture content, ash, crude fibre and crude protein were all determined in the samples. Carbohydrate content was obtained by difference, that is, 100 - (% moisture content + % ash + % crude fat + % crude protein).

Statistical analysis

The data collected from the above analysis were subjected to one-way analysis of variance, using Minitab software, and where there were significant differences; means separation was done using the Student-Newman-Keuls (SNK) Test.

Results

The growth performance of the experimental *Z. variegatus* is shown in Table 1. The results showed that grasshoppers fed with unsterilized food plant (group B) had significantly higher weight gain (0.42 g) than the grasshoppers fed with sterilized food plant (group A) (0.20 g). There was no significant different ($p > 0.05$) in the feed intake recorded by the insects from the two groups.

The growth pattern of the experimental grasshoppers is shown in Figure 1. The *Z. variegatus* fed unsterilized food plant had higher growth rate (0.0486x) than those fed with sterilized food plant (0.0029x). Similarly, grasshoppers in group B recorded a stronger positive relationship with the weeks of experiment ($r^2 = 0.32$) than their counterparts in group A ($r^2 = 0.001$).

The result of the proximate analysis of grasshoppers in both groups is shown in Table 2. The type of feed had significant effect on the nutritive value of the grasshoppers. The *Z. variegatus* in group B, that is, those fed with unsterilized leaves had a significantly higher crude fibre, crude fat, crude protein and carbohydrate values than those fed with sterilized feed.

Table 1. Growth performance of *Z. variegatus* fed different diets (n = 20).

Parameters	Group A (sterilized leaves)	Group B (unsterilized leaves)
Final average body weight(g)	1.13^b	1.36^a
Initial average body weight (g)	0.93	0.94
Average body weight gain (g)	0.20^b	0.42^a
Feed intake (g)	15.23	15.99

Means values in the same row having different superscript are significantly different at $p < 0.05$ (Student-Newman-Keuls Test).

Table 2. Proximate composition of *Z. variegatus* fed sterilized and unsterilized food plant (%).

Parameter	Moisture Content	Crude fat	Ash Content	Crude Fibre	Crude Protein	Carbohydrate
Group A	66.67	4.32^b	1.33	10.12^b	12.29^b	5.27^b
Group B	55.56	5.82^a	1.67	12.29^a	15.85^a	8.81^a

Means values in the same column having different superscript are significantly different at $p < 0.05$ (Student-Newman-Keuls Test).

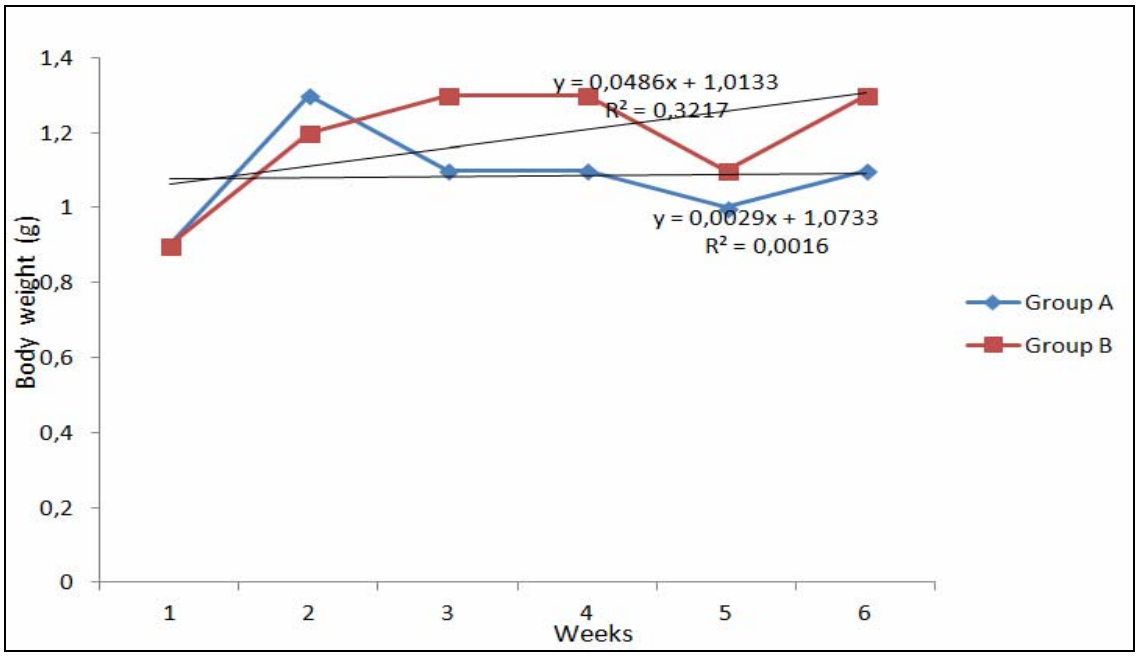

Figure 1. Growth pattern of grasshoppers fed sterilized and unsterilized food plant.

Discussion

The *Z. variegatus* fed unsterilized food plants recorded a higher weight gain than those fed sterilised leaves. This observation confirms the relevance of microorganisms in the growth and development of the insect. Breznaks and Brune (1994) reported that growth, reproduction and survival of insects are often response to variation in diet quality. In a related experiment, cockroaches whose bacteroids were eliminated by tetracycline had poor growth as their gut lack microbes (Kerkut and Gilbert, 1985). Ademolu and Idowu (2011) confirmed that the gut microbes isolated in the gut of *Z. variegatus* were actually transmitted from their food plant because both gut and food plant consumed by them had same types of organisms. Furthermore, apart from enzymes synthesis, microbes produced steroids, unsaturated fatty acids that are required by insects for normal growth and development (Martin and Kukor, 1984). The non-significant difference in the feed intake by the two groups implies that the food plant treatment had little or no influence on the consumption of the leaves.

Like the weight gain, insects fed unsterilized leaves similarly had higher growth rate and better relationship with the week of the experiment. This suggest a better utilization of the diet by the insects. Microbes are reported to convert poor diets to good ones that are useful to the insects (Kerkut and Girbert, 1985). A positive relationship existed between the body weight of the insect and the weeks of the experiment. Ademolu et al. (2011) reported a similar positive relationship between body length and stages of development of *Z. variegatus*.

There was significant difference in proximate composition of the *Z. variegatus* fed different leaves based diets. The *Z. variegatus* fed with sterilized food had significantly lower crude protein, ash, crude fibre, crude fat and carbohyrate that their counterparts on unsterilized. This result is achievable possibly bacause the *Z. variegatus* in this group had no access to microbes which are necessary for the nutrients synthesis. Microorganisms are rich sources of protein, macro nutrients like lipids, carbohydrate and vitamins (Breznak and Brune, 1994). The microbes are sources of nutrients to insects apart from aiding digestion (Idowu and Edema, 2003).

The higher carbohydrate and protein composition of *Z. variegatus* fed with unsterilized food is not unexpected as microorganisms in the gut help in the production of nitrogen which is converted to protein in the insect. Similarly, through fermentation process, microbes provide carbon structure skeleton for carbohydrate synthesis. Therefore, ingested microorganisms contributed to meeting of the nutrients requirement of the insects (Martin and Kukor, 1984).

It is also observed that the experimental insects have moderate crude protein value but low fat composition. These values compare favourably with values recorded by Banjo et al. (2006) and Idowu et al. (2004) for *Z. variegatus* found in Southwestern, Nigeria. This indicates that *Z. variegatus* is a rich source of protein which can be added to diets of man without causing any high cholesterol-related ailments.

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