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Population fluctuation of *Diastocera trifasciata* (Fabricius, 1775) (Coleoptera: Cerambycidae), cashew branches girdler in the Brobo locality (Central Côte d'Ivoire)

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Abstract

Diastocera trifasciata (Coleoptera: Cerambycidae), formerly known as the *Analeptes trifasciata,* is a fearful girdler of cashew branches in Côte d'Ivoire. The lack of effective means of control and data on the dynamics of this species motivated the present work which aims to study the fluctuations of its population. Specifically, the aim is to determine the period of occurrence of the species, to study the interactions between abiotic and biotic factors and the population of *D. trifasciata*. Study was conducted from October 2015 to September 2017 in three orchards located in three villages. Manual captures were made on 150 cashew trees per orchard every two weeks during the two years of study. Temperature, relative humidity and rainfall of the area were recorded. Results revealed that there is a significant positive correlation between rainfall and *D. trifasciata* population. During the two years of study, adults were observed from May after the first rains and persist until January of the following year with a peak in October. No adults were observed from February to April, a period corresponding to the dry season. Mean temperature revealed a significant negative correlation, in contrast to the mean relative humidity being positively correlated with the pest population. Peaks of individuals were recorded when the trees were in the pre-floral vegetative flush phase. All this information guides the choice of the method and the moments of intervention for an efficient fight.

Keywords: Population, fluctuation, *Diastocera trifasciata,* cashew girdler, Côte d'Ivoire

1. Introduction

The cultivation of cashew has developed in West Africa because of its great hardiness and its many products. It grows preferably at altitudes below 1000 m, in warm tropical areas with alternating dry and wet seasons. It adapts to a various types of soils, but prefers light, sandy, deep, well-drained soils with 25% clay content [1].

Introduced between 1959 and 1960 in Côte d'Ivoire to fight against the threats of desertification [2], the cashew tree is now cultivated in the North, North-West, North-East and Central Ivory Coast regions. With cotton, it constitutes one of the two main cash crops and important source of income for the populations of these most deprived areas of the country [3]. Since 2015, Côte d'Ivoire has become the leading exporter of cashew nuts, providing 25% of world production. However, despite its importance, culture faces many constraints that threaten its sustainability.

Indeed, it is recognized that insect pests are a major source of crop losses in many cashew cultivation areas in Africa [4]. Of all insects infesting cashew, *Diastocera trifasciata* formerly known as *Analeptes trifasciata* is the one that causes serious branches and / or trunk losses to the crop [5]. Adults cut branches and / or trunk into the larger crop and the female lays her eggs inside [5-7]. The infestation rate ranges from 40% to 80%, resulting in up to 55% yield loss of cashew [8].

Unfortunately, since the first description of its damage in Côte d'Ivoire in 1964 [9]**,** no study has been done on the dynamics of its population. The distribution of the species was monitored over one year in Nigeria, where the species showed periods of high and low population levels [10]. But what about the behaviour of individuals in Côte d'Ivoire? Is the species present all year round? What are the periods of high outbreaks of the species in orchards? What is the influence of abiotic and biotic parameters on *D. trifasciata* populations? The answers to all these questions remain unknown in Côte d'Ivoire. However, knowledge of the parameters controlling population dynamics is essential for better pest management. It is therefore important to understand the different population fluctuations of these pests according to the phenological stages of cashew, rainfall, temperature and relative humidity for an effective control of this pest. The purpose of this study was to study the fluctuation of *Diastocera trifasciata* in orchards in the Brobo locality.

2. Materials and Methods

2.1. Study area

The studies were conducted in the locality of Brobo located 20 km from Bouaké on the axis Bouaké-M'Bahiakro, in the center of Côte d'Ivoire (latitude : 07°36.598 N, longitude : 004°49.590 W, altitude 253 m). The climate of the zone is of the transitional equatorial type, characterized by four seasons. There is long dry season from November to February, marked by the harmattan, which continually blows from December to February, a long rainy season from March to June, a small dry season from July to August and a small rainy season from September to October. Rainfall ranges from 1,200 to 1,500 mm, but is erratic [11]. The average temperature ranges from 20°C to 27.5 °C. Relative humidity ranges from 57% to 85% [12].

2.2. Study sites

The choice of each Orchard site was based on several criteria: it must be attacked by *D. trifasciata*, it must have an area of at least 1 ha, it must be accessible all year round, and it must remain without any form of insect control throughout the study. Thus, three peasant orchards with an area of 3 ha were selected: site 1 well maintained, site 2 well maintained, site 3 less maintained. The three sites are approximately 5 Km apart.

2.3. Study of the fluctuation of the population of *D. trifasciata*

The study was conducted from October 2015 to September 2017.

2.3.1. Experimental device

At each site, population sampling was done by the transect method along one of the diagonals of the field. On each transect, three non-contiguous blocks (B1, B2 and B3) were determined with one at each of its two ends and one in the middle for each site. This method used by Ouédraogo [13] has been adapted for this study (Figure 1). Each block consists of 51 cashew trees, so a total of 153 trees per site. All selected trees were numbered and marked with red paint. No insecticide treatments were applied to the sites during the study period.

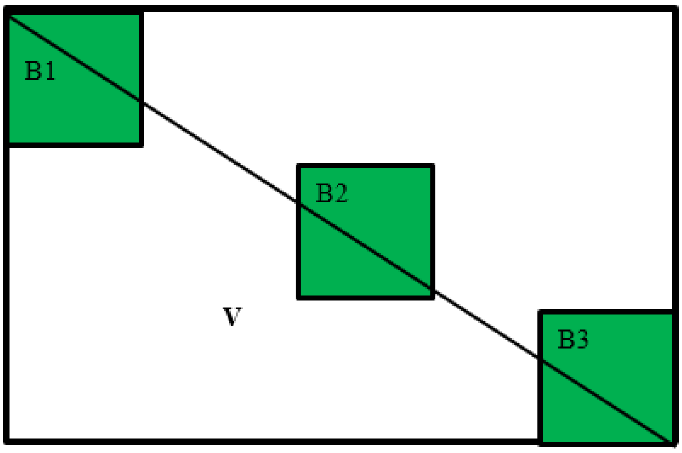

Fig 1: Experimental device for the sampling of individuals *D. trifasciata* V = orchard; B1 = block 1; B2 = block 2; B3: block 3

2.3.2. Collection and counting of *D. trifasciata*

In each block, trees were inspected every two weeks from October 2015 to September 2017. All individuals observed on each marked tree were captured by hand or with a pole. They were put in collection boxes containing alcohol at 70°. The site, the date of capture, the number of individuals captured and the phenological stage of the trees were marked on the collection boxes and on the survey sheet. Counting of individuals was done by sex. The sexual dimorphism of these insects was observed by the length of the male antennae which largely exceeds the length of the body, whereas they were limited in females at the apex of the elytra (Akessé, article submitted). The numbers of captured males and females were recorded and the average number of individuals per month was calculated.

2.3.3. Collection of abiotic data

To assess the influence of these abiotic factors on the evolution of the *D. trifasciata* population, temperature and relative humidity were collected using a permanently installed El-USB-2 data Logger in an orchard. The rainfall was measured using a direct reading pluviometer installed at site 2.

2.3.4. Collection of biotic data

The relationship between tree phenology and changes in population levels of *D. trifasciata* was determined. The phenological stages of the trees were recorded during the different capture. The stages considered are vegetative growth, flowering and fruiting.

2.4. Statistical Analysis

All data processing was performed using the Statistica Version 7.1 software. Analysis of variance (ANOVA) and Newman-Keuls test at the 5% threshold made it possible to analyze and compare the averages. The Pearson correlation test was conducted to investigate the relationship between mean temperature (°C), mean relative humidity (%), rainfall (mm), and *D. trifasciata* population.

3. Results

3.1. Population Fluctuation of *D. trifasciata* in the three orchards.

The results show that for all sites, 40,613 individuals were captured in two years in cashew orchards. These catches are divided into 21,024 females (51.77 %) and 19,589 males (48.23%). Females outnumbered males at all sites ($p < 0.05$). By analyzing Figure 3, site 1 recorded the highest average number of individuals with 897.16 individuals, followed by site 2 (484.37 individuals) and site 3 (311.92 individuals). The number of individuals captured in year 1 (October 2015 - September 2016) is higher than in year 2 (October 2016 - September 2017) at sites 1 and 2 (Figure 2). In year 1, the average number of individuals was 926.83 against 867.5 in year 2. However, analysis of variance revealed a non-significant difference between these two numbers ($p > 0.05$).

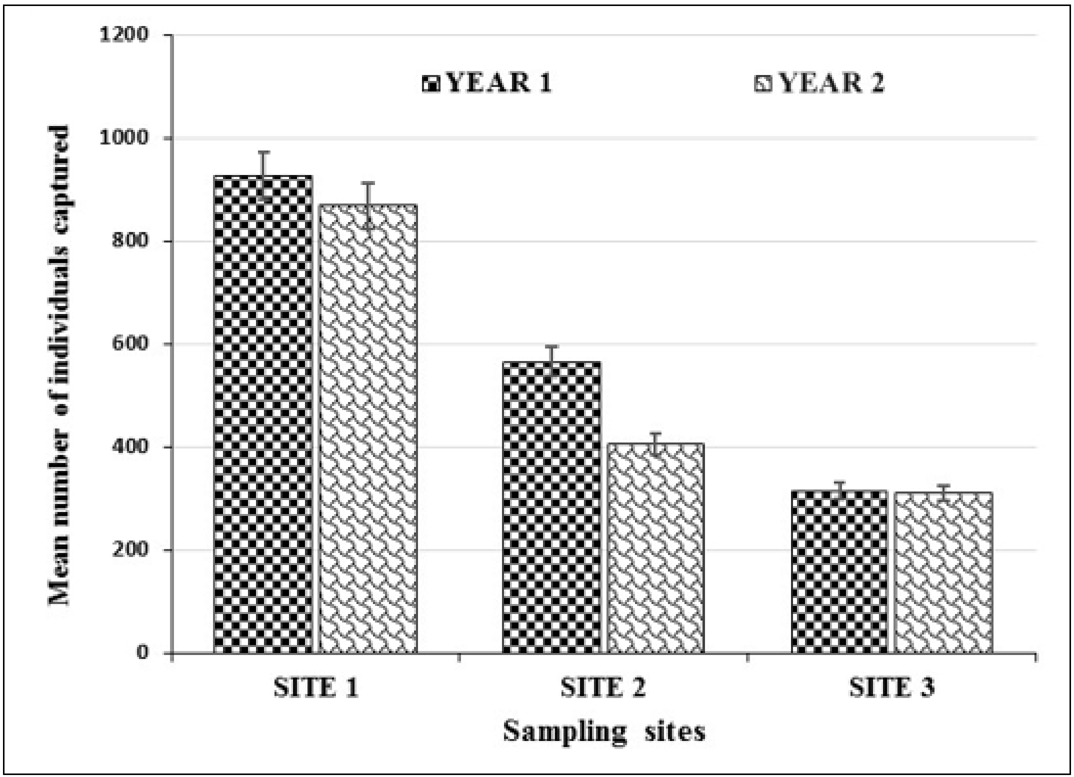

Fig 2: Mean numbers of adults of *D. trifasciata* by site during two years of study. The error bars represent the percentage

3.2. Influence of abiotic factors on the population fluctuation of *D. trifasciata*

The table 1 presents the matrix of Pearson's correlation coefficients R between the population of *D. trifasciata* at each site and the climatic parameters.

Table 1: Matrix of correlation coefficients (R) between catch sites and climate parameters from October 2015 to September 2017

Parameters	Designation	Site 1	Site 2	Site 3
Temperature (°C)	r	-0,80	- 0,75	-0,78
	P-value	0,000	0,000	0,000
	Sample	24	24	24
Relative humidity (%)	r	0,85	0,82	0,84
	P-value	0,000	0,000	0,000
	Sample	24	24	24
Rainfall (mm)	r	0,60	0,62	0,60
	P-value	0,002	0,001	0,002
	Sample	24	24	24

p: 5% threshold probability values; Pearson correlation coefficients (R)

3.2.1. Influence of rainfall on population fluctuation of the adult of *D. trifasciata*

The Figure 3 shows that the evolution of the population follows that of rainfall (Table 1). In general, insects begin to appear from May after the first rains and persist until January. On the other hand, there is a total disappearance of adult insects from February until April when rainfall is low or even zero. In 2016, the peak of the population is recorded in October which corresponds to the wettest month of the year (446 mm). Observation of the curve shows that the period of occurrence of adults extends from May to January.

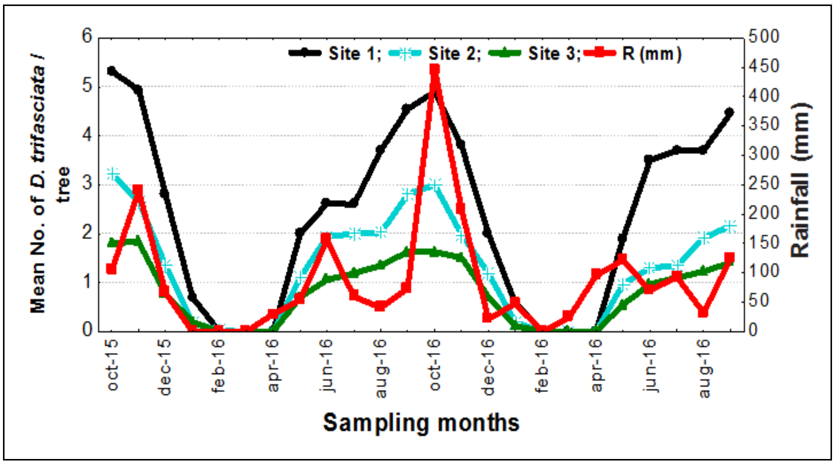

Fig 3: Population Fluctuation of *D. trifasciata* on cashew trees in relation to rainfall from October 2015 to September 2017

3.2.2. Influence of temperature on population fluctuation of adult of *D. trifasciata*

The Figure 4 reveals a significant negative correlation between the fluctuation of adults of *D. trifasciata* and the mean temperature of the sites (Table 1, $p < 0.05$). The analysis of the curve reveals that whatever the study site, the two factors evolve inversely. The highest population levels are observed in the months of September and October when the average temperature is below 25 ° C. From November, when the average temperature is above 25°C, the level of the population begins to drop drastically until January. During the warmer periods from February to April, there are no adult captured.

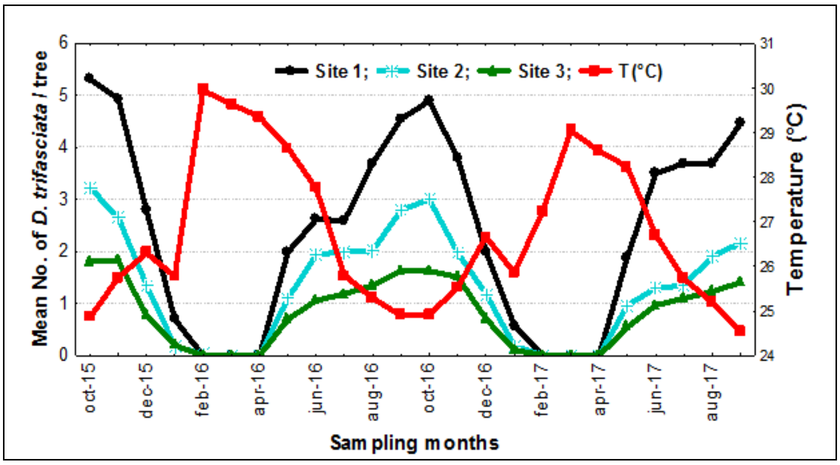

Fig 4: Population Fluctuation of *D. trifasciata* on cashew trees in relation to average temperature from October 2015 to September 2017

3.2.3. Influence of relative humidity on Population fluctuation of adult of *D. trifasciata*. The Figure 5 illustrates the positive influence of relative humidity on the evolution of the adult population of *D. trifasciata*. As the population decreases, the relative humidity also decreases. There was a significant positive correlation between population change and relative humidity (Table 1, $p < 0.05$). The relative humidity is high in the months of September and October, when peaks of individuals are recorded.

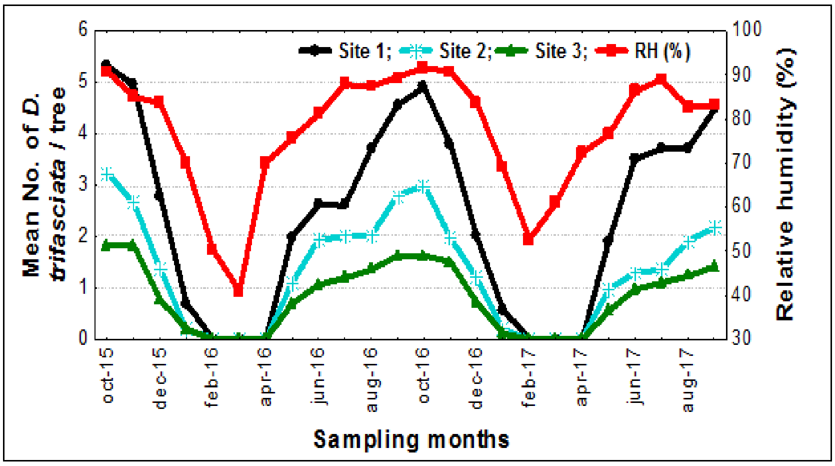

Fig 5: Population Fluctuation of *D. trifasciata* on cashew trees in relation with relative humidity from October 2015 to September 2017

3.3. Influence of biotic factors (host plant phenology) on the population fluctuation of *D. trifasciata*

The various stages recorded are the first vegetative growth (post-harvest) which takes place from May to August, the second most important vegetative growth (pre-floral) occurs from September to November, the flowering takes place in December and January, fruiting is observed from February to April.

The first individuals are recorded in May when the trees are in the post-harvest vegetative growth stage. The population evolves progressively until reaching the maximum between September and October when the trees are in the pre-floral vegetative growth. From December to January, trees flower and the number of individuals decreases until the total disappearance of individuals in February. From February to April, while trees are in the fruiting stage, adults are absent in orchards (Figure 6).

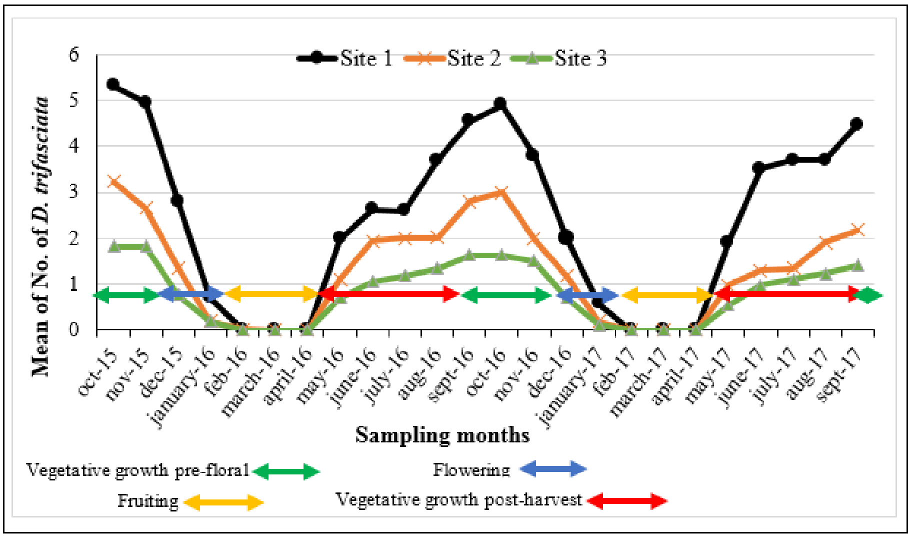

Fig 6: Population Fluctuation of *D. trifasciata* on cashew trees following phenological stages from October 2015 to September 2017

4. Discussion

The results of this study revealed that the *D. trifasciata* population fluctuates over time in relation to the various abiotic and biotic factors considered. During the two years of study, site 1 recorded more insects 52.94% of the catches compared to other sites. This difference could be explained by the attractiveness of the trees from one orchard to another, by the level of attacks and the previous maintenance of the plots before the study. The rate of females captured was 51.77% as against 48.23% for males at all three sites. These results corroborate those of Cláudia *et al.* [14] who noted that females of *Onciderini* species (Coleoptera Cerambycidae: Lamiinae) found in Brazil were more abundant than males. In contrast, Asogwa *et al*. [10] found no significant difference between the number of males and females of *D. trifasciata* in Nigeria. Catches in the first year would influence the size of the next generation through a gradual reduction in the number and consequently the number of eggs and the number of individuals in subsequent stages.

The evolution of the *D. trifasciata* population, despite the reduction from the first to the second year, followed the same trend. Indeed, insects begin to appear in May after the first rains and the highest abundance of adults is obtained in October in the rainy season. No adults were observed and captured in orchards between February and April corresponding to the dry season. As a result, the fluctuation of the adult population of *D. trifasciata* is seasonal with an occurrence period of 09 months from May to January. Various authors have reported similar results on the occurrence and disappearance of Cerambycidae adults in the wild. In Africa, Dwomoh *et al*. [15] reported that *D. trifasciata* adults were present in orchards in Ghana between September and March, Asogwa *et al*. [10] between November and March in Nigeria during the rainy season. However, in the tropical forests of Guyana, the rainy season is the period when adult abundance of some species of Cerambycidae is reduced [16]**.** Similarly, Aneni *et al.* [17] reported that the *Coelaenomenodera elaeidis* beetle was more abundant in the dry season.

The appearance of adults in May after the first rains and their presence only during the rainy season would be linked to the availability of food resources, which is essential to the life of Cerambycidae Lamiinae. These are exclusively related to reproduction, they must feed after emergence of foliage and soft bark of the host plant before reaching sexual maturity [18]. In this way, the activity of the adults of this group would be synchronized with the rainy season which implies a greater availability of resources. Host plants would then produce tissues suitable for feeding adults, and the larvae will complete their development to emerge [19]**.**

When taking into account the influence of the average temperature on the population, the correlation was significantly negative. The drop in the level of the population from November until their total disappearance is due to the gradual rise in temperature. This temperature level would exceed the adult survival threshold of *D. trifasciata*. Marchioro and Foerster [20] reported that the influence of temperature on insect abundance is noted when the temperature exceeds the lower and higher development thresholds thus causing insect mortality. Similarly, Keena and Moore [21] reported that temperature influences development time, survival and reproduction of insects. The highest catches were recorded during the low temperatures months. Although many studies have concluded that insect pests will become more abundant as temperatures increase [22, 23].

Analysis of the influence of relative humidity on the fluctuation of *D. trifasciata* shows that high relative humidity values are favorable for the development of adults of *D. trifasciata*. Similar observations were made by Gupta and Sharma [24] who revealed a significant positive correlation between the population of *Aeolesthes holosericea* F. (Coleoptera: Cerambycidae) and mean relative humidity. Matilda *et al.* [25] add that among the abiotic factors, temperature and humidity are the most important, because they play a major role in limiting the abundance and distribution of insects.

The results of this study show that population fluctuation is also influenced by the annual cycle of cashew which is the host tree of *D. trifasciata*. Maximum of individuals were obtained when the trees are in the pre-floral vegetative growth stage in September and October. Adult abundance at this phenological phase of cashew is thought to be related to the reproductive behavior of the species. Adult emergence of *D. trifasciata* occurs after the first rains in May and ends in June (Akessé, article submitted). This should lead to an explosion in the number of adults during the month of July. Yet, this explosion takes place in September and October. According to Berkov *et al*. [26], the adult life of Cerambycids is entirely devoted to reproduction and this crucial stage of their life is preceded by several activities such as dispersal, localization of the suitable host plant and sexual partners. These pre-reproductive activities could lead to the infestation of orchards by other individuals in these months corresponding to the beginning of the *D. trifasciata* reproductive period. These activities are also induced, as in various insects, by physiological changes of the cashew tree. According to Berkov *et al*. [26], volatile scented compounds released by host plants would attract Cerambycidae while stimulating feeding, mating and oviposition. On the other hand, the decrease in the level of the adult population from flowering to their disappearance during fruiting is explained by the fact that the stages of the host plant and the weather conditions are no longer favorable to their survival. On the other hand this period is favorable to the larvae which develop in the branches cut by the adult parents during the moments of attack. It is known that Cerambycidae larvae develop in the dry season in branches that adults cut in rainy weather [14].

5. Conclusion

The present study revealed that the population fluctuation of *D. trifasciata* on cashew tree was cyclical and seasonal. Only one period of occurrence from May to January of the following year was observed. Climatic factors such as rainfall and relative humidity have had a positive and significant influence on the fluctuation of adults. On the other hand, the temperature had a negative and significant influence on the fluctuation of the population. The study of the fluctuation of this species reveals the presence of adults only during the rainy season when the conditions are favourable to them. The larva and pupal phase takes place in the dry season in the branches cut by adults. From these results, two management options for this pest emerge. First, there is a mechanical control against larvae of removing the branches containing the larvae and pupae of the future generation and incinerated them. This could reduce the population of the insect pest if it is carried out during the dry season from February to April. Secondarily, chemical control against adults who should be mainly during the rainy season between September and October. Other control techniques could be combined for the implementation of an efficient control strategy.

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