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# Abundance and Dynamics of the Main Heteroptera Pests of Cocoa Tree in the Orchards of the Department of Méagui (South-West, Côte d'Ivoire)

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**Abstract**

The capsids *Sahlbergella singularis* and *Distantiella theobromae*, the cocoa mosquito *Helopeltis* sp., and the green bug *Bathycoelia thalassina* are the main Heteroptera pests causing immense damage in cocoa fields in the department of Méagui, the main cocoa producing area of Côte d'Ivoire. The actual study was conducted to assess the spatial and temporal distribution of these pests in this department. From May 2020 to April 2021, the pest abundance and population dynamics were recorded once a month in seven selected cocoa farms in the localities of Yaodankro and Sérigbangan. Tarping and systematic search methods were used. The results indicated that the three types of insect pests are present and the abundance rates ranging from 20.83% to 42.22% from 15 910 individuals recorded. Capsids were more abundant in the Sérigbangan orchards than in those of Yaodankro, while the cocoa mosquito and the green bug were more abundant in Yaodankro than in Sérigbangan. The number of individuals remained relatively high throughout the year except in May-June (months of intense rainfall) where capsid and cocoa mosquito populations were less abundant. Peak populations occurred during the dry season (July, August, February, and March-April) and during the low/medium rainfall season (September and November). The cocoa mosquito and the green bug once considered minor pests were shown to be major pests.

**Keywords:** cocoa orchards, distribution, main Heteroptera pests, Méagui

## 1. Introduction

According to the International Cocoa Organization (ICCO), West and Central Africa is the main cocoa bean producing region with about 75% of the world's cocoa beans, largely produced in Côte d'Ivoire. This country provides more than 42% of the international supply, making it the largest cocoa producer and the basis of the global supply (ICCO, 2018, 2019, 2020, 2021, 2022).

However, cocoa production in Africa has several constraints, including aging orchards, the negative impact of climate change, poor farming practices, and pests and diseases. The latter constraints have a considerable negative influence on yields considering that production losses due to diseases and insect pests are estimated between 30% and 80% depending on pests and production areas. Some pests can even cause the complete destruction of the orchard after a few years if adequate pest management is not provided (Oro, 2011; Pohe et al., 2013; Tra Bi, 2013; Kouakou, 2014; Wessel & QuistWessel, 2015; Dufumier, 2016; N'Guessan et al., 2016; Ndoungue, 2020).

Several research studies have been carried out on the most damaging cocoa insect pests in Africa such as the two mirids (formerly known as capsids) *Sahlbergella singularis* and *Distantiella theobromae*. Production losses due to these two insect species are estimated between 30 and 50% (Babin, 2009; Adu-Acheampong et al., 2014; Danho et al., 2014; Akesse-Ransford, 2016; N'Guessan et al., 2016; Mahob et al., 2018). Taking only into account the seasons of heavy outbreaks studied by Lavabre et al. in the early 1960s and re-evaluated by Kouamé et al. (2014, 2015) recommended two insecticide treatment periods (with two to four applications/year) in Côte d'Ivoire for appropriate management of insect pests (Le Conseil du Café-Cacao, 2015; Koua et al., 2018).

Despite compliance with this recommendation, these pests are still present in some zones such as the department of Méagui which is one of the main cocoa-producing areas of the country. In addition, the green bug *Bathycoelia thalassina* and the cocoa mosquito *Helopeltis* sp. seem also to be dangerous pests of cocoa in this zone. Simultaneous assessments of the populations of these three types of pests do not seem to be carried out in Côte d'Ivoire although the abundance and fluctuation of the populations of *S. singularis* and *D. theobromae* complex are known. The objective of this study is to estimate the abundance and fluctuations of populations of *S. singularis*, *D. theobromae* complex, *Helopeltis* sp., and *B. thalassina* with a view to redefining, if necessary, the periods of effective phytosanitary treatments in cocoa farms.

## 2. Material and Methods

### *2.1 Study Area*

The study was carried out in the department of Méagui located between 5°18′ and 5°26′ North latitude, and 6°31′ and 6°50′ West longitude in the south-west of Côte d'Ivoire. The climate is subequatorial hot-humid (Ouattara et al., 2018) and characterized by four seasons, including two rainy seasons (March-June and September-November) and two dry seasons (December-March and July-August). Average rainfall varies between 1,300 and 1,600 mm/year and average temperatures are between 25 and 28 °C. The average hygrometry varies between 80 and 85% (Danho et al., 2014; Conseil Régional de la NAWA, 2019). The department's economy is mainly based on cocoa production, which is estimated at around 20% of national production (Danho et al., 2014). Sérigbangan and Yaodankro are the sampling areas. Yaodankro has cocoa farms bordering the north-east side of the Taï National Park (TNP) and seems to be one of the most important in terms of cocoa production in the department, whereas the locality of Sérigbangan is relatively further away from the TNP.

### *2.2 Selection of Sampling Orchards*

Sampling was carried out in seven (7) two-ha-cocoa-orchards, three (3) in Sérigbangan and four (4) in Yaodankro selected following a survey that took place in February 2020 taking into consideration the condition of orchards, insects pests commonly observed (by farmers) in the plantations and prophylactic practices (especially the frequency of insecticide treatments).

### *2.3 Collection and Counting of Insects*

#### 2.3.1 Sampling Period and Frequency

During 12 months (from May 2020 to April 2021), individuals of capsids *S. singularis* and *D. theobromae*, cocoa mosquito *Helopeltis* sp., and green bug *B. thalassina* were counted every month in each of the seven selected cocoa farms. This counting was made according to the larva stage and the adult stage of these insects. Sampling activities were carried out during the second week of the month in Sérigbangan cocoa farms and during the third week in Yaodankro cocoa farms.

#### 2.3.2 Collection and Counting Using the Tarping Method

The tarping method consisted of spreading black plastic sheets at the foot of cocoa trees and applying a double dose of a registered chemical insecticide on the trees. For our sampling, nine cocoa trees, *i.e.*, three neighboring cocoa trees with at least one showing signs of pest attack and/or harboring individuals of capsids, are selected at different locations in the field. Under each selected tree, two 2 m × 4 m mini black tarpaulins are placed to create a 4 m x 4 m area. The tarped cocoa trees are treated with a double dose of an insecticide combining two active molecules (30 g/l Imidacloprid and 15 g/l Lambda-cyhalothrin). Pesticide application occurred between 7 and 8 am. Five hours and 30 to 32 hours after the treatments, the insects killed were collected and preserved in a 70% ethanol solution for determining the types of insects and for counting. Thereafter the sprayed trees were vigorously shaken for any insect still remaining on the trees to fall on the sheets. The sampling area was about one hectare in each orchard.

#### 2.3.3 Collection and Counting Using the Systematic Search Method

The systematic search method consisted of inspecting cocoa trees over an area of about 70 m × 80 m for four hours in order to count the targeted insect pests. In this area, all the cocoa tree feet (except for some unintentional omissions) were visited at each inspection, the number of cocoa trees on which pests were actually observed and the number of individuals of these pests were recorded. At the end of the insect collection period, 35 cocoa trees were defined as the overall average number of cocoa tree feet on which pest individuals were actually observed in each orchard/month during the 12 months of sampling. The search for and counting of individuals of capsids was done on the accessible parts of the cocoa trees, *i.e.*, from the ground up to 2 m high, and the search for and counting of individuals of cocoa mosquito and the green bug was done between 3 m to 4 m above the ground, where they are clearly visible with the naked eye.

2.3.4 Data processing and Statistical Analysis

The Excel 2013 software was used to register the collected data, perform logarithmic transformations, and produce the various graphs. The Statistica version 7.1 (Statsoft, Tulsa, USA) software was used to perform various statistical analyses. The one-factor analysis of variance (ANOVA 1) or the non-parametric Kruskal-Wallis ANOVA test was used whenever appropriate to compare the average numbers of insects. In case of significant differences between means, the Newman-Keuls test or the Kruskal-Wallis multiple comparison tests (5% threshold) was used to determine homogeneous groups. The Student t-test or the Mann-Whitney U-test was used to compare populations between localities and between collection methods.

## 3. Results

### *3.1 Characteristics of the Sampled Orchards*

The cocoa orchards sampled had a variety of characteristics. The three orchards selected in Sérigbangan were more than 30 years old. Generally, the canopy of the cocoa trees was thinned out and a few dead trees were observed. From January 2020 to April 2021, two to six insecticide applications were made in the orchards by the owners. Two of the four orchards selected in Yaodankro were 10-11 years old, and the other two were more than 30 years old. Their phytosanitary and canopy status and the frequency of insecticide applications varied. The number of insecticide applications ranged from six to eight in the same period.

### *3.2 Population Abundance of Heteroptera Pests*

3.2.1 Overall Population Proportions and Abundances

A total of 15 910 individuals of the three types of Heteroptera were collected. The capsids and the cocoa mosquito were the most numerous with 6718 capsids (42.22% of insects collected) and 5878 cocoa mosquitoes (36.95%) with 79.09% capsids larvae and 61.48% cocoa mosquito larvae. Statistical analysis showed no significant difference between the average number of capsids (559.83 individuals) and that of the cocoa mosquito (489.83 individuals). 3314 green bugs (20.83%), consisting of 74.41% larvae, were collected with the average abundance (276.17 individuals) which differs significantly ($p < 0.05$) from that of the other two types of Heteroptera (Table 1).

3.2.2 Population Proportions and Abundances per Locality

The abundance and proportion of the total population of the three pest types varied considerably between locations. 5854 individuals of the targeted pests (36.79%) were counted in Sérigbangan and 10 056 (63.21%) in Yaodankro. Statistical analyses showed a significant difference ($p < 0.05$) between the average abundance of populations of these Heteroptera in the two localities (Table 1). In Sérigbangan, the population of capsids was significantly higher (67.07%) than that of green bugs (16.91%) and cocoa mosquitoes (16.02%). However, in Yaodankro, the population of cocoa mosquitoes (49.12%) was significantly higher ($p < 0.05$) than those of capsids and green bugs with respectively 27.76% and 23.11% of the total local population of these insects.

Table 1. Comparison of averages between pests per locality

| Types of Heteroptera pests | The average number of insects per location | | |
|---|---|---|---|
| | Overall | Sérigbangan | Yaodankro |
| Capsids | 559.83±72.69 $^{a}$ | 327.17±62.99 $^{a}$ | 232.67±23.49 $^{b}$ |
| Mosquito | 489.83±49.81 $^{a}$ | 78.17±14.04 $^{b}$ | 411.67±52.85 $^{a}$ |
| Green bug | 276.17±20.60 $^{b}$ | 82.50±10.69 $^{b}$ | 193.67±17.17 $^{b}$ |
| p | 0.001 | 0.000 | 0.000 |

*Note*. In each column, the average values±standard error followed by the same letter are statistically similar at the 5% threshold according to the one-way ANOVA test; p: probability associated with the test.

3.2.3 Population Proportion and Abundance by Collection Method

The systematic search method yielded 9595 individuals i.e. 60.31% of the total three types of insects collected and the tarping method yielded 6315 individuals (39.69%). These numbers show that the three types of insects were collected regardless of the collection method. They varied significantly ($P < 0.05$) in each collection method. The tarping method collected significantly more individuals of capsids (299.67) than the other two pest types (approx. 100 individuals). The systematic search method made it possible to count more individuals of cocoa mosquito (average 359.17) than the other two types of insects (approx. 160 and 260 individuals) (Table 2).

Table 2. Average populations of the three types of pests according to collection methods

| Methods | Average population | | | p |
|---|---|---|---|---|
| | Capsids | Mosquito | Green bug | |
| Tarping | 299.67±34.73 [a] | 111.17±12.29 [b] | 115.42±9.84 [b] | 0.000 |
| Search | 260.17±52.28 [ab] | 359.17±42.24 [a] | 160.75±13.99 [b] | 0.000 |

*Note*. In each row, the average values±standard error followed by the same letter are statistically similar at the 5% threshold according to the Kruskal-Wallis ANOVA test, p: probability associated with the test.

#### 3.2.4 Population densities of Heteroptera pests

(1) Overall Population Densities

The average number of individuals/tree of the insects varied significantly ($p < 0.05$) according to the types of pests. The density of capsids was the highest with an average of 3.83 individuals/tree. The cocoa mosquito and green bug had on average 1.71 individuals/tree, and 1.54 individuals/tree respectively. Statistical analysis showed that the cumulative population of cocoa mosquitoes and green bugs (3.25 individuals/tree) was as important as that of capsids (Table 3).

(2) Population Densities per Locality

In Sérigbangan, cocoa trees were significantly ($p < 0.05$) more colonized by capsids (4.66 individuals/tree) than by the green bug (1.07 individuals/tree) and then by a cocoa mosquito (0.62 individuals/tree). The density of capsids was even higher than the combined population density of the other two pests. In Yaodankro the density of capsids (3.21 individuals/tree) was as high as that of cocoa mosquito (2.52 individuals/tree). These densities were significantly higher ($p < 0.05$) than that of the green bug (1.89 individuals/tree). In this locality, the combined population density of green bug and cocoa mosquito (4.41 individuals/tree) was higher than that of capsids (3.21 individuals/tree). Between locations, capsid density was higher in Sérigbangan than in Yaodankro, while those of cocoa mosquito and green Bug in Yaodankro were higher than in Sérigbangan (Table 3).

Table 3. Average population densities of the three types of Heteroptera pests

| Types of Heteroptera pests | Average density (average number of individuals/tree) | | | p |
|---|---|---|---|---|
| | Overall | Sérigbangan | Yaodankro | |
| Capsids | 3.83±0.30 [a] | 4.66±0.51 [a A] | 3.21±0.36 [b B] | 0.035 |
| Mosquito | 1.71±0.14 [b] | 0.62±0.10 [d B] | 2.52±0.22 [bc A] | 0.000 |
| Green bug | 1.54±0.11 [b] | 1.07±0.12 [c B] | 1.89±0.17 [c A] | 0.000 |
| Mosquito & Green bug | 3.25±0.20 [a] | 1.70±0.17 [b B] | 4.41±0.31 [a A] | 0.000 |
| p | 0.00 | 0.00 | 0.000 | |

*Note*. In each column, the average values±standard error followed by the same lower case letter are statistically similar at the 5% threshold according to the Kruskal-Wallis ANOVA test; and in each row, the average values±standard error followed by the same upper case letter are similar at the 5% threshold according to the Mann-Whiney U test; p: probability associated with the tests.

(3) Comparison of Population Densities Based on Collection Methods

The population densities of capsids and that of green bug varied significantly ($p < 0.05$) between the two collection methods (systematic search and tarping methods), contrary to the cocoa mosquito whose population densities were statistically similar regardless of the collection method. The tarping method provided a better estimate of capsid and green bug densities (4.76 and 1.83 individuals/tree respectively) compared to the systematic search method with 1.06 capsids/tree and 0.66 green bugs/tree (Table 4).

Table 4. Comparison of collection methods based on pest population densities

| Methods | Population density | | | |
|---|---|---|---|---|
| | Capsids | Mosquito | Green bug | Mosquito & Green bug |
| Tarping | 4.76±0.38 [a] | 1.76±0.17 [a] | 1.83±0.14 [a] | 3.60±0.25 [a] |
| Search | 1.06±0.17 [b] | 1.55±0.25 [a] | 0.66±0.07 [b] | 2.20±0.30 [b] |
| p | 0.000 | 0.493 | 0.000 | 0.001 |

*Note*. In each column, the mean values±standard error followed by the same letter are similar at the 5% threshold according to the Mann-Whiney U test; p: probability associated with the test.

### *3.3 Population Dynamics of Heteroptera Pests in Cocoa Orchards in the Department of Méagui*

#### 3.3.1 General Fluctuation of Populations

In the cocoa orchards of Méagui, the outbreak of capsids *S. singularis* and *D. theobromae* began in June and the level of the population remained relatively high from July to April with some variations (Figure 1). The maximum population density (approx. 5 individuals/tree) was observed during some months of the dry season (August, February, and March) and during low/medium rainfall periods (September, November). However, the population gradually decreased to almost zero individuals during the main rainy season (end of May and beginning of June). Populations of the green bug *B. thalassina* and the cocoa mosquito *Helopeltis* sp. hovered around two individuals/tree throughout the year while a peak density of three cocoa mosquitoes per tree was recorded in July and February. Furthermore, the density of the combined population of cocoa mosquitoes and the green bugs was as high as that of capsids during the sampling period.

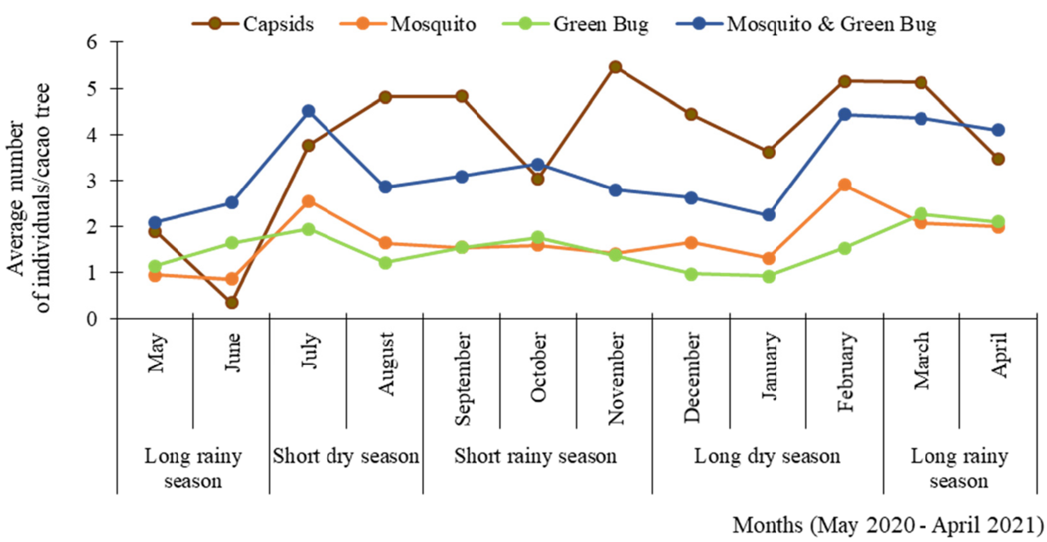


Figure 1. Overall population fluctuation of three Heteroptera pests of cocoa trees in the department of Méagui

#### 3.3.2 Population Fluctuation in Each Locality

In Sérigbangan the capsids were observed throughout the year except in May and June. Two periods of heavy outbreaks were noted. A high population was observed between July and November with a maximum density of eight individuals/tree in August-September and November. Density then decreased to three individuals/tree in December-January. Another major high population was observed from January to March with a maximum of seven individuals/tree in February. From March onwards the population gradually decreased to zero until May-June. Densities of cocoa mosquito and green Bug were around one individual/tree throughout the year. For the cocoa mosquito, no individuals were observed in May, July, and November whereas for the green bug there were two individuals per tree collected in April (Figure 2).

In Yaodankro, the capsid outbreak also started in June and reached a first high population level (about three individuals/tree) in July and August and then decreased to one individual per tree in October. Between November and May, populations increased with densities of four to five individuals/tree from November to April then decreased rapidly to zero until June. The highest population density (about 5/tree) of the cocoa mosquito was recorded in July and February, and the lowest (approx. one/tree) was recorded in May and June. The density of the green bug remained between one and two/tree all year round, with the highest density (three/tree) in March. It was also noted that the combined populations of cocoa mosquito and green bug remained relatively higher than that of capsids in the Yaodankro orchards, except during November and December (Figure 3).

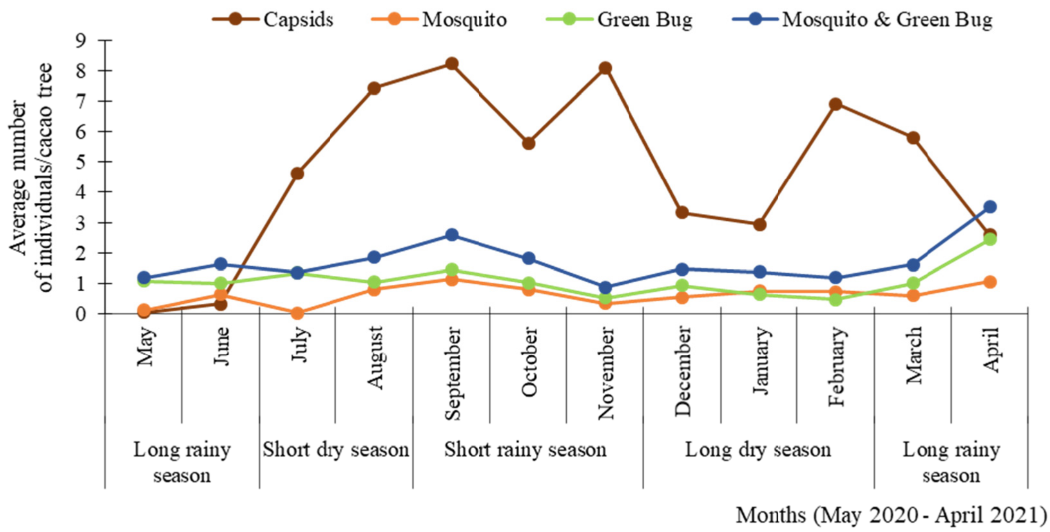


Figure 2. Population fluctuation of three Heteroptera pests of cocoa trees in Sérigbangan

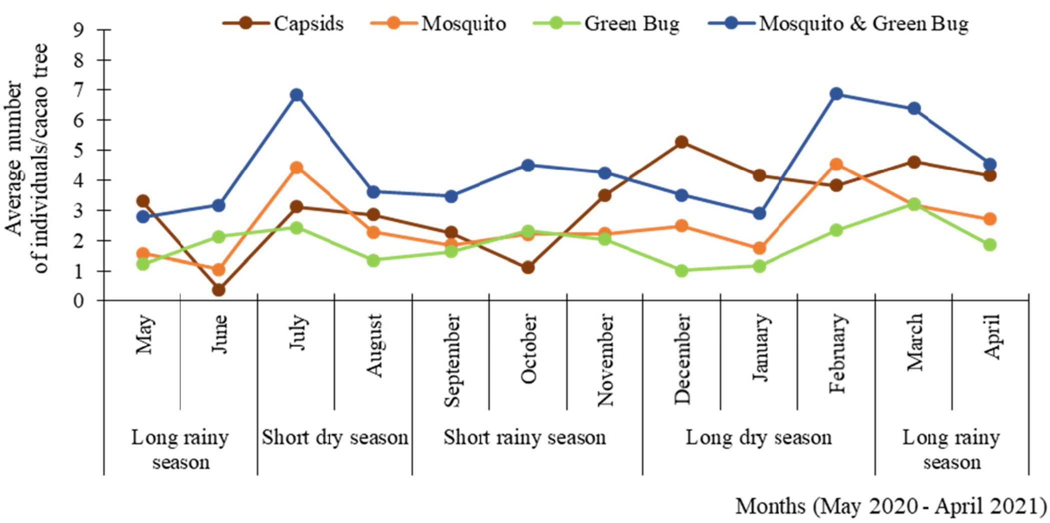


Figure 3. Population fluctuation of three Heteroptera pests of cocoa trees in Yaodankro

## 4. Discussion

The results of our study showed that the populations of the three main harmful Heteroptera to cocoa trees namely the capsids *Sahlbergella singularis* and *Distantiella theobromae*, the cocoa mosquito *Helopeltis* sp. and the green bug *Bathycoelia thalassina* are present and abundant in the department of Méagui considering the number of these insects collected in the areas of Sérigbangan and Yaodankro. The overall population of the pests was generally higher in Yaodankro than in Sérigbangan. This difference in population-level between the two localities could be due to environmental parameters impacting reproduction and development and, therefore the abundance of pests in the orchards. The vicinity of Yaodankro to the Taï National Park which is an important natural forest may have provided favorable conditions for the development of insect populations in this locality. Results of the work carried out by Adjaloo et al. (2012) which showed that the abundance of insect species in cocoa plantations depended on the proximity of the orchards to the forest confirm our results. According to these authors, the closer the plantations are to the forest, the more abundant and diverse the insects are. Regarding the abundance between types of pests, the overall population of capsids and that of the cocoa mosquito were equally abundant. These results differ from those of Kouamé et al. (2014, 2015) who showed a very large predominance of capsids over cocoa mosquitoes in cocoa orchards in the Eastern and Central-West regions of Côte d'Ivoire. Vos et al. (2003) mentioned that adult fecundity and larval development rate, and life cycle duration of Helopeltis species are highly variable from one locality to another depending on local conditions. Climatic and trophic parameters such as temperature, humidity, rainfall, and availability of food quantity and quality are important factors influencing the development and maintenance of some insects. This was also highlighted by Gerin (1956) who stated that the natural biotope of Helopeltis is rainforest, "and most species remain confined either to the forest zone or to areas in the immediate vicinity of forests, and prefer high humidity climates, and low thermal variations". Similarly, Babin (2018), building on Ferrari et al. (2014), reported that African Helopeltis found on cocoa trees, particularly *Helopeltis bergrothi* Reut dwell mainly in the forest zone. The variation in population abundance of cocoa mosquito between our study area and the regions mentioned by Kouamé et al. (2014, 2015) on the one hand, and between the two study areas (Sérigbangan and Yaodankro) on the other hand, could be justified by the earlier works. The environmental factors above mentioned would also explain the high population of green bugs observed in Yaodankro. The results also showed that the populations of capsids were higher in Sérigbangan than in Yaodankro, which could be related to the variability of cocoa orchard characteristics between localities. Cocoa plantations in Sérigbangan generally had a thinned canopy, while in Yaodankro some plantations had a relatively closed canopy and others had a variable canopy. However, Babin (2009) reported that in the 1970s, some researchers demonstrated that the favorable environment for capsids to multiply is the degraded canopy. According to him, it has been shown that the cocoa trees mostly ravaged by capsids were found in areas where the under canopy light intensity was the highest. This would imply that the more canopy is degraded (or open), the more capsid clusters would be found.

Regarding population densities, our results showed that the density of capsids was higher than those of the cocoa mosquito and green bug. This is probably due to the fact that capsids generally live in clusters (aggregative distribution) in plantations, and cause a severe infestation of cocoa trees at several locations in the plantation, developing the so-called mirid clusters (Babin, 2009). With regard to the abundance of populations according to sampling methods, the probable explanation could be that the green bug and the cocoa mosquito are more dispersive in the plantation than the capsids. Although similar average population abundances of capsids were obtained through both methods, the tarping method provided the highest density of capsids. The systematic search method provided a better assessment of the population proportions and densities of the cocoa mosquito. With this method, more green bugs were collected but their density was poorly assessed. The Cocoa mosquito and green bug were observed on more cocoa trees compared to capsids. Low densities of cocoa mosquito and green bug (compared to capsids) should be monitored as Darko (2014) found that a single green bug on a cocoa tree can cause premature ripening and abortion of up to eight cherelles (young pods), and impact pod development and feeding on the bean. Mahob et al. (2018) showed that cocoa mosquitoes can cause up to 80% of cherelles abortion. Given the high level of combined populations, it could be said that the combined actions of cocoa mosquitoes and green bugs on the development of cocoa pods and cocoa beans could be as important as, or even more important, than the damage caused by the capsids on these organs of cocoa in Méagui.

The three types of Heteroptera pests were present throughout the year. Specifically, the outbreak of capsids observed weakly in May and June remained globally important between July and April (density varying from three to five per cocoa tree). The highest population levels were recorded in August, September, November, February, and March. These findings have some similarities and differences with the work of Kouamé et al. (2014, 2015) in the Indénié-Djuablin and Haut-Sassandra regions. In the Indénié-Djuablin region, they noted a single period of heavy infestation from July to February with a single population peak recorded in August or September. In the Haut-Sassandra region, they identified two outbreak periods. One from June to November with a high population in July-September and a peak in August, and another outbreak period from December to May with a peak population in January. But they noted a low population from April to June in both regions. Several authors have considered trophic factors such as the physiology of cocoa trees to be the main cause and climatic factors (including rainfall and temperature) as indirect causes of fluctuating capsid populations (Adja et al., 2005; Babin, 2009; Adu-Acheampong et al., 2014; Kouamé et al., 2014, 2015; Akesse-Ransford, 2016). They have indicated that variations of capsid populations are strongly influenced by the availability and quality of food resources through the circulation of sap in pods and regrowth on which these insects feed. A correlation between climatic factors and seasonal variations in pest populations has not yet been observed. However, food production and quality for mirids are strongly conditioned by rainfall and temperature in addition to soil quality.

Reproduction and survival of capsid *S. singularis* are most important during the vegetative growth period of the plant and especially during pod development (Babin, 2009). Kouamé et al. (2015) explained that the population variations could be due to the presence or absence of sufficient food for these pests. They indicated that the sharp decline in populations from April to June happened after a long dry season from December to January with high temperatures causing dehydration and drying of plant tissues. This could explain the fluctuation of populations of capsid and the two other pests in the Méagui area. Regarding the temporal fluctuation of the cocoa mosquito and green bug, the results showed that their population density remained relatively high all year round with one to three cocoa mosquitoes per tree and one to two green bugs per tree. These results confirmed findings by Awudzi et al. (2017) who also revealed the year-round presence of a green bug in cocoa plantations in Ghana. The probable existence of pods on cocoa trees throughout the year would explain this continuous presence of these two pests, given that they feed exclusively on cherelles and pods (Awudzi et al., 2017; Babin, 2018) on which they were mainly recorded using the systematic search method.

In our study, the monthly densities of capsids were generally higher in Sérigbangan than in Yaodankro. This difference is thought to be related to the insecticide treatment practices in each locality. In Yaodankro farmers use insecticides more often than in Sérigbangan where insecticides are sometimes not applied at the recommended periods. According to Babin (2009), the frequency of phytosanitary treatments has had a considerable impact on variations in population densities of *S. singularis* in Cameroon. Babin's work showed high capsid densities in plantations with non-frequent insecticide treatments and low densities in plantations with frequent insecticide treatments. Monthly population densities of cocoa mosquito and green bug in Yaodankro cocoa orchards were higher than those recorded in Serigbangan. This result can be explained by the fact that in Yaodankro these pests could have developed some resistance to chemical insecticides, in addition to favorable local trophic and environmental conditions. In addition to behavioral and physiological resistance described by Haubruge and Amichot (1998) and FAO (2012), cocoa mosquitoes and green bugs could have developed a "biological resistance" resulting from frequent disturbances of their habitat by insecticide treatments in Yaodankro. To maintain their populations in this continuously disturbed environment, these pests would modify their biological cycle through a genetic transformation in order to be more fecund to allow females to lay more eggs and have a high survival rate and hatching capacity.

## 5. Conclusion

This study carried out in two localities in the department of Méagui showed that the populations of the main Heteroptera pests of cocoa trees, namely the capsids *Sahlbergella singularis* and *Distantiella theobromae*, the cocoa mosquito *Helopeltis* sp. and the green bug *Bathycoelia thalassina* are present and abundant in the cocoa orchards of the department. Capsids were more abundant in the orchards of Sérigbangan than in Yaodankro, while the cocoa mosquito and the green bug were more abundant in Yaodankro. Populations of these three main pests remained relatively high throughout the year except during heavy rainfall periods (May-June).

This study indicated that the period from July to April is the time of intense activity of these pests with marked population peaks in dry seasons (July, August, February, and March-April) and in low/medium rainfall (September and November). It also found that *Helopeltis* sp. and *B. thalassina* once considered minor pests have become important pests in cocoa orchards in study localities (Sérigbangan and Yaodankro) in the department of Méagui.

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