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Seasonal variations of the population of *Eulophonotus myrmeleon* Felder (Lepidoptera: Cossidae) in the Sud-Bandama region of Côte d'Ivoire

[Variations saisonnières des populations d'*Eulophonotus myrmeleon* Felder (Lépidoptère: Cossidae) dans la région du Sud-Bandama en Côte d'Ivoire]

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ABSTRACT
Objectives: The cocoa stem borer, *Eulophonotus myrmeleon* Felder (Lepidoptera: Cossidae) has recently become a serious pest of cocoa in west and central African countries. This study aimed to determine the periods of severe attacks of this new pest in the Sud-Bandama region, a major cocoa growing area of Côte d'Ivoire.
Methodology and results: The experiment was conducted in 2005-2009 at the CNRA research station in Divo, Côte d'Ivoire. Six cocoa plots, planted in 1972, 1984, 1987, 1988, 1993, and 2000, and naturally attacked by *Eulophonotus myrmeleon* were selected. In each plot, a bloc of 300 cacao trees was demarcated and the trees were numbered from 1 to 300. Every tree was inspected monthly and the fresh holes of *E. myrmeleon* were counted till hand height. Rainfall data was taken twice a day (morning and afternoon) at the station. The results revealed two periods of severe borers' attacks during the year. Heavy damages of occur from May to August with a peak in June, and from November to February with a peak around December-January. These two periods correspond to the time when the larvae excavate and tunnel in the cocoa trees. The attacks usually start in May and November each year. Adults' emergence starts three months later in August and February. The levels of attacks seemed to be directly influenced by the rainfall pattern and drought seemed to adversely affect the level of borers' attacks.
Conclusion and application of the findings: The results of this study could be helpful in decision making regarding the application of control measures directed against the larvae or the adults. For example a rational insecticide application should be done during the periods of severe borers' attacks or when adult moths are active in the field in order to reduce the population for the next generation. In addition, any investigation regarding the use of pheromone against *E. myrmeleon* will take into account the emergence period of the adults.
Key words: Cocoa, stem borer, *Eulophonotus myrmeleon,* population dynamic.

RESUME
Objectif: Le foreur des tiges du cacaoyer, *Eulophonotus myrmeleon* Felder (Lépidoptère: Cossidae) est devenu aujourd'hui un ravageur important du cacaoyer dans les pays producteurs d'Afrique de l'ouest et du

centre. La présente étude vise à déterminer les périodes de fortes attaques de ce déprédateur nouveau dans la région du Sud-Bandama, une importante zone de production cacaoyère en Côte d'Ivoire.
Méthodologie et résultats : L'étude a été réalisée en 2005-2009 à la station de recherche du CNRA à Divo, Côte d'Ivoire. Six parcelles de cacaoyers attaquées par *Eulophonotus myrmeleon* ont été choisies. Dans chaque parcelle, un bloc de 300 cacaoyers a été délimité et les cacaoyers ont été numérotes de 1 à 300. Chaque cacaoyer a été inspecté tous les mois et les orifices récents d'*E. myrmeleon* ont été dénombrés jusqu'à portée de main. Les données pluviométriques ont été collectées 2 fois par jours (matin et après-midi). Les résultats ont révélé deux périodes de fortes attaques d'*Eulophonotus myrmeleon* au cours de l'année. Ces périodes se situent de Mai à Août avec un pic en juin, et de Novembre à Février avec un pic autour de décembre-janvier. Ces deux périodes correspondent à une activité intense des larves qui creusent des galeries dans le tronc et les branches du cacaoyer. Ces attaques commencent dans les mois de Mai et Novembre chaque année. L'émergence des adultes commence en Août et Février. Le niveau d'attaques semble augmenter avec la pluviométrie. Les périodes sèches semblent réduire le niveau d'infestation des cacaoyères par les foreurs des tiges.
Conclusion et application des résultats: Ces résultats peuvent jouer un rôle important dans la prise de décision quant à l'application des méthodes de lutte contre les larves et les adultes. Par exemple une application rationnelle d'insecticide doit être effectué pendant les périodes de fortes attaques ou pendant que les adultes sont actifs dans les plantations. Par ailleurs, toute étude en rapport avec l'utilisation de phéromone contre *E. myrmeleon* tiendra compte des périodes d'émergence des adultes.
Mots clés: Cacaoyer, foreur des tiges, *Eulophonotus myrmeleon,* dynamique des populations.

INTRODUCTION

Cocoa is the most important export crop in Côte d'Ivoire and the main source of revenues for many producers. Unfortunately, the durability of cocoa production is threatened by many constraints, including damage by pests and diseases. The cocoa mirids, *Sahlbergella singularis* (Haglund) and *Distantiella theobromae* (Distant) have always been considered to be the most important insect pests of cocoa in Côte d'Ivoire, as well as in other growing countries in west and central Africa (Lavabre, 1977; N'Guessan and Coulibaly, 2000). These insects may cause between 30 and 40% yield losses annually (Lavabre, 1977).

Recently, a new insect species, *Eulophonotus myrmeleon* Felder (Lepidoptera: Cossidae) has been reported to cause damage to cocoa trees in the west and central African producing countries, including Côte d'Ivoire, Ghana, Cameroon and Togo (Caplong et al., 1993; Wegbe et al., 1995; Gnakpenou et al, 1996; Padi and Adu-Acheampong, 2000). Earlier, this insect was recorded in Cameroon, Côte d'Ivoire, Congo Republic, Ghana, Nigeria, Sierra Leone, Togo and the island of Sao Thomé, Democratic Republic of Congo and South Africa where it attacks members of the Sterculiacae family (Entwistle, 1963, 1972). *E. myrmeleon* used to be considered as a minor pest of cocoa. It occurred in low numbers in cocoa farms and the level of attack was very low, less than 5% of the trees showing damage and therefore very little work was conducted to address the problem (Hill and Waller, 1988). Damage started to become important since 1989 in most cocoa growing countries in West Africa. A survey carried out in Togo indicated that 50 % of the cocoa farms in the Kloto region were infested (Wegbe et al., 1995). By 1995, the number of cocoa farms attacked by *E. myrmeleon* had increased to 100% in the Kloto region and reached over 70% in the Agou, Litimé and Akposso-akébou regions (Gnapkenou et al., 1996). Similar observations were reported in Ghana (Padi and Adu-acheampong, 2000).

In Côte d'Ivoire, noticeable infestations started in the early 1990s in the Abengourou region around the border with Ghana (Caplong et al., 1993). The attacks have since spread in the entire cocoa growing areas of the country to reach major cacao growing regions such as Sud-Bandama, Haut-Sassandra and Bas-Sassandra where damage levels have become high (N'Guessan, 2006). A

survey carried out in the cocoa growing regions showed that 100% of the farms were infested throughout the entire cocoa growing area of the country and the number of entrance/exit holes per tree varied between 0 and 45 at hand height (N'Guessan, 2006).

In order to develop an appropriate control strategy and/or to make recommendations regarding the timing of application of control measures, the population dynamics was studied to determine the periods of severe attacks and adults emergence in the cocoa orchards of the Sud-Bandama region where many complaints have been received from farmers regarding borers' attacks and dieback of cocoa trees.

MATERIALS AND METHODS

Study site: The experiment was conducted in 2005-2008 at the CNRA (Centre National de Recherche Agronomique) research station in Divo. This station is located on about 3500 ha of land area, part of which is planted with cacao, coffee, cola and oil palm. The remaining area is occupied by offices, laboratories, housings, nurseries, bud-wood gardens and about 1000 ha of forest.

Selection of plants: Six cocoa plots Ci1, Ai4, E4/3, E2/1, D15/2 and E6/1, planted respectively in 1972, 1984, 1987, 1993, 1988 and 2000, naturally attacked by *Eulophonotus myrmeleon* were selected for this study. The plots were selected in such a way that they spread over a large area of the station. The age of the plots where letters A, C, D and E correspond to groups of plots located far apart in the station. Young and relatively old plots were chosen for the study. In each of the selected plots, a bloc of 300 cacao trees was demarcated and the trees were numbered from 1 to 300. The trees were selected on 12 adjacent rows of 25 trees so that the sub-plots covered 0.225 ha of cacao.

Observations: In each sub-plot, every tree was inspected monthly for fresh borer hole, knowing from previous work (Entwistle, 1972) that the larva could tunnel in the tree for about three months. Fresh borer holes were characterized by the presence of fresh reddish excrement exuding from a small hole on the trunk, indicating that an active larva is burrowing in the wood. The holes were counted every month on the marked trees till hand height (up to 2 m). All the fresh holes were systematically counted without considering any previously count. Thus, the number of holes counted every time was a cumulative number. During the inspection of the trees, any hole no longer showing fresh reddish excrement was no longer considered fresh. Rainfall data was taken twice a day (morning and afternoon).

In order to assess the time of adult emergence, sleeve cages of 90 cm long and 30 cm in diameter, made of mosquito screen, were used to enclose *Eulophonotus'* fresh holes separately on selected trees to trap the adult moths. Both ends of the sleeve cages were securely tied to prevent any insect larger than mosquito getting in or out of the cage. Ten trees housing active larvae were selected in each plot during a visible period of attack which is characterized by the presence of fresh reddish excrement exuding from many holes on cocoa trunks and branches in cocoa farms. The cages were visited every day to collect the adult moths that emerge from the holes. Any adult that emerged was brought to the laboratory after being immobilized using alcohol (90%) injection, using a hypodermic syringe (with a 10-gauge needle) to avoid loosing the scales. The date of emergence was noted for each adult trapped.The mean number of borers' holes per tree was calculated and plotted on a graph to assess seasonal variations of borers' damage and/or population level in relation to the rainfall pattern.

RESULTS AND DISCUSSION

The seasonal variation of *Eulophonotus'* attack on cacao trees indicated two periods of severe borers' attacks during the year (Figures 1 and 2). Heavy damages by borers occur from May to August with a peak in June, and from November to February with a peak around December-January. These two periods

correspond to the time when active larvae excavate and tunnel in the cacao trees (Figure 3), and therefore a period of high larval population. The attacks usually start in May and November each year. The first adults (Figure 4) were captured in July and in January, suggesting that adult emergence start about 3 months after the onset of the attacks. Indeed, Entwistle (1972) and Lavabre (1977) stated that *E. myrmeleon* larvae stay up to 3 months in the trees before maturing into adults. It is therefore expected to have high adult populations in August and February each year as a result of the high larval populations 3 months before. The level of attack was generally higher in the old farms than in the young ones (Figures 5 and 6).

Both male and female adults were captured during this study. When a female emerged, several males were attracted to the cage, certainly because they were responding to a sex pheromone from the females. This behavior enabled us to collect more males beside those directly captured from the cages. On the other hand, when a male was captured, there was no other moth attracted to the cage. These findings, not only confirm that adult moths were active in the farms, but corroborate results of Adu-Acheampong et al. (2003) who suspected sex attractants in the adult female of *E. myrmeleon*.

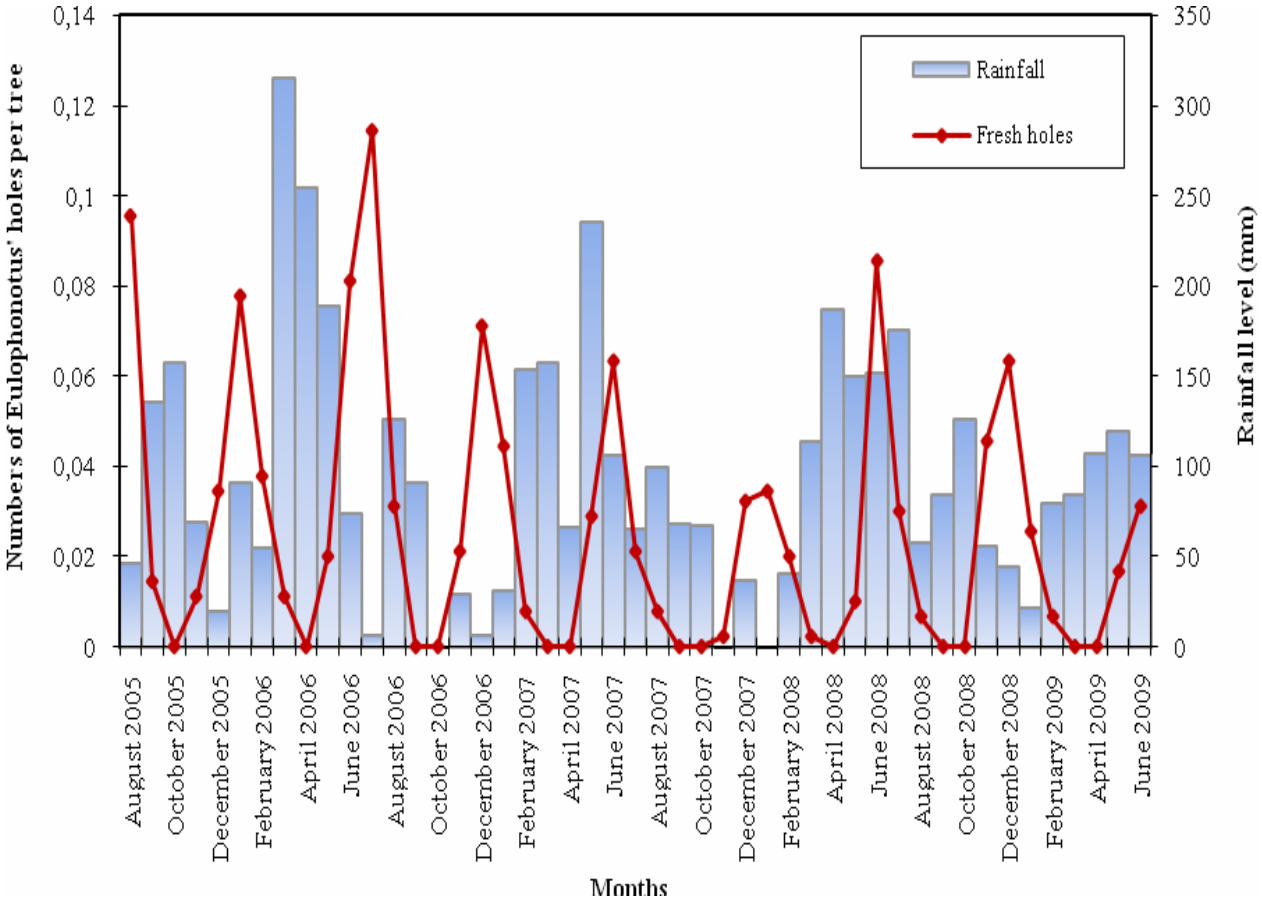

Figure 1: Seasonal variations of *Eulophonotus myrmeleon* fresh holes containing active larvae in cacao farms according to the rainfall pattern in the Sud-Bandama region of Côte d'Ivoire.

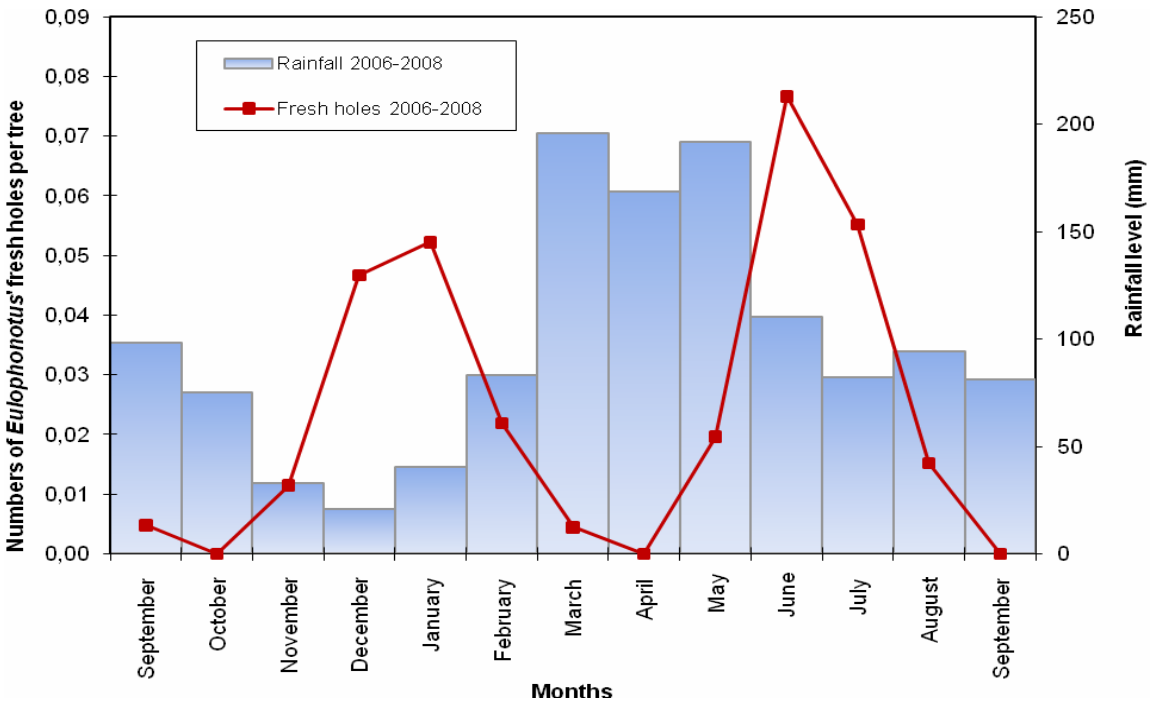

Figure 2: Average monthly variations of *Eulophonotus myrmeleon* fresh holes according to the average rainfall pattern from 2005 to 2008 in cacao farms in the Sud-Bandama region of Côte d'Ivoire.

Figure 3: *Eulophonotus* larva at the entrance/exit hole.

Figure 4: A newly emerged *Eulophonotus* adult

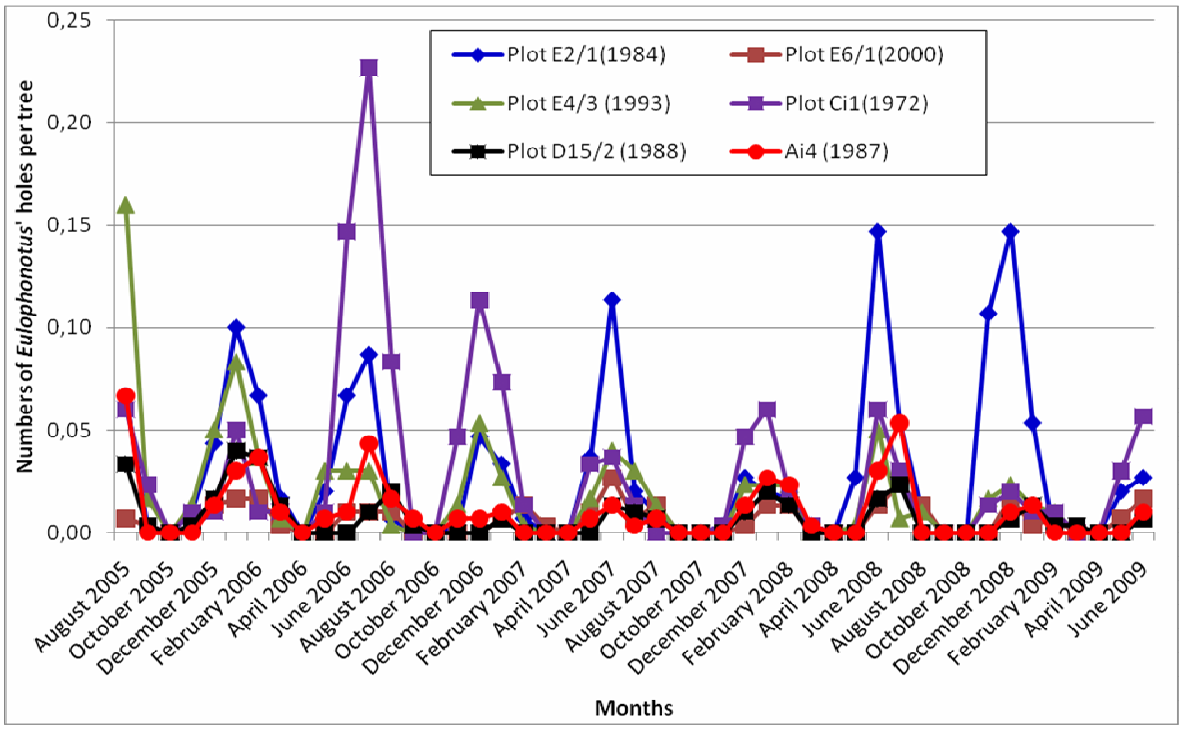

Figure 5: Seasonal variations of *Eulophonotus myrmeleon* fresh holes, containing active larvae, in 6 cacao plots with different ages, in the Sud-Bandama region of Côte d'Ivoire. (NB: The year of planting of each plot is indicated in parenthesis within the legend).

The population dynamic of many insect species is influenced by several environmental factors, including natural enemies and the climate. For *Eulophonotus*, a number of parasitoids in the family Braconidae (Hymenoptera) such as *Amicrocentrum* sp. and a tachinid fly have been reported to parasitize the larvae (Entwistle, 1972). An ant species has also been described to be the principal predator of *Eulophonotus* larvae (Alibert, 1951). Thus, predators and parasitoids can regulate the number of fresh holes in the cocoa farms and reduce the population of the adults. However, in this study, no data was collected regarding natural enemies. On the other hand, the rainfall level and pattern seemed to have more influence on the population level of *Eulophonotus*.

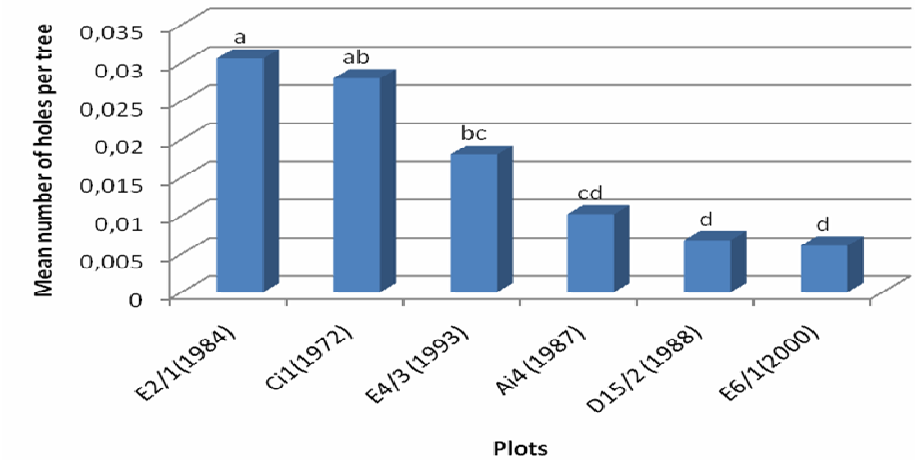

Figure 6: Number of *Eulophonotus myrmeleon* fresh holes, containing active larvae, in 6 cacao plots with different ages, in the Sud-Bandama region of Côte d'Ivoire.

The effect of the rainfall on the seasonal variations of the populations of other cocoa pests such as capsids have been demonstrated by Lavabre et al. (1962 and 1963), Bruneau De Miré (1970) and Decazy (1974). Theses researchers indicated that rainfall may not directly affect the populations but it creates favorable environmental conditions regarding food availability for the capsids. In our study, the levels *E. myrmeleon* attacks seemed to be related to the level of rainfall. Indeed, the number of fresh holes was high, following an abundant and well distributed rainfall. This was the case for years 2006 and 2008 (Figure 1). On the other hand, in 2007, the rainfall was low between September and November. As a result, the level of attack was also relatively low following that period. As with the cocoa capsids, for *Eulophonotus*, succulent wood must be an important source of food. This can explain the increase in the level of attacks following a rainy season.

The results obtained in this study corroborate those of Wegbe et al. (1995) who also found two outbreak periods of *E. myrmeleon* population in Kloto (Togo). However, only one of the outbreak periods from July to September overlaps with the trend in the Sud-Bandama region (Côte d'Ivoire). The other outbreak period observed by Wegbe et al. (1995) covered from February to May, whereas in our study, the second outbreak period covered from November to February. These similarities and differences may be attributed to the strong influence of the rainfall intensity and pattern on the development cycle of *E. myrmeleon,* as also confirmed by the two studies. The levels of attacks increase following the rainy seasons and decline after the dry seasons.

Entwistle (1972) stated that larvae desert galleries in wood which has become too dry and form fresh galleries in moister wood. This was confirmed by Wegbe et al (1995). Although this behavior was not observed in Côte d'Ivoire during this study, current results indicated that rainfall is important in *Eulophonotus* outbreak. Severe drought may cause *Eulophonotus* population to decrease because of lack of adequate food. In addition, if drought causes the larvae to desert galleries in wood which has become too dry, they become exposed to natural enemies such as predators and parasitoids. The reduction of the number of *Eulophonotus* larvae by these natural enemies may contribute to a decrease in the number of fresh holes in the cocoa orchard. It is important to note that the effect of parasitoids and predators are more important when the larvae start to excavate and enter in the wood at young stages or when the larvae desert galleries in wood which has become too dry to search for fresh wood (Entwistle, 1972).

Although the population dynamic of cocoa capsids were not taken into account in this study, previous studies indicated that for most of the major cocoa growing regions, cocoa capsids have two outbreak periods during the year, from July to September and from December to February, related to the two rainy seasons in the country (Lavabre et al., 1962, 1963). The results obtained in this study shows that the outbreak periods of *Eulophonotus* populations overlap, to some extent, with capsids' outbreak periods. The emergence of *Eulophonotus* adults occurs during these periods and any insecticides treatment against mirids may reduce adult population and as a result, minimize oviposition. This will subsequently reduce the number of holes during the following generation.

The results obtained in this study showed that the level of *E. myrmeleon* attacks varied to some extent with the age of the plots. This may be an indirect response to the effect of shade. Indeed, most old cocoa farms are partially degraded and present some open canopy compared to younger farms which have closed canopy. The difference in the levels of attacks between young and old cocoa may be explained by the effect of light on the oviposition process. This behavior has been observed in cocoa capsids. The adult females of capsids become photopositive in a short transitory period and fly toward lighted areas for oviposition, whereas all stages (nymphs and adults) are usually photonegative and avoid direct exposure to sun light in order to reduce dehydration and predation (Youdeowei, 1971). This behavior results in eggs being laid in breaks in the canopy and the subsequent development of mirids pockets ((Youdeowei, 1971; Entwisle, 1972).

The maximum number of *Eulophonotus* fresh holes recorded on one tree up to hand height was 12 and the minimum number was 0, suggesting that the number of holes varies and that some trees did not sustain any damage, at least up to hand height (about 2 m). Indeed, above hand height, the total number of fresh holes would have been higher for each tree, but the differences between trees with regard to the number of fresh holes would have been about the same. In addition, the trend regarding the change in the level of attack over time would remain the same. This may indicate that there is a high variability in the level of susceptibility of the cacao genotypes to *Eulophonotus* attacks. Indeed, in a previous study, Caplong et al. (1993) have shown that the percentage of attacked trees varied significantly between genotypes. In our

study, the plots are planted with hybrids cocoa and individual trees represent different genotypes. The results obtained by Caplong et al. (1993) and ours suggest that a study should be carried out to elucidate the reaction of cacao genotypes vis-à-vis *Eulophonotus* damage, in order to undertake breeding for resistance to this pest.

CONCLUSION

The results obtained in this study have shown that the cocoa stem borer, *Eulophonotus myrmeleon* Felder, has become a serious concern for cocoa growers and researchers in Côte d'Ivoire. The level of attack is high every year. The seasonal variation of *E. myrmeleon* population showed two outbreak periods. These two periods overlap somewhat with that of the cocoa mirids in most of the cocoa growing areas. This may be helpful in making recommendations based on rational use of insecticide. Insecticide treatment directed against cocoa mirids may be effective in reducing *E. myrmeleon* Felder population. Elsewhere, the evidence of a sex attractant in *E. myrmeleon* and the variability in the level of susceptibility of cacao genotypes to *Eulophonotus* attacks could be exploited as parts of a global management strategy. In addition, the effect of shade on the behaviour of *E. myrmeleon* adults should be investigated and used in the management strategy of this resurged pest.

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