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RESEARCH ARTICLE

ATTACKS AND DAMAGE OF TERMITES (INSECTA: ISOPTERA) IN COCOA PLANTATIONS (THEOBROMA CACAO L.) OF M'BRIMBO S.A.B STATION (SOUTH CÔTE D'IVOIRE)

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Abstract

Termites (Isoptera) are invertebrates that play many ecological functions in terrestrial ecosystems, especially in tropical areas. Despite the beneficial impact on agriculture, some termites are caused the important damages to crops and plantations in agrosystems. Knowledge of pest species is a prerequisite for undertaking an adequate fight against these insects. A study was carried out to evaluate the incidence of termite attack on cocoa trees of the station S.A.B. (Société Agricole du Bandama) in the south of Côte d'Ivoire. Termites were searched on the cacao trees and the rate of their attack was calculated. The results show that a total of 9 species from 5 genera of termites were identified. Termite attacks on cocoa trees were mainly due to the group of Fungus-growers and wood-feeders. These termites were responsible for 52.66% of attacks on cocoa trees. The *Ancistrotermes* and *Pseudacanthotermes*, genus of fungus-growers group, with respectively54% and 23% attack rates, constitute the most aggressive genera for cocoa trees. However, the attack intensity index was low (16.95%). The major damages were mainly caused by the genera *Pseudacanthotermes* and *Coptotermes*. It is therefore necessary to consider adequate control methods against these species.

Introduction:-

Cocoa is an export product of major interest around the world. It is one of the main export crops of some producing countries like Brazil, Ecuador, India, Nigeria, Ghana and Côte d'Ivoire. World cocoa production was estimated at more than 3.5 million tonnes per year (BTC, 2011). This culture supports nearly 3.5 million people worldwide. Eight (8) to ten (10) million hectares are devoted to cocoa cultivation worldwide. In Africa, cocoa is the main product exported by states. West Africa alone contributes over 70% of global cocoa bean production (CTB, 214). In Côte d'Ivoire, cocoa is the support of the agricultural sub-sector and, thus, is of strategic importance for balance (balance) and social stability. It contributes more than 15% to Gross Domestic Product. This crop is today confronted with many pests and diseases. The most destructive in Côte d'Ivoire are mirids, stem borers and termites. There is little data on termite attacks on this crop. Termites are an essential constituent of soil (Donovan et al., 2001;

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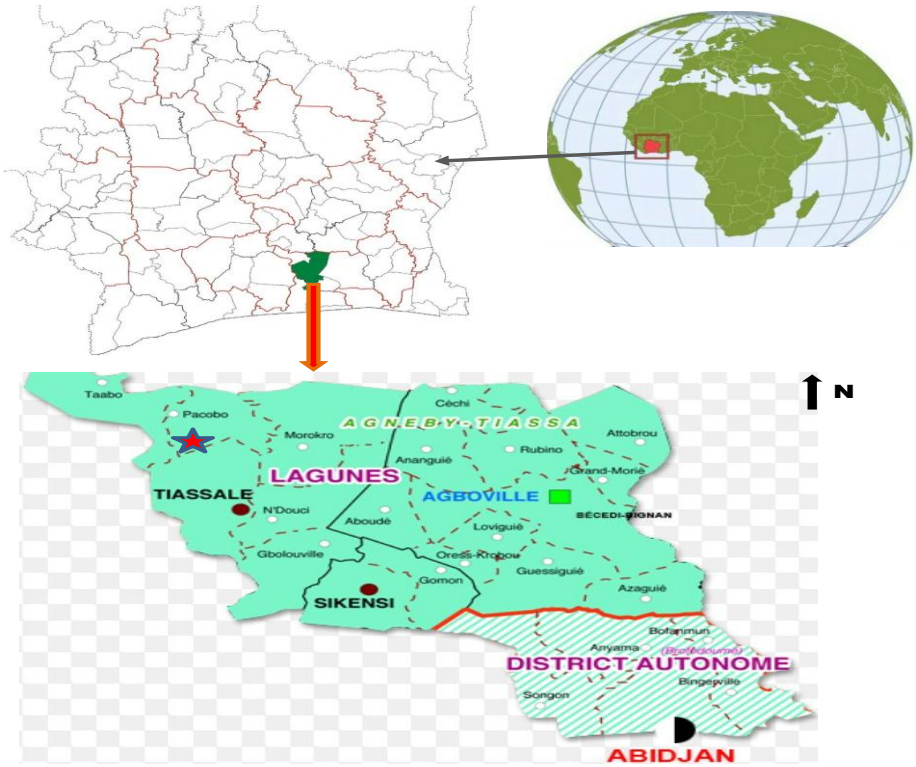
Inoue et al., 2001). They can account for more than 95% of insect biomass depending on the nature of the environment and soil structure (Bignell and Eggleton, 2000). These social insects are best known for the damage they cause to homes and crops (Zaremski et al., 2009). Sometimes they attack cultivated plants and causing damage and significant yield losses ((Han et al., 1998; Akpesse et al., 2008). Termites can attack plants at any stage of development, from seed to mature plant. They are considered the main source of nuisance in the tropics. Their presence is not noticed all the time because of their appearance. Termite attack on cultivated plants can be facilitated by water stress, accidental cuts in plant maintenance and cutting of tree trunks and branches. Recently, Tra-Bi, (2013) showed in the Oumé area, that termites were real aggressors in cocoa growing in southwestern Côte d'Ivoire. Thus, in order to always improve the production and quality of cocoa beans, entomological studies deserve to be carried out in other cocoa producing areas in order to better identify this threat with a view to finding suitable solutions. It is for this purpose that this study was carried out in the region of Tiassalé, one of the cocoa producing areas in southern Côte d'Ivoire. The objective is to answer the following questions: 1) what is the diversity of cocoa termites in this zone and 2) evaluate the attacks of these termites in these plantations.

Material And Methods:

Study Zone

This study was conducted in the Tiassalé region; located in the region of Lagunes, in the south of Côte d'Ivoire (5° 50 'N and 4° 50'W). It is about 120 km north-west of Abidjan and about 117 km southeast of Yamoussoukro (Fig 1). The climate is warm and rainy equatorial type with 4 seasons including a great rainy season from April to July; a short dry season from August to September; a small rainy season from October to November and a long dry season from December to March. The average annual temperature is 28 ° C. The minimum humidity is around 60%. The Bandama farm (SAB) in M'brimbo is an area of the former African canning company (SAFCO). The site was acquired by SAB in 2004 and development work began in 2007. It has a total area of 1012 hectares. Today this farm is intended for cocoa farming, rubber growing, fruit growing and beekeeping. The 8-years old plot of 10 hectares was randomly selected from the 100 ha site. The chosen plot counts on approximately 1200 cacao tree/ha with spacings of 03 meters. The cultural antecedent of this parcel is the pineapple.



Termites Sampling

Termites were searched in galleries and veneers, trunks, branches and apparent roots of cocoa trees up to a height of 1.5 m.

Study Zone

Termite's identification

Termites harvested were identified in the Laboratory of Biology and Animal Zoology of the University Felix Houphouet-Boigny of Abidjan. Specimens were determined up to the level of the genus and species using various classification documents such as: Hamad (1950), Bouillon and Mathot (1965), Roy-Noel (1966) and Engel (2011). After identification, each species was classified into one of the trophic groups (fungus-growers and wood-feeders), taking into account the shape of the mandible and intestinal contents for the worker caste.

Data Analysis:

Evaluation of termites attack rates

The rate of attack of termites was estimated based on the principle of Han and Ndiaye (1996). The organ is said to be attacked when it carries galleries or veneers with or without termites. The rate of attack of termites per plot was calculated according to the following formula:

Ta = Npa x 100 / Ntp

Ta = rate of attack of termites per plot

Npa = Number of feet attacked by termites

Ntp = Total number of feet observed per plot.

At the end of the observations, a rating scale of termite damage on trees was established because the presence of termites on a tree does not necessarily imply major damages. The observed damage was classified in 4 groups according to the density of the veneers of harvest and especially on the progression of the termites from superficial anatomical structures to deeper ones of the plant: bark, sapwood and heartwood (Table I). This damage was then organized into two types, minor damage and major damage.

Table I:-Rating Scale of Damages

Types	Rating (groups)	Caracteristic
Minor Damages	D1	Reduced number of termites harvest galleries
	D2	Increased number of harvest galleries and termite installation between bark and sapwood
Major Damages	D3	Significant recovery of cocoa tree by harvest galleries and the installation of termites in the sapwood and the abundance of harvesting termite
	D4	Transition of termites in the heartwood with decomposition of the trunk

The intensity index of attacks was calculated according to the method of Gbenyedji et al., (2016) to determine the vulnerability of cocoa trees to termite attacks.

I = [(D0 x 0%) + (D1 x 25%) + (D2 x 50%) + (D3 x 75%) + (D4 x 100%)] / [D0 + D1 + D2 + D3 + D4].

I = plot intensification index, D0 = number of healthy tree, D1 = number of tree with type 1 damage, D2 = number of tree with type 2 damage, D3: number of tree with type 2 damage, P4 = number of tree with type 4 damage.

Results:

Inventory of Species

A total of 09 species belonging to 05 genera and 2 families were collected on cacao trees in the study plot. The Macrotermitinae family was the most diverse with 8 species of termite pests (Table 2). Only one species of Rhinotermitinae was harvested. Species harvested at two trophic groups, fungus-growers and wood-feeders. The fungus-growers present with 8 species grouped into 4 genera (*Ancistrotermes, Microtermes, Odontotermes and Pseudacanthotermes*) were the most diversified group. The wood-feeders were represented by a single species (*Coptotermes intermedius*).

Table 2:-Diversity of cocoa pest termites

Family	Sub family	Species	Trophic Group
RHINOTERMITIDAE			
	Coptotermitinae		
		Coptotermes intermedius	Wood-feeders
TERMITIDAE			
	Macrotermitinae		
		Ancistrotermes cavithorax	Fungus-growers
		Ancistrotermes guineensis	Fungus-growers
		Ancistrotermes crucifer	Fungus-growers
		Pseudacanthotermes spiniger	Fungus-growers
		Pseudacanthotermes militaris	Fungus-growers
		Microtermes subhyalinus	Fungus-growers
		Odontotermes sp	Fungus-growers

Assessment of attacks

Termite attacks were observed on different parts of the seedlings of cocoa. They relate to the feet (stem), the roots and the grafts. Of the 600 cocoa plants in the plot, 316 plants were attacked by termites. This represented an overall attack rate of 52.66%.

Fungus-growers termites of *Ancistrotermes* and *Pseudacanthotermes* were the most aggressive genera for cacao with respectively 54% and 23% of the total rate of termite (Fig 2). The wood-feeders termites of the genus Odontotermes with only 2% of attack was the least aggressive genera on the cocoa trees. The 4 types of damage, grouped in two categories, were observed on the study plot (Fig. 3). The presence of termites on a tree does not necessarily imply major damage. Minor damages were highest with 41, 83% of damage type I (D1) and 7.66% of type II (D2) damage, respectively. This damage does not necessarily cause the degradation of the cocoa tree (Fig 4A & B). Major damage was less observed with respectively 2% of type III damage (D3) and 1.66% of type IV damage (D4). This damage caused the destruction of the tree, even causing the tree to die (Fig 3). On the feet bearing the major damage, it was observed mainly the genera *Coptotermes* and *Pseudacanthotermes*.

The index of intensification of termite attacks on the plot was low (16.95%). This index between [0%; 20%], shows that the intensity of termite attacks was low on cocoa trees.

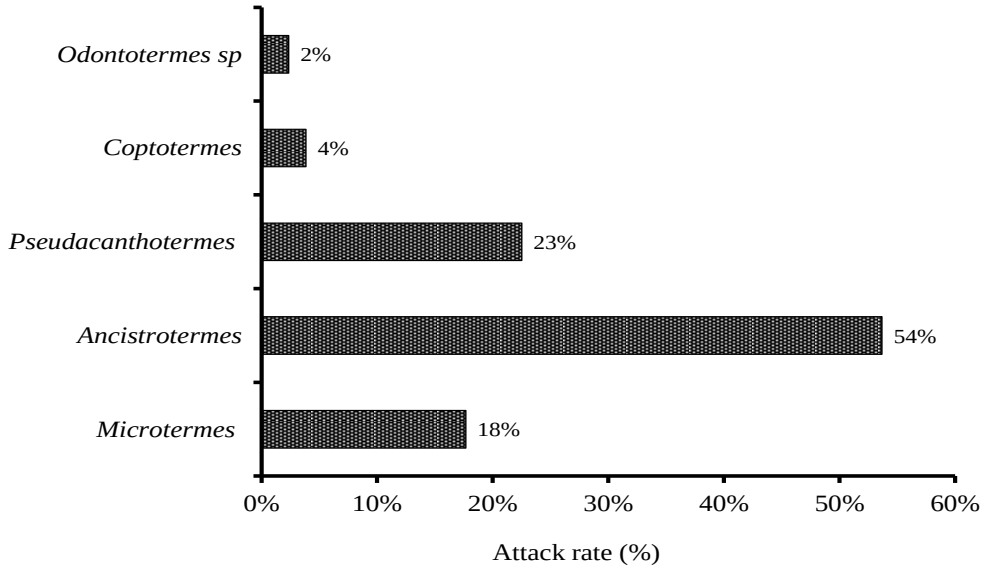


Figure 2: Attack rate according to termite's genera

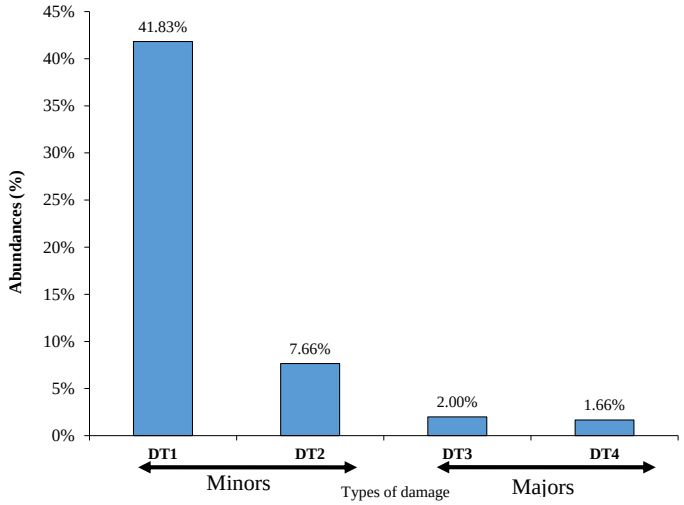


Figure 3: Abundance of damage types

A= Harvest Veneer

B= Degradation of the Bark

C= Wood Degradation

D= Dead Tree

Figure 4: Types of damages observed
A and B : Minor Damages; **C and D:** Major Damages

Modality of termite attacks on the cocoa trees of the plot

Attack of fungus-growers termites

Termites in this group access the plant by building veneer crops on the soil and on the plant. These veneers are true shields of protection against the rays of the sun and especially against the attacks of the ants. The perforation of the bark is done for most cases from the base to 1.5m height. Once the bark is perforated, the termites pass under the bark. They consume all the structures of this one by letting the thin outer bark conceal their presence. At the base of the foot, in general, there are many ramifications of the crop galleries. They proceed to the stuffing of the stem by the clayey ground as they advance towards the heartwood. Fungus-growers termites sometimes suffocate the stipe of the flowers by the veneer of soil which can lead to the premature death of this one.

Attacks of wood-feeders termites on cocoa trees

Wood-feeders of the genus *Coptotermes* preferentially attack recaptured cocoa trees or trees with slits. He builds harvest veneers on the outer parts of the plant (trunk and branches) and digs galleries in the internal structures of the tree. Severe attacks are mainly located in the heart of the tree with total destruction of the wood. Sawdust or feces derived from the consumption of wood by workers are observed. At this point, the tree has no chance of surviving.

Discussion:-

This study, based essentially on observations of cocoa stock, identified a total of nine (9) species of cocoa termites. This result was very slightly lower than those obtained respectively by Tra Bi (2013) with 12 species harvested in cocoa plantations in the region of Oume and Ano et al., (2018) with 11 species inventoried in the cocoa plantations of Abengourou in eastern Côte d'Ivoire. The high number of termites pests collected by Tra Bi (2013), was related to the fact that this author had sampled in several cocoa plantations along an age gradient from cocoa from less than 1 year to more than 30 years.

The termite pest species harvested in this study belong to the fungus-growers and wood-feeders groups. These two trophic groups are recognized as the main pests of rubber trees (Koudou et al., 2004 ; Hidayat ; 2018**)** and mango trees (Coulibaly et al., 2014). They attack trees because of their diet mainly based on cellulose and their need for water. Han et al. (1998) and Tahiri (2010) also showed that in perennial crops (oil palm and rubber tree), young cultivated feet were most prone to termite attack, especially those of the fungus-growers group. The observations of Anani et al., (2010) also showed that most of the termite species responsible for tree damage on the Lomé campus belong to the wood-feeders and fungus-growers groups. The pest species observed in this study have already been reported by authors in Ethiopia. Abdurahman et al. (2010) showed in western Wallaga (Ethiopia) that *Macrotermes subhayalinus, Microtermes* sp, *Ancictrotermes* sp, *Pseudacanthotermes militaris* and *Odontotermes* sp are the most damaging species.

The infestation rate observed is 52.66%. This rate is very close to that of Tra Bi (2013) which recorded a strong infestation of cocoa trees. The high rate of cocoa plantation infestation is thought to be due to the decline in plot maintenance and the decline in the use of adequate plant protection products. The fungus-growers group termites of the *Ancistrotermes* and *Pseudacanthotermes* genus with respectively 54% and 23% attack rate were the most aggressive genera for cocoa trees. However, the genera *Coptotermes* and *Pseudacanthotermes* have been identified as being responsible for major damage to cocoa. The genus *Ancistrotermes* has been identified as the main pest of rubber trees (Koudou et al., 2004; Tahiri and Mangué, 2007), young mango trees (Coulibaly et al., 2014). Tra-Bi, 2013, identified *Coptotermes intermedius* as the species responsible for major damage to aged cocoa trees in Oumé, Côte d'Ivoire. In addition, the presence of *Coptotermes* species on cocoa trees has also confirmed that this termite is closely related to cocoa trees. *Coptotermes*, particularly C. intermedius, was an important termite because its economic importance has been shown in crops (Hidayat, 2018) and it was one of the most destructive species of cocoa trees.

In addition, the attack intensity index of 16.95% shows that the intensity of termite attacks is low on the cocoa trees of our study plot. This could be explained by the resistance of cocoa trees of this age (8 years) characterized by a strong growth activity which gives a vigor to the plant. Tra Bi, (2013) has shown that in cocoa cultivation, termites preferentially attack plants less than one year old and the size class [20-30 cm] and] 30-40 cm] of older plants. The relatively large contact area of the trunk would facilitate the installation of biogenic structures (harvest veneer, internal galleries, sawdust ...) and especially the progression in the internal anatomical structures of the plant.

In this study, no soil feeder species were harvested from cocoa trees. The results were similar to those of Ano et al. (2018). Indeed, this author did not collect species of soil feeder on cocoa trees in Abengourou in the East of Côte d'Ivoire. These results would be related to their diet. soil feeder develop rather mushroom-shaped termite nests, or "nests" of cardboard material made of digested wood, more or less bound by soil particles on the ground, or hypogeous nests with little or no visible surface.

Conclusion:-

This study, which took place at the S.A.B. station (Société Agricole du Bandama) has collected a total of 9 species of cocoa termites pests in this region of Côte d'Ivoire. These species are grouped into 5 genera. Termite attacks on cocoa trees were mainly due to the groups of fungus-growers and wood-feeders groups. These termites were responsible for 52.66% of attacks on cocoa trees. However, the attack intensity index was low (16.95%). The most important damage (major damage D3 and D4) was caused by *Pseudacanthotermes* and *Coptotermes* genera

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