



Bionomics and Importance of an Emerging Pest *Pseudotheraptus devastans* (Distant) (Heteroptera: Coreidae) in the Cocoa Orchards of Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. Author NNK managed the literature searches, wrote the protocol, monitored the experimentation, performed the statistical analysis, wrote the first draft and the revisions to the manuscript. Author FKN designed the study, wrote the protocol, wrote the first draft and the revisions to the manuscript. Authors PWN wrote the protocol, performed the statistical analysis and the revisions to the manuscript. Author AJAK revised the manuscript. Author YT wrote the first draft and the revisions to the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The cocoa tree is a very important plant in Côte d'Ivoire (formerly known as Ivory Coast) with a production of 2,15 million tons. In spite of this performance, cocoa production is attacked by several pests of which the emerging ones are *Pseudotheraptus devastans* (Distant). These insects attack cherelles, pods, gourmands and young shoots. This study aims to locate these pests and determine their importance in the different cocoa production areas. The device used is total randomization. The leaching carried out in the orchard revealed the presence of *P.devastans* in all the cocoa producing districts. The means were $0,02 \pm 0,00$ to $2,35 \pm 0,38$ *P. devastans* / tree. The districts of Sassandra-Marahoué, Comoé and Montagnes recorded more *P.devastans*. However, the districts of Bas-Sassandra, Lagunes et Lacs had fewer *P.devastans*.

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1. INTRODUCTION

The cocoa tree (*Theobroma cacao* Linné) is a plant imported in Côte d'Ivoire. With 2,15 million tons in the 2018/2019 season, Côte d'Ivoire is the leading producer country [1]. Despite this remarkable performance, the sustainability of cocoa cultivation is threatened by numerous insects, the most important of which are mirids, stem borers, bugs, and scale insects [2,3]. Besides, the bug, *Pseudotheraptus devastans* Distant (Heteroptera: Coreidae) also attacks cocoa trees [4]. This insect is known as a pest of several perennial plants worldwide [5,6]. In Côte d'Ivoire, in addition to cocoa, this bug attacks crops such as coconut, cashew, cassava and rubber [7]. It causes damage to young and mature fruits, branches and young shoots. The infestation causes fruit fall and drying of leaves. *P. devastans* is also controlled by several methods to control mirids. These include agronomic, biological, genetic and chemical control. Chemical control is the main method of controlling these pests. Effective management of these pests is necessary to ensure the good productivity of Ivorian cocoa. For this we need to know which are the cocoa producing areas in Côte d'Ivoire is affected by the pest, *P. devastans*? In order to get a solution to this, it is important to find the geographical distribution of this species in the cocoa orchards of Côte d'Ivoire. as well as to identify its importance in each of the cocoa producing areas, on which this paper is based.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted from 2018 to 2020 in the southern half of Côte d'Ivoire, the major cocoa production zone. This part was covered by dense mesophile forest. The climate is tropical humid semi-deciduous. There are four seasons including two rainy seasons and two dry seasons. A major rainy season begins in March and ends in July with maximum rainfall in June. The average rainfall varies from 200 to 600 mm/month. The small rainy season is from September to November with an average rainfall between 100 and 200 mm/month [8]. A large dry season begins in December and ends in March, and finally, a small, mild dry season occurs in August. The southern forest region of Côte

d'Ivoire is characterized by abundant rainfall, which varies from 1200 to 1400 mm per year [9]. Average annual temperatures in the southern Ivorian forest vary from 21 to 32°C [10].

2.2 Sampling Method

The study was carried out in each region of the different districts; 3 localities or representative of the area were used for sampling of the *P. devastans*. In each locality, 2 observation points were selected. The observation points were distributed on different axis in order to better cover the region. In a plot of 1 ha, 12 feet of cocoa trees, attacked or infested by coreid bug were selected.

2.3 Collecting Insects

P. devastans bugs were collected by using the tarpaulin technique. For this purpose, tarpaulins with a surface area of 16 m² were spread out over 12 cocoa trees located in the infested area. Cocoa trees identified and covered with tarpaulins were treated with an approved insecticide. The insecticide used contains Acetamiprid (20 g/l) and Bifenthrin (20 g/l) as active ingredients. This insecticide was used at a concentration of 250 ml per 12 liters of water to kill all insects in the cocoa trees covered with tarpaulin. Treatments were carried out early in the morning between 7:00 and 8:00 am.

2.4 Bug Count

Counting of dead bugs on tarpaulins was done 5 hours after the insecticide treatment. For this purpose, the tarpaulin-covered cocoa trees were shaken to drop all dead insects, which were retained in the foliage. The bugs were collected using flexible entomological pliers, placed in Petri dishes and then counted. The number of coreid bug per tree was determined. Also, the length and width of each bug were recorded.

2.5 Data Analysis

The data collected were subjected to an analysis of variance using SAS' General Linear Model (GLM) procedure to compare bug populations in different regions. The means were separated by the Student-Newman-Keuls test at the 5% threshold.

3. RESULTS

3.1 Bionomics of *Pseudotheraptus devastans* from the Ivorian Cocoa Tree

P. devastans (Distant) (Heteroptera: Coreidae) is a sucking insect. The general body color is brown (Fig. 1). The hindwing membranes are black. The adult has long and thin antennae with

4 articles. The antennae of these insects are as long as the body. The nymphs of *P. devastans* are similar in appearance and coloration to the adults. Adults are winged. The nymphs usually hide between pods and trunk or in between pods. These insects have an average length between $13,90 \pm 1,83$ to $14,31 \pm 2,26$ mm. There were no significant differences in length between regions (Table 1).



Fig. 1. Cocoa insect *Pseudotheraptus devastans*

A: Dorsal view of adult
B: Ventral view of adult
C et D: Nymphs

Table 1. Different lengths of *P. devastans* harvested in the cocoa orchard

District	Length (mm)
Lagunes	14,31 ± 2,26 a
Gôh-Djiboua	14,15 ± 1,72 a
Comoé	14,13 ± 2,04 a
Montagnes	14,08 ± 2,54 a
Sassandra-Marahoué	14,05 ± 1,81 a
Bas-sassandra	14,03 ± 1,90 a
Lacs	13,90 ± 1,83 a
Overall average	14,09 ± 2,01

Averages in the same column followed by the same letters are not statistically different according to the Student Newman-Keuls test at the 5% threshold.

3.2 Damage on the Cocoa Tree

The nymphs and adults of *P. devastans* pierce and suck the sap from cherelles, pods and young shoots of the cocoa tree. The bites of these insects cause brown grooves on the shanks and pods (Fig. 2), leading to deformation and reduction pod size. The bites of *P. devastans* cause deformation of the pods. Also, the bites of these insects can make the young pods fall. Necrosis caused by the feeding of these pests develop into cracks as the cherrille continues to grow. They also cause drying of the leaves.

3.3 Abundance of *Pseudotheraptus devastans*

P. devastans bugs were found in the seven (07) districts of the cocoa orchard in Côte d'Ivoire where the study was conducted (Fig. 3). The number of *P. devastans* was higher in the districts of Sassandra-Marahoué, Comoé and Montagnes. These districts recorded $2,35 \pm 0,38$; $2,33 \pm 0,68$ and $2,02 \pm 0,83$ *P. devastans* /tree respectively. Cocoa trees in the Gôh-Djiboua district recorded $0,41 \pm 0,05$ *P. devastans* /tree. The districts of Bas-Sassandra, Lagunes et Lacs had less *P. devastans* /tree. The average of these districts was $0,02 \pm 0,00$ to $0,09 \pm 0,01$ during the study period (Table 2).



Fig. 2. Damage of *Pseudotheraptus devastans* (Distant) on pods

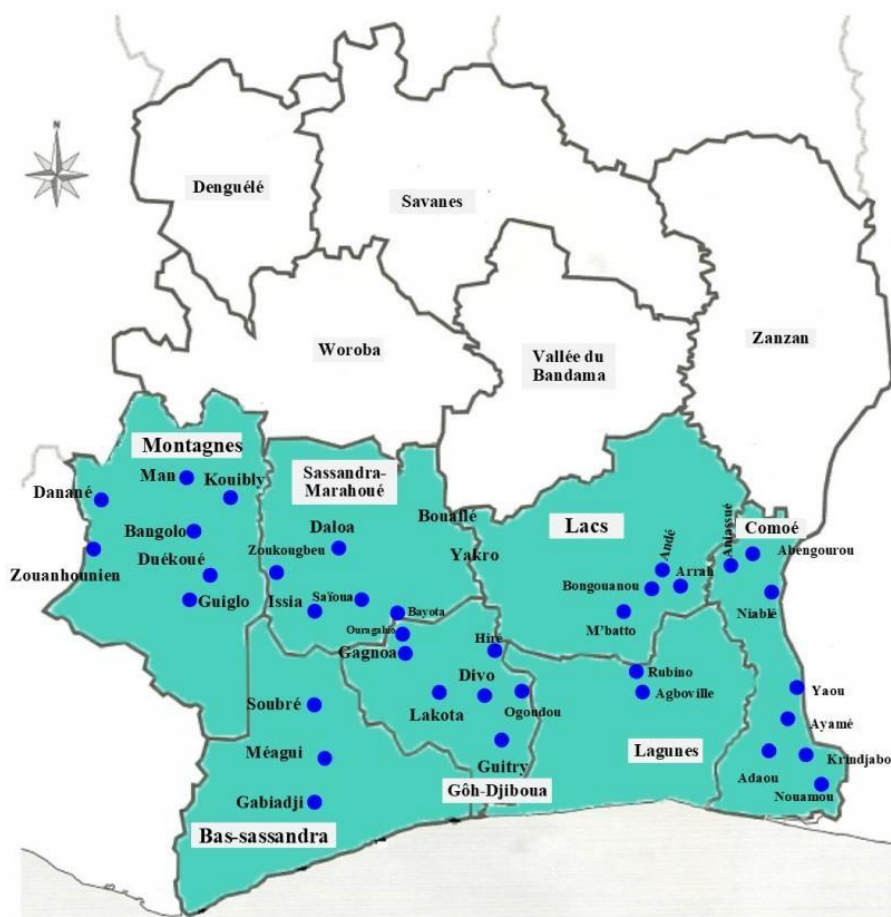


Fig. 3. Geographical distribution of *P. devastans* in the cocoa orchards of Côte d'Ivoire
Pseudothrus devastans Cocoa production areas

Table 2. Average number of *P. devastans* per tree in the various cocoa production districts in Côte d'Ivoire

District	Average / Tree
Sassandra-Marahoué	2,35 ± 0,38 a
Comoé	2,33 ± 0,68 a
Montagnes	2,02 ± 0,83 a
Gôh-Djiboua	0,41 ± 0,05 b
Bas-Sassandra	0,09 ± 0,01 c
Lagunes	0,06 ± 0,01 c
Lacs	0,02 ± 0,00 c
P	< 0,0001

Averages in the same column followed by the same letters are not statistically different according to the Student Newman-Keuls test at the 5% threshold

4. DISCUSSION

P. devastans collected in the different districts ranged in length from $13,90 \pm 1,83$ to $14,31 \pm 2,26$. These results would be due to the feeding of these insects. Similarly, the average length of *P. devastans* collected was $14,09 \pm 2,01$ mm. These bugs were present in all the districts

studied. The presence of *P. devastans* in these production areas could be explained by the favorable conditions offered by Ivorian cocoa production. Indeed, cocoa production in Côte d'Ivoire is developing in the southern half of the country [11]. The climate of this zone is of the humid tropical type characterized by 4 seasons of unequal duration [12,9], which is favorable to

the development of bugs. These insects were collected from the gourmands, young shoots, young fruits and pods. The presence of *P. devastans* on all cocoa organs could be due to insufficient phytosanitary interventions in Ivorian cocoa production [13]. Indeed, 44% of plantations are not treated in Côte d'Ivoire. Even when treatments are carried out, they are incomplete [14]. Antimirid treatments that would allow control of *P. devastans* are carried out with only one or two insecticide applications out of the four recommended per year. The doses are reportedly insufficient and the treatments are carried out in the off-season, which favors the proliferation of the pests in the cocoa orchard [11]. In addition, climatic changes in recent decades have favored the development of *P. devastans* on cocoa trees.

Although present in the orchard, the average number of *P. devastans* per tree varied from $0,02 \pm 0,00$ to $2,35 \pm 0,38$ in the different production districts. The average number of this insect per tree was low in the districts studied. The low number of these insects could be explained by the fact that in Côte d'Ivoire the cocoa tree is not the main plant for these bugs [15]. The damage caused by *P. devastans* is important and is characterized by the fall of flowers and fruits before maturity. This pest can more or less disrupt the development of the fruits and thus lead to a reduction in the yield of the cocoa tree. However, according to [15], *P. devastans* is more likely to attack the coconut tree which is its main crop. This is in contrast to [5] and [4] which stated that *P. devastans* was the main pest of coconut. The damage caused by this species on coconut trees could reach 80% of the crop. Furthermore, our diagnostic results revealed that *P. devastans* is more important in the districts of Sassandra-Marahoué, Comoé and Montagnes. The reasons for the high numbers in these districts may be numerous. *P. devastans* may have a preference for host plants that have different production periods than cocoa. These plants are thought to have disappeared because of full sun planting of cocoa trees, the method adopted by Côte d'Ivoire since independence [13]. This method has been accused of devouring the forests of Côte d'Ivoire [16], which would have eliminated the natural host plants of these insects. The cocoa tree being the main plant of the region, it would have become the food of *P. devastans*. Also, studies have shown that *P. devastans* is an important pest of plants in the coconut family [4,17]. Therefore, the absence of these plants in these areas due to

deforestation could favor the development of these pests in cocoa production. *P. devastans* had a low population level in the cocoa orchard in the Bas-Sassandra, Lagunes, and Lacs district. The low population level of these insects could be explained by the strong presence of natural enemies in these areas. Indeed, according to [18] and [19], the ant *Oecophylla longinoda* Smith (1860) is a good predator of *P. devastans*. Therefore, the abundance of this insect in cocoa plantations could reduce the proliferation of these pests [20]. Studies conducted by [21] and [22] on coconut trees had shown that *P. devastans* would remain below the pest threshold if 70% of these plants harbored red *O. longinoda* ants.

5. CONCLUSION

The leaching carried out in the orchard revealed the presence of *P. devastans* in all the cocoa producing districts. The means were $0,02 \pm 0,00$ to $2,35 \pm 0,38$ *P. devastans* / tree. The districts of Sassandra-Marahoué, Comoé and Montagnes recorded more *P. devastans*. However, the districts of Bas-Sassandra, Lagunes et Lacs had fewer *P. devastans*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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