GROWTH RESPONSE OF *ZONOCERUS VARIEGATUS* (LINNAEUS) (ORTHOPTERA: PYRGOMORPHIDAE) NYMPHS TO FEEDING AT DIFFERENT PERIODS OF THE DAY

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ABSTRACT: Ninety second instars were used to investigate the growth response of *Zonocerus variegatus* (L) (Orthoptera: Pyrgomorphidae) nymphs at three feeding periods namely 7.00am-7.00pm, 7.00pm -7.00am and 7.00am-7.00am. Nine cages were constructed and divided into groups of three tagged A, B and C; representing each of the three feeding periods studied. Three replicates per treatment with 10 nymphs per replicate were produced in a completely randomized design. The nymphs were fed with leaves of cassava (*Manihot esculenta* Cranz). In all the five bodily parameters measured, *Z. variegatus* nymphs fed better during 7.00am-7.00am period (P< 0.05) than other feeding periods; and this was followed by nymphs that were fed during 7.00am -7.00pm. Consequently, *Z. variegatus* nymphs recorded higher growth rates in three morphometric and one gravimetric parameter namely mean body length, mean antennal length, mean femur length, and mean body weight during 7.00am-7.00am period. Even, in the mean internotal lenght where significant difference was not shown (P>0.05), higher mean value was still shown by nymphs that were fed during 7.00am-7.00am period. This study has implicated among other factors the role of the length of time of food availability as important in growth response of *Z. variegatus* nymphs.

KEY WORDS: *Zonocerus variegatus*, nymphs, gravimetric parameters, morphometric parameters.

The variegated grasshopper, *Zonocerus variegatus* (L.) is a polyphagous and ubiquitous pest of many crops and trees of economic importance in West Africa. Currently, it has become one of the most important grasshopper pests of crops in the humid forests of low altitude and savannas of West and Central Africa (De Grégorio, 1989; Modder, 1984, 1994; Idowu and Modder, 1996). In Nigeria, *Z. variegatus* has been implicated in the transmission of both okra mosaic virus as well as bacterial burn of cassava (De Visscher, 1990).

Like a typical hemimetabolous insect, the life cycle of *Z. variegatus* consists of egg, six nymphal instars and the adult stage which is reached by progressive increases in structure and complexity (Chapman et al., 1986; Idowu, 1997; Ademolu, et al., 2006).

Z. variegatus is known to feed as polyphagous insect whose food plants have been found to include a wide range of uncultivated plants, though it exhibits preference (Bernays et al., 1992). Such range of crops on which the insects feed has been confirmed to include coffee and banana as well as a variety of subsistence crops, like cassava, yam and some weed plants (Chapman et al., 1986). Modder (1984) found out that confined nymph of *Z. variegatus* had the ability to start active feeding in the morning at a temperature as low as 17°C with

extreme massive feeding recorded at 34°C. Later in the day (mostly in the evening), they were able to ascend to the top of their food plants to roost. *Z. variegatus* begins feeding in the morning when the temperature reaches about 26°C or 23°C with a slowing down at temperature over 35°C (Kaufmann, 1965). Some of the primary factors which determine feeding in grasshoppers had been identified; they include time since the previous meal, size and nutritional quality of the meal (Simpson, 1990). This work aims at investigating the effect of feeding periods on some aspects of the growth of *Z. variegatus*.

MATERIALS AND METHODS

The experiment was carried out between the months of August and September, 2009 in the open field behind the main building of the Department of Pure and Applied Biology, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Nigeria.

Cage Construction: Nine wire meshed cages were constructed. Each cage measured 30 x 30 x 45 cm^3 in dimension. The topmost part of the cage was not wired but had a replaceable wooden section that served for feed introduction and withdrawal of nymphs during measurements and weighing.

Insect Collection: Nymphs of *Z. variegatus* at the second instar were collected by sweeping net from the premises of the Health Centre of the university. The nymphs were collected into a large paper box measuring 40 x 40 x 50 cm^3. The nine wire meshed cages were divided into groups of three with each group representing the three feeding durations under investigation, namely: 7.00am-7.00pm, 7.00pm-7.00am and 7.00am- 7.00am.

Nymph introduction and feeding: Ninety second instar nymphs were randomly picked from the large paper box and starved for 24 hours. After starving, the nymphs were divided into three groups of thirty insects with each randomly assigned to three treatments diets in a completely randomized design experiment. Each treatment group was further divided into three replicates of ten nymphs of *Z. variegatus* per replicate. Thus, 30 nymphs were counted into each of three treatments representing the three feeding periods under investigation viz, 7.00am-7.00pm, 7.00pm-7.00am and 7.00am-7.00am). Nymphs in each treatment were fed with 15g of fleshly plucked cassava, *Manihot esculenta* (Cranz) leaf, obtained from LAUTECH Teaching and Research Farm, Ogbomoso. The left over feed and accumulated frass after each feeding period were collected before new feed were provided.

Data collection

The following morphometric and gravimetric parameters were taken at interval of four days for a period of 36 days on the nymphs of each cage/subgroup; after which the data were cumulated: Antenna length, Internodal length, Femur length, Total body length and Body weight. Each of the parameters is defined as follows:

Antenna length: The distance of each antenna from the base of scape to the tip of filament.

Internodal length: The distance of the thorax lying between the tip of pronotum and base of metanotum.

Femur length: The distance between the base of trochanter to the head of tibia.

Total Body length: The distance between the epicranium of the head and tip of the abdomen.
Body weight: Weight of an individual nymph expressed in grams.

All length parameters were measured in millimeters. Data collected were subjected to analysis of variance (Steel and Torrie, 1980) and significance between means were separated using Duncan's multiple range test at 5 % level of probability.

RESULTS AND DISCUSSION

Tables 1 shows the mean body weight of *Z. variegatus* nymphs fed with cassava (*M. esculenta* (Cranz)) leaf during the three feeding periods investigated. It is evident from the table that significant difference ($P < 0.05$) existed in the body weights of nymphs fed at different periods of the day. In each of the three feeding periods, the mean body weight was in the order 7.00am-7.00am > 7.00am-7.00pm > 7.00pm-7.00am. This implies that *Z. variegatus* nymphs fed better in the order- A whole day feeding (7.00am-7.00am) > diurnal /daily feeding (7.00am-7.00pm) > Nocturnal feeding (7.00pm-7.00am).

Similarly, significant difference ($P < 0.05$) was also established in the mean body length of the *Z. variegatus* nymphs fed at different periods of the day; in this parameter, a growth order similar to the one observed in the mean body weight was obtained, that is, a whole day feeding (7.00am-7.00am) > diurnal /daily feeding (7.00am-7.00pm) > Nocturnal feeding (7.00pm-7.00am).

From Table 1 however, the growth order seen in both the mean body weight and the mean body length was not followed in the mean antennal length of *Z. variegatus* nymphs fed at different periods of the day. Although, significant difference ($P < 0.05$) was still evident, the mean antennal length of nymphs measured during 7.00am-7.00am and 7.00am-7.00pm were both higher than those obtained during 7.00pm-7.00am.

Although, no significant difference was observed in the mean femur lengths of *Z. variegatus* nymphs fed during 7.00am-7.00am and 7.00am-7.00pm, the values of the two periods were however significantly higher than the nymphs fed during 7.00pm-7.00am (nocturnal) feeding.

From Tables 1, there were no significant difference in the mean internodal length of *Z. variegatus* nymphs measured during the three feeding periods ($P > 0.05$). However, the internodal length of nymphs measured during 7.00am-7.00am was still higher than those observed during 7.00am-7.00pm and 7.00pm-7.00am. Consequently, the observation that *Z. variegatus* nymphs showed better growth response in the order- A whole day feeding (7.00am-7.00am) > diurnal /daily feeding (7.00am-7.00pm) > nocturnal feeding (7.00pm-7.00am) was established in four out of the five parameters determined.

Feeding and foraging in grasshoppers is known to be determined by several demands and constraints. It has been confirmed that grasshoppers' demands include such needs like nutrients, minerals, and water (Bernays and Simpson, 1990; Chapman, 1990; Joern and Behmer, 1998). In the like manner, constraints on grasshopper foraging and feeding are known to include food availability, environmental conditions, competition, and predation (Lockwood et al., 1967; Bernays et al., 1997; Rothley et al., 1997; Woods et al., 1997). Although, thermoregulation, along with other factors, has been identified as one of the important determinants of when a grasshopper feeds, the time since the previous meal, size and nutritional quality of the previous meal have also been identified

(Simpson, 1990). Apart from indicating the usefulness of some parameters as growth indicators in *Z. variegatus*, this investigation also underlines the period when optimum growth can be obtained in grasshoppers.

CONCLUSION

From the result of this study, it is recommended that when *Z. variegatus* is to be cultured for laboratory studies, the best feeding period for optimum growth performance is 7.00am-7.00am, which is a whole day feeding. Furthermore, it can be deduced that some bodily parameters are indicative of growth trend in grasshoppers.

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Table 1. Bodily parameters (±) of *Zonocerus variegatus* nymphs fed with cassava (*Manihot esculenta* (Cranz)) leaf at different periods of the day for 36 days.

Period of Day	Mean Body Weight	Mean Body Length	Mean Antennal Length	Mean Femur Length	Mean Internodal Length
7.00am-7.00pm	0.299± 0.004^{b}	2.192± 0.004^{b}	0.770± 0.006^{a}	1.098± 0.05^{a}	0.480± 0.006^{a}
7.00pm-7.00am	0.250± 0.007^{a}	2.050±0.006^{a}	0.710±0.007^{b}	1.050± 0.05^{b}	0.480± 0.007^{a}
7.00am-7.00am	0.330± 0.006^{c}	2.390± 0.006^{c}	0.750±0.007^{c}	1.110± 0.06^{a}	0.490± 0.007^{a}

Data are means of three replicates. Means with different superscripts in a column are significantly different using DMRT at 5% probability level.