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Abundance of *Zonocerus variegatus* (L.) (Orthoptera: Pyrgomorphidae) in the Natural Herbaceous Fallow and Planted Forest: Effect of *Chromolaena odorata* (Asteraceae)

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Abstract: This study assesses the abundance of *Zonocerus variegatus* in 2 natural herbaceous fallow and 2 planted forest types of the forest reserve of Mbalmayo (Cameroon) with the aim of testing the hypothesis that the high abundance of the grasshopper is linked to the presence of *C. odorata*. In each of 3 replications of each treatment, we carried out once every 14 days (from February, 2002 to December, 2003), regular collection and observation with sweep netting for a period of 30 mn. The results showed that, *Z. variegatus* is found in herbaceous fallows, but is extremely rare in the *Inga edulis* planted fallow. Within natural herbaceous fallows, it is significantly more abundant in those with, than in those without *C. odorata*, only in the dry season. No individuals were observed in the type I planted forest (without *C. odorata)* while 0.29 individuals were captured in the type II (with *C. odorata*). These data suggest that the type of vegetation has an important effect on *Z. variegatus* abundance.

Key words: Fallow, planted forest, *C. odorata*, variegated grasshopper

INTRODUCTION

The exclusively African variegated grasshopper *Zonocerus variegatus* (L.) (Orthoptera: Pyrgomorphidae) is the main grasshopper crop pest in over twenty countries, which occupy the extensive forest and savanna areas of West and Central Africa (Modder, 1994). *Z. variegatus* is a non-migratory grasshopper, which may avoids the pure forest (Modder, 1994); cleared forest areas seem particularly suitable for the grasshopper (Modder, 1994; Kekeunou *et al*., 2005). There is no quantitative data to support these suggestions. In its natural habitat, *Z. variegatus* has six larvae stages; stage 1-3 larvae are gregarious while stage 4-6 larvae and adults are solitaries (Chiffaud and Mestre, 1990). In Southern Cameroon, *Z. variegatus* is present throughout the year in the undegraded and degraded zones in two univoltine populations, which has unequal abundance and durations (Messi *et al*., 2006). *Z. variegatus* live and feed on about 300 host plant species, including a wide range of plantation and subsistence crops (Chiffaud and Mestre, 1990; De Gregorio, 1989a,b). *Chromolaena odorata* (Asteraceae) is a most dominant herbaceous species in newly cleared areas in forest and along roadsides (Chapman *et al*., 1986). It is known to be one of the most important host plants of *Z. variegatus*, because it is consumed by all the post embryonic stages, it provides sites for laying and shelters and also serve as a source of Pyrrolyzidine Alkaloids for *Z. variegatus* (De Grégorio 1989b; Chiffaud and Mestre, 1990; Timbilla *et al*., 2007). From the southern Cameroon farmers' point of view, the damage caused by *Z. variegatus* is higher in fields adjacent to *C. odorata* and herbaceous

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fallows than in those adjacent to forests and shrubby fallow (Kekeunou *et al*., 2006). In this study, we testing the hypothesis that the high abundance of the grasshopper is linked to the presence of *C. odorata* (Toye-Afolabi, 1974). It is generally established that the occurrence of acridid species primarily depends on the presence of host plant species (Kemp In Joshi *et al*., 1999). In Cameroon, short fallow systems (1-5 years) are dominated by *Chromolaena odorata* (Asteraceae). Because of the lack of adequate fertility, some leguminous species like *Inga edulis* are used for their improvement (IITA, 1998).

This paper evaluates the abundance of *Z. variegatus* (L.) (Orthoptera: Pyrgomorphidae) in natural herbaceous fallows and planted forests, with the aim to understand the effect of *Chromolaena odorata* presence on *Z. variegatus* population.

MATERIALS AND METHODS

Study Site

The study was carried out in the experimental station of the International Institute of Tropical Agriculture (IITA) located in the forest reserve of Mbalmayo (3°27'- 4°10'N and 11°32'-11°49'E, elevation = 600-1042 m asl), which covers approximately 109.3 km^2 surface (Holland *et al*., 1992). Approximately 94.5% of this area is occupied by dense humid forest characterized by an abundance of Sterculiaceae and Ulmaceae (Holland *et al*., 1992). In the forest reserve, the forest canopy is irregular with towering emergent trees overtopping the main stratum of dominants, with smaller shade-dwelling trees below (Holland *et al*., 1992). In the undisturbed areas, the forest floor is relatively free of herbs, but there are many tree seedlings and saplings living in the shade below the canopy. This seedling bank is ready to compete for the increased light in a canopy gap when a decayed specimen collapses or a tree is brought down by lightning (Holland *et al*., 1992). The experimental station is an open area of approximately 400×400 m in which, the natural vegetation, consists of *Chromolaena odorata*, *Mucuna* sp., *Triumfeta cordifolia.* The rainfall pattern is bimodal, characteristic of equatorial climate. The small rainy season (March to June) is followed by the small dry season (July to August), and the great rainy season (September to November) is followed by the great dry season (November to March). The mean annual rainfall total for Mbalmayo from 35 years of data is 1513 mm, with a maximum of 1990 mm (1950) and minimum of 1017 mm (1946) (Holland *et al*., 1992). Overall there are six months in which average maximum temperature exceeds 30°C, December through to May. The monthly average minimum temperature is very stable, between 16.5 and 17.5°C (Holland *et al*., 1992).

Experimental Design

The observations were carried out in 4 types of existing fallows: two planted *I. edulis* forest (about 8 years old) and two natural bush fallows (4 years old) (one with *C. odorata* and another without *C. odorata*). The planted forest. Based on *C. odorata* presence, specific richness, presence and structure of herbaceous and shrubby layers, two types of *I. edulis* planted forest can be distinguished (type I and II). The trees of these two forests have heights of approximately 8 m; these trees are equidistant approximately 1 m (Table 1). These two forests installed on a surface of approximately 1500 m^2 and separated by a distance of about 20 m. In type I, the herbaceous layer was weak and poor and deprived of *C. odorata.* The shrubby layer was absent. Type II, consists of an herbaceous layer dominated by *C. odorata.* In these two types of *I. edulis* forest, many plant species were found in *Z. variegatus* diet (Chiffaud and Mestre, 1990). In type I, specific richness (S = 28) is higher than that of type II (S = 24). Only 6 species were simultaneously present in the two types (*Ficus exasperata*, *Lavigeria macrocarpa*, *Mallotus opasitifolium*, *Manihot esculenta*, *Rhinoria dentata* and *Terminalia* sp.,). In each of these planted forests, captures were done in three selected 11.5×10.5 m plots. The herbaceous fallows. Three replicates (11.5×10.5 m) of each of two

Table 1: Main characteristics of two types of planted *Inga edulis* forests

Inga edulis forest	Height of the trees	Tree canopy	Litter	*Chromolaena odorata*	Herbaceous layer	Shrub layer	Arborescent layer the	Sunning of under story
Type-1	About 8 m	Joint	Abundant and rich in leaves and fruits of *I. edulis*	Absent	Poor and slightly abundant in species	Absent	Present	Null
Type-2	About 8 m	Joint	Abundant and rich in leaves and fruits of *I. edulis*	Present	Abundant and rich in species	Present	Present	Null

herbaceous fallow types (with *C. odorata* and without *C. odorata*) were selected in the existing natural vegetation, surrounding the planted forest (in a distance of about 20 m). The natural herbaceous fallows were entirely dominated by *C. odorata*. Therefore, monthly mechanical extirpation was needed to remove *C. odorata* in order to create the without *C. odorata* treatment.

Sampling Procedure

Samples of *Z. variegatus* were collected by sweep netting for a period of 30 min in each plot (11.5×10.5 m) (Duranton *et al*., 1987; Dent, 1999). We carried out regular collection and observation once every 14 days in each fallow. Initially, we started the capture in the *I. edulis* forest type I, from February 2002 to February 2003. To confirm observed absence of *Z. variegatus* in this planted forest (without *C. odorata*), sampling was extended from June 2003 to December 2003 into the 4 types of fallow (herbaceous and forest with and whitout *C. odorata*). All the collections were started from a fixed point (chosen alternatively from the four corners) and extended across the entire plot. The collected individuals were kept in aerated bags and the individual numbers were counted by stage (larval and adult stages) and sex in the field. Thereafter, they were released at the plot where they were collected.

Statistical Analysis

Statistical analysis was carried out using SAS ver. eight (SAS Inc., Chicago, Illinois, USA). The averages were calculated by the MEANS procedure' and compared by the Fisher ANOVA test using the GLM procedure. A pair of data was compared with Student Newman-Keuls test. All probabilities were appreciated at 5%.

RESULTS AND DISCUSSION

The levels of *Z. variegatus* population in the fallow vegetation depended on the vegetation type available (Table 2). The highest abundance was observed in natural herbaceous fallows and *Z. variegatus* is extremely rare in the planted *I. edulis* forest. This results confirm the assumptions of Modder (1994) that herbaceous fallows are an ideal habitat for *Z. variegatus* population. In fact, the majority of species consumed by *Z. variegatus* are found in the herbaceous fallows (Chiffaud and Mestre, 1990). Most grasshoppers including *Z. variegatus* live on or near their host plants. The ratio of host to non-host plants in an ecosystem plays an important role in determining the herbivore abundance (Rao *et al*., 2000). The abundance in the planted forest (*I. edulis)* was very weak because, *Z. variegatus* is an heliophilous insect (De Gregorio, 1989a,b). The herbaceous vegetation is sunny than forest under story. Forests under story maintain a shade and humidity hostile to the presence of *Z. variegatus*. Within closed forest, high humidity always favors *Entomophaga grylli*, which induces high mortality of *Z. variegatus* (Chapman *et al*., 1986; Modder, 1994).

The present study also showed that, within the herbaceous fallows the abundance was two fold greater in the fallows with (48 individuals) than those without (24 individuals) *C. odorata*. No

Table 2: Number of *Zonocerus variegatus* captured in 30 min in 2 herbaceous fallows and 2 planted forest types

Vegetation types	Gregarious larvae	Solitary stages larvae 4	Larvae 5	Larvae 6	Adults	All stages
C. odorata (natural fallow) fallows	40.67a	3.18a	2.85a	1.44a	0.1500	48.28a
Natural fallow without *C. odorata*	20.62ab	1.62b	1.08b	0.85a	0.1300	24.28ab
I. edulis forest without *C. odorata* in the understory	0.00b	0.00c	0.00b	0.00b	0.0000	0.00b
I. edulis forest with *C.odorata* in the understory	0.03b	0.15c	0.26b	0.10b	0.0500	0.29b
p-value	0.0100	<0.0001	<0.0001	0.0002	0.2094	0.0011
F-value	3.9200	8.3100	9.3000	6.8200	1.5300	5.6300
Means	15.3300	1.2400	1.0500	0.6000	0.0800	18.2900

p-value is the significance level of Fischer test-ANOVA (GLM). Similar letter(s) indicate non-significant differences

Table 3: Number of *Zonocerus variegatus* captured in 30 min during the rainy season in 2 herbaceous and 2-planted forest types

Vegetation types	Gregarious larvae	Solitary stages Larvae 4	Larvae 5	Larvae 6	Adults	All stages
C. odorata (natural fallow) fallows	92.58a	3.00a	0.3300	0.0800	0.0000	96.00a
Natural fallow without *C. odorata*	57.75ab	1.67ab	0.2500	0.0800	0.0800	59.83ab
I. edulis forest without *C. odorata* in the understory	0.00b	0.00b	0.0000	0.0000	0.0000	0.00b
I. edulis forest with *C.odorata* in the understory	0.08b	0.17b	0.1700	0.0000	0.0000	0.42b
p-value	0.0634	0.0790	0.3046	0.5770	0.4018	0.0487
F-value	2.6100	2.4200	1.2500	0.6700	1.0000	2.8400
Means	37.6100	1.2100	0.1900	0.0400	0.0200	39.0600

p-value is the significance level of Fischer test-ANOVA (GLM). Similar letter(s) indicate non-significant differences. Rainy season = Great and small rainy season

Table 4: Number of *Zonocerus variegatus* captured in 30 min during the dry season in 2 herbaceous and 2-planted forest types

Vegetation types	Gregarious larvae	Solitary stages Larvae 4	Larvae 5	Larvae 6	Adults	All stages
C. odorata (natural fallow) fallows	17.59a	3.26a	3.96a	2.04a	0.2200	27.07a
Natural fallow without *C. odorata*	4.11ab	1.59ab	1.44b	1.19a	0.1500	8.48b
I. edulis forest without *C. odorata* in the understory	0.00b	0.00b	0.00b	0.00b	0.0000	0.00c
I. edulis forest with *C.odorata* in the understory	0.00b	0.15b	0.30b	0.15b	0.0070	0.67c
p-value	0.0753	0.0012	<0.0001	0.0002	0.2376	0.0013
F-value	2.3600	5.7000	9.8800	7.2700	1.4300	5.6500
Means	5.4300	1.2500	1.4300	0.8400	0.1100	9.0600

p-value is the significance level of Fischer test-ANOVA (GLM). Similar letter(s) indicate non-significant differences. Dry season = Great and small dry season

individuals were observed in the type I planted forest (without *C. odorata)* while 0.29 individuals were captured in the type II (with *C. odorata*) (Table 2). This absence of *C. odorata* in the fallows induce a significant fall of *Z. variegatus* abundance only in the dry season (Table 3 and 4). This results confirm the Toye-Afolabi (1974) assumption that, increase in the dry season populations of *Z. variegatus* is linked to the spread of *C. odorata*. This result is explained by the fact that, in the dry season, most of *C. odorata* plants are in bloom (Mbarga, 1985). *Z. variegatus* is strongly attracted to flowers of *C. odorata* and grasshopper consumes the flowers in large numbers (Modder, 1984; Marks and Seddon, 1985). *Z. variegatus* consumes the pyrrolizidic alkaloids rinderine and intermedine from the flowers of *C. odorata* and transforms them into lycospamine and echinatine, respectively (Robins, 1995). *Z. variegatus* would use these pyrrolizidic alkaloids in the manufacture of the secretions of the repellent glands. These information's could be useful in est management strategies. But, before final conclusion, complementaries studies need to be carried out on the effect of the non nutritional relationship between *Z. variegatus* and *C. odorata*.

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