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Variation of grasshopper abundance in light and heavy rain periods, significant for effective pest control measures

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ABSTRACT: Varying abundance of grasshoppers relative to light and heavy rain periods, significant for effective pest control measures was investigated on Oilpalm trees in experimental field 54, located in Nigerian Institute for Oilpalm Research (NIFOR), Edo State, Nigeria. The survey was conducted on a twice-a-week interval using systematic random sampling technique, within a period of four months during the early rains in the month of April through the month of heavy rains in July. Grasshoppers of interest: *Zonocerus variegatus, Catantops spissus spissus and Cyrtacanthacris aeruginosa* were recorded on oilpalm fronds 17 and 25. Being a pre-requisite for an effective and well planned timing for subsequent control program for these leaf feeding pests of oilpalm trees in the region, the survey was done to establish a baseline data on occurrence of the grasshoppers relative to the various climatic parameters used. Meteorological data (mean monthly temperature, monthly total rainfall and mean monthly relative humidity) were collected from Meteorological unit in NIFOR. *Zonocerus variegatus* had the highest mean monthly occurrence all through the period of survey (7.75±0.32, 12.97±0.55, 14.48±0.60 and 14.71±0.29 for April, May, June and July respectively) relative to the climatic parameters. No clear second position was occupied by either of the other grasshoppers, as *Cyrtacanthacris aeruginosa* occupied it in April (6.38±0.80) and June (11.85±0.91) and *Catantops spissus spissus* in May (10.14±0.80) and July (12.63±0.34). The grasshopper population correlated positively (r=+0.753, and +0.807) with rainfall and relative humidity respectively, revealing their population abundance and reduction with the parameters. A strong mean negative correlation (-0.718) also existed between them and environmental temperature. This study has revealed the higher occurrence of *Zonocerus variegatus* more than the other grasshopper species surveyed during this period and the sensitivity of the surveyed grasshoppers' occurrence to their ambient weather conditions in this region.

Keywords: Grasshoppers, Leaf feeding pests, Oil palm trees, Light and Heavy rain periods.

Introduction

The oil palm *Elaeis guineensis* is an important economic crop indigenous to Nigeria. Despite its importance in the country's economy, both as essential domestic food item and also hitherto as one of the foremost foreign exchange earners of the country (sometime in the past), its entomological problems were, until not too long ago neglected. There is therefore the need for a thorough insight into the pest inhibiting their survival and better yield.

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Agwu (1981) confirmed the presence of *Zonocerus variegatus*, *Catantops spissus spissus* and *Cyrtacanthacris aeruginosa unicolor* as some of the leaf-feeding pests of oil palm nursery and field oil palm in the Nigerian Institute for Oil palm Research (NIFOR).

Analysis on the leaf of Nigerian tall coconuts by Amalu *et al* (1988), to know the distribution of nutrient elements in the leaf revealed that Nitrogen accumulates in the tip sections, potassium in the basal sections while phosphorus, calcium, magnesium and sodium contents varied somewhat uniformly in all sections. This implies that damage to any part of the leaf is in essence displacing one or more nutrients useful for the general well being of the crop plant thereby reducing yield. It is also a known fact that photosynthesis takes place mainly in the leaves of green plants and light which is the major resource needed for the process to occur is trapped by the green portion of the leaf. Again, damage to any part reduces the surface area for trapping the light energy. As grasshoppers moult from instar to instar and grow bigger, it will eat more resulting in a great drop in quality and quantity of the food plant. The amount of food they eat also depends on the stage of development within the instar. According to Bernays *et al*, 1975 and McCaffery *et al*, 1978, most damage to crops by *Zonocerus variegatus* occurs in the later stages of development when the individual consumption rates are relatively high and the insects are effectively forced on the crops by shortage of alternative, naturally occurring source of food like *Chronolina odoratum* and Ice plant.

The wide variety of food eaten clearly shows the polyphagous nature of grasshoppers. Food, therefore to a great extent, determines the abundance and diversity of grasshoppers in a given environment (Dadd, 1963, Kaufman, 1965, Toye, 1974). Apart from food, abiotic factors such as light intensity, temperature, relative humidity, precipitation and such other factors affect the distribution and abundance of grasshoppers. The effect of a combination of some or all of these factors has been found to affect the population dynamics of grasshoppers (Ross, 1964). Temperature is a vital condition in the development and growth of grasshoppers (Kaufman, 1965). Also, Amatobi *et al*, (1986) showed that temperature has a role to play in the diurnal activities of grasshoppers.

The life cycle of *Zonocerus variegatus* can be strongly regulated by the distribution and abundance of rainfall and vegetation types (Phipps, cited in De Gregorio, 1982). The availability of food plants in the form of green vegetation in the field plays an important role in the survival capacity and duration of life cycles of the grasshoppers' population (Corp and Okere, cited in Toye-Afolabi, 1982).

Furthermore, eggs laid in rainy seasons will have sufficient humidity which is essential for embryonic development in the first month following oviposition (Modder, 1978). Infact, *Zonocerus variegatus* oothecae cannot survive more than 15 days in completely dessicated soil (De Gregorio, 1989a). Chapman *et al* (1986) in a study on *Zonocerus variegatus* in Southern Nigeria discovered that most of the insects hatched in November and became adult in February or March (although the precise timing varied from year to year and place to place). The grasshopper may eat only a small part of the plants but they attack them at vulnerable points. They bite off grain heads and floax boll and so many injure the rest of the plant only slightly, (Steffernd, 1952).

As a result of their pest status, control measures are as a matter of necessity, employed by farmers from time to time to manage their population. The timing for execution of a control measure against the pest is of great importance for obtaining the required impact on the pest population for better crop yield.

The aim of this work therefore, is to obtain a baseline data on occurrence of *Zonocerus variegatus, Catantops spissus spissus* and *Cyrtacanthacris aeruginosa*, relative to monthly temperature, rainfall and relative humidity which are prerequisites for any control plan that may be carried out.

MATERIALS AND METHODS

This survey was carried out in experimental field 54 located in the Nigerian Institute for Oil palm Research (NIFOR) which was planted in the year, 2000. NIFOR is located on Altitude 149.4^{o} above sea level, between approximately Latitude 6^{o}33'N and Longitude 5^{o}37'E . This region experiences two seasons, the dry season (November to March) and the wet season (April to October).

There are a total of six hundred and seventy nine (679) oil palm trees in this field. Constituting the kinds of oil palm trees in this field are mainly those of the Dura and Tenera varieties; with the latter being relatively smaller in numbers. Survey was done on a twice-a-week interval of Tuesdays and Thursdays, within the hours of 6.30am and 8.30am. The whole survey lasted for four (4) months from April to July, 2007.

In the field, systematic Random Sampling technique was adopted, wherein one (1) row in every five (5) rows of palms were examined individually and the numbers of grasshoppers encountered, recorded. About ten (10) oil palm trees were randomly selected for survey in each row of oil palm in the field. On the next day of survey, the row next to the one that was surveyed first in the previous day of survey was treated first. Thirty (30) oil palm trees were surveyed for each day of survey. Preliminary identification was done in the Museum of the Entomology division of NIFOR where the external morphological features of the grasshoppers of interest; *Zonocerus variegatus*; *Catantops spissus spissus* and *Cyrtacanthacris aeruginosa*, especially their colour and shape, were noted.

In the field, observation of grasshoppers was done with the eyes, where grasshoppers of interest were looked for on the oilpalm tree being surveyed. Oilpalm fronds 17 and 25 were the plant parts examined for the grasshopper populations

Meteorological data were obtained from the Meteorological unit in NIFOR. Data collected during the period of survey were analyzed using the Duncan Multiple Range Test (DMRT) and simple linear correlation test to relate the grasshoppers' occurrence with the climatic parameters.

Results

A total of 8,185 grasshoppers belonging to 3 species *Zonocerus variegatus* (66.44%), *Catantops spissus spissus* (17.86%) and *Cyrtacanthacris aeruginosa* (15.70%) were recorded in this survey. The varying environmental parameters considered were rainfall, relative humidity and temperature. Rainfall and humidity increased from April to June with a slight drop in July while temperature decreased from April to June with a slight increase in July. (Table 1 and Fig.1)

Table 1: Climatic Parameters for the period of Survey

PARAMETERS	APRIL	MAY	JUNE	JULY
Rainfall (mm)	197.70	246.20	380.90	284.70
Temperature (^{0}C)	27.60	26.75	22.95	25.45
Relative humidity (%)	74.10	75.45	85.10	83.25

Table 2: Mean Occurrence of Grasshoppers Surveyed

MONTHS	***Zonocerus variegatus*** $\left[\overline{X} \pm S.E\right]$	***C. spissus spissus*** $\left[\overline{X} \pm S.E\right]$	***C. aeruginosa*** $\left[\overline{X} \pm S.E\right]$
April	7.75±0.32	6.24±0.72	6.38±0.80
May	12.97±0.55	10.14±0.80	10.05±0.62
June	14.48±0.60	10.80±0.92	11.85±0.91
July	14.71±0.29	12.63±0.34	11.31±0.32

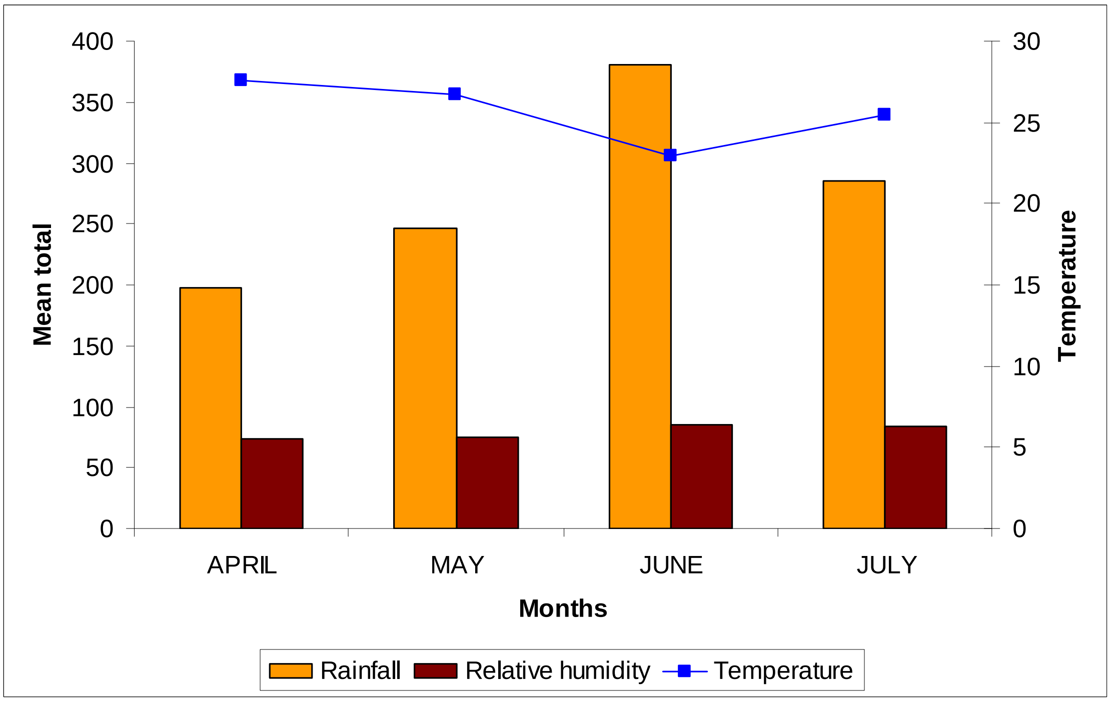

Fig 1: Climatic Parameters of the different months of survey.

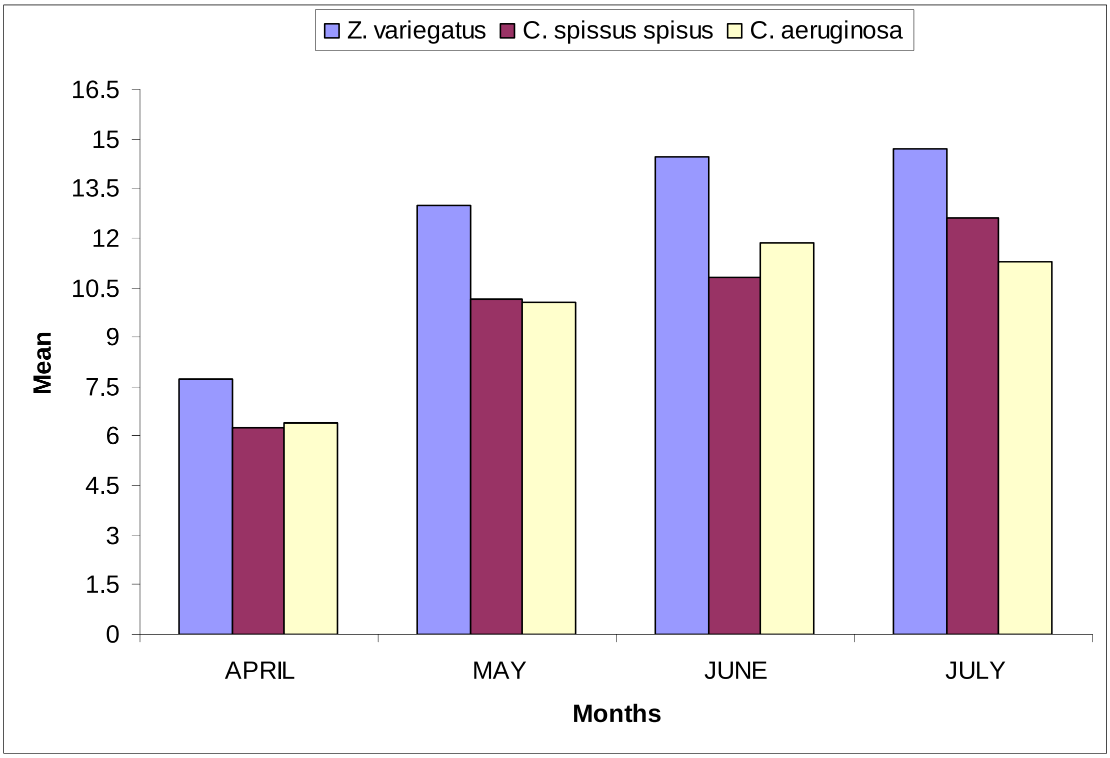

Fig 2: Mean occurrence of the grasshoppers surveyed for each month.

The mean occurrence of grasshoppers (*Z. variegatus* and *C. spissus spissus*) increased from April to July with the highest mean in July (*Z. variegatus*, 14.71±0.29 and *C. spissus spissus*, 12.63±0.34). For *C. aeruginosa*, the highest mean (11.85±0.91) was recorded in June (Table 2 and Fig.2). A direct relationship was observed between mean occurrence of grasshoppers, rainfall and humidity while an inverse relationship was observed for mean occurrence of the grasshoppers and temperature.

An increase in rainfall from the month of April, May and June brought about an increase in the occurrence of grasshoppers with the highest mean occurrence of *C. aeruginosa* (11.85±0.91) influenced by the highest rainfall in the month of June (380.90mm) but the highest mean occurrence of *Z. variegatus* 14.71±0.29 and *C. spissus spissus*, 12.63±0.34 was influenced by a slight drop in the total rainfall from June (380.90mm) to July (284.70mm).

The highest mean relative humidity recorded in June (85.10%) brought about the highest mean occurrence of *C. aeruginosa* in that same month. As for *Z. variegatus* and *C. spissus spissus*, their highest mean occurrence was recorded in July when there was a slight drop in relative humidity from its highest monthly mean in June (85.10%) to July (83.25%).

As the mean monthly temperature decreased from April (27.60^{o}C) through May (26.75^{o}C) to June (22.95^{o}C) and an increase in July (25.45^{o}C) the mean occurrence of *C. aeruginosa* increased from April to June and decreased. In July, that of *Z. variegatus* and *C. spissus spissus*, however conformed with that of *C. aeruginosa* regarding the temperature till July, where an increase in the temperature caused a concurrent further increase in their occurrence (Fig.1 and Fig.2)

The mean occurrence of the grasshoppers; *Zonocerus variegatus*, *Catantops spissus spissus* and *Cyrtacanthacris aeruginosa* were highly significant (P < 0.001) for the four months (April to July) period of survey. The multiple comparison test (Duncan Multiple Range Test, DMRT) was used to locate the source of significant difference (Table 3).

Table 3: Mean Rank of Grasshoppers Surveyed

GRASSHOPPERS	APRIL	MAY	JUNE	JULY	P-VALUE
Zonocerus variegates	98.22^{a}	222.02^{b}	259.92^{c}	288.93^{c}	P<0.001
Catantops spissus spissus	28.94^{a}	60.38^{b}	63.58^{b}	90.59^{c}	P<0.001
Cyrtacanthacris aeruginosa	33.25^{a}	66.08^{b}	72.72^{b}	82.44^{b}	P<0.001

Where
Similar letters indicate mean ranks that are not significantly different.
P < 0.001 = Very highly significant

The result showed that for *Zonocerus variegatus*, occurrence in April [Mean Rank (H) = 98.22] was significantly lower than May and that of May, significantly lower than June and July. However, June (H= 259.92) and July (H= 288.93) which had the highest mean occurrence were not significantly different from each other (April < May < June = July).

The highest significant value (H= 90.59) was recorded for *Catantops spissus spissus* in July, being also higher than April, May and June's. May (H= 60.38) and June's occurrence (H= 63.58) though significantly higher than April's occurrence, were not significantly different from each other. However, April's occurrence (H= 28.94) is significantly the lowest for the entre survey period. (April < May = June < July).

Cyrtacanthacris aeruginosa had in April, its significantly lowest occurrence (H= 33.25). Nevertheless, May (H= 66.08) June (H= 72.22) and July's (H= 82.44) occurrence were not significantly different from each other (April < May = June = July) (Table 3).

The result of a simple linear correlation test run between the mean occurrence of each grasshopper and the climatic data revealed the strongest positive correlation of r=+0.850 between mean monthly occurrence of *Cyrtacanthacris aeruginosa* and monthly total rainfall, likewise the mean monthly occurrence of *C. aeruginosa* and mean monthly relative humidity. The strongest negative correlation of r=-0.817 was observed between the mean monthly occurrence of C. *aeruginosa* and mean monthly temperature.

However, negative correlation was observed between the mean monthly occurrence of all the grasshoppers surveyed and the mean monthly temperature (Table 4).

Table 4: Correlation between occurrence of each grasshopper surveyed and climatic parameters for the period of survey

GRASSHOPPERS VS CLIMATE PARAMETERS	CORRELATION RESULT
Zonocerus variegatus vs RAINFALL	+0.774
Zonocerus variegatus vs TEMPERATURE	-0.736
Zonocerus variegatus vs RELATIVE HUMIDITY	+0.804
Catantops spissus spissus vs RAINFALL	+0.634
Catantops spissus spissus vs TEMPERATURE	-0.602
Catantops spissus spissus vs RELATIVE HUMIDITY	+0.767
Cyrtacanthacris aeruginosa vs RAINFALL	+0.850
Cyrtacanthacris aeruginosa vs TEMPERATURE	-0.817
Cyrtacanthacris aeruginosa vs RELATIVE HUMIDITY	+0.850

Where
r value close to +1= the two factors are strongly correlated positively.
r value close to -1= the two factors are strongly correlated negatively.
r value close to 0 = the correlation is poor.

Discussion

This present study reveals the varying occurrence of *Zonocerus variegatus*, *Catantops spissus spissus* and *Cyrtacanthacris aeruginosa* in NIFOR. The results of the increase in the monthly occurrence of the grasshoppers on the oil palm trees with increasing monthly rainfall total agrees with the findings of Centre for Overseas Pest Research, London (COPR) and Okere (cited in Toye-Afolabi, 1982) that the availability of food plants in the form of green vegetation in the field plays an important role in the survival capacity and duration of life cycles of the *Zonocerus variegatus* population. In this study, this increase along side rainfall total for each month was observed especially in occurrence of *Cyrtacanthacris aeruginosa*. Rainfall of course brings about greenness in vegetation and when these vegetations are fresh, enough food becomes available to organisms. These organisms tend to blossom, reproduce and survive the more. Phipps (cited in De Gregorio, 1982) and De Gregorio (1982) also reported that the lifecycle of *Zonocerus variegatus* could be strongly regulated by the distribution and abundance of rainfall and vegetation types.

Messi *et al*. (2006) also reported that oviposition in *Zonocerus variegatus*, occurred in the rainy season when the soil is soft and thus allows the ovipositor to penetrate easily into the ground. Furthermore, eggs laid in rainy season will have sufficient humidity which is essential for embryonic development in the first month following oviposition (Modder, 1978). In fact, *Zonocerus variegatus* oothecae cannot survive more than fifteen (15) days in completely desiccated soil (De Gregorio, 1989a). Most grasshoppers, including *Zonocerus variegatus, C. spissus spissus* and *Cyrtacanthacris aeruginosa* live on or near their host plants. Chapman *et al*. (1986) discovered that in *Z. variegatus* populations, the availability of food plants affects the number of eggs produced by females and so; changes in the host plants can affect the fertility of the adults and induce changes in the size of the hatching population.

The response of arthropods to different humidity gradients as first demonstrated by Shelford (1913) was observed in this study. The three (3) grasshoppers surveyed, all had their first and second mean monthly lowest occurrence in concurrence with the first and second lowest mean monthly relative humidity in the field. The only variance in this trend was in the third and fourth month where *Cyrtacanthacris aeruginosa'*s rose and fell in the third and fourth month consecutively, as the relative humidity. However, *Zonocerus variegatus* and *Catantops spissus spissus* did the opposite.

Varying correlation existed between the grasshoppers and the climatic parameters throughout the period of this study. The strongest positive correlation of r = +0.850 was observed between the mean occurrence of *Cyrtacanthacris aeruginosa* and rainfall and *C. aeruginosa* and relative humidity while the strongest negative correlation of r = -0.817 was observed between *C. aeruginosa* and temperature. It might have been possible to observe a negative correlation in those pairs that had positive values and those with negative values, having positive correlation values if this study had extended into the dry season periods. However, Fasoranti and Ajiboye (1993) reported cases of grasshoppers [*Zonocerus variegatus* (Linn)] with large dry season population in South Western Nigeria. This study carried out in NIFOR, a humid zone of the South Southern part of Nigeria, which started at the beginning of the rains, revealed an increase in occurrence of all the grasshoppers surveyed, directly proportional to increasing relative humidity and rainfall and decreasing temperature.

The impact of various climatic parameters on the occurrence of the various grasshoppers revealed through this work has shown that their occurrence (*Zonocerus variegatus*, *Catantops spissus spissus* and *Cyrtacanthacris aeruginosa*) correlate negatively with environmental temperature and positively with rainfall and relative humidity. These grasshoppers are certainly insect pests capable of causing severe harm to our crop plants when their occurrence in the field has reached its pest status which some authors suggests is reached when there is a 5% loss in a particular crop yield.

Pest control can only be introduced if a pest problem is believed to exist actually or potentially. Actually, in the sense that its presence in the field has reached its Economic Injury Level and potentially in that, conditions necessary to cause its activities as a pest in the environment or field is not present yet. The population of these grasshoppers especially *Z. variegatus* as encountered in this survey calls for concern in finding ways of introducing necessary measures in controlling their population especially before the onset of the rains in which they flourish as revealed through this study.

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