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Termite assemblages and infestation in rubber plantations of M'Brimbo in southern Côte d'Ivoire

AKPESSE[1] Akpa Alexandre M., KISSI[1] Thérèse Appoh P., COULIBALY Tenon[2*], Diby[1] Yao Kan S., KOUASSI[1] Kouassi P. and KOUA[1] Hervé K.

[1] Laboratory of Zoology and Animal Biology, UFR-Biosciences, Félix Houphouët-Boigny University of Abidjan, Côte d'Ivoire.
[2] Department of Animal Biology, UFR Sciences Biologiques, Université Péléforo Gon Coulibaly de Korhogo, Côte d'Ivoire.
*Corresponding Author: *tenondezana@yahoo.fr*

Abstract

Termites are in Africa one of the most important components of the soil macrofauna. Despite the beneficial impact on agriculture, some of these termites constitute for peasants in Africa, a major problem because of the damage caused to crops and plantations in agro-systems. Knowledge of their specific diversity in ecosystems is a prerequisite for undertaking adequate control of these insects. It is for this purpose that a systematic inventory of termites has been carried out in three age classes of rubber plantations. For the study of diversity, termites were harvested according to the standardized method of rapid estimation (RAP) of biodiversity. For each plot, 100 feet of rubber were observed for the assessment of termite attacks. The results show that a total of 11 termite species grouped into 7 genera were collected. The results obtained show that in the rubber plantation the diversity and abundance of termites are relatively low. This would be related to the fact that it is a monoculture and the use of herbicides. The high use of the 11 species harvested, 6 species belonging to fungus-growers and wood-feeders were recognized as aggressive for rubber plants. The fungus-growers were most involved in the attacks on the rubber plants. These termites were responsible respectively for 88%, and 38% of attacks on plants older than 10 years and 4-year-old seedlings. The greatest damage was, however, observed on seedlings in the nursery.

Keywords: Termites, diversity, agriculture, damage, RAP, rubber plantation.

Introduction

Established in Côte d'Ivoire in 1955 (Keli et al., 2005), rubber tree cultivation (*Hevea brasiliensis*) flourished and spread from primary growing areas to the interior of the country. . This crop is growing significantly with a significant change in the area planted (Keli et al., 2005, Ruf, 2008) which today reach nearly 110 000 ha. In twelve (12) years, Ivorian rubber production has tripled (Ruf, 2012) from 100 000 tonnes in 2000 to 310 000 tonnes in 2011. However, rubber cultivation in most tropical countries has many constraints that affect the level of production. These include diseases and pests. Of the rubbery pests, termites are one of the relatively under-researched insect groups. Despite the fact that termites

can serve as biological indicators for assessing ecosystem degradation, they constitute one of the greatest scourges in tropical agriculture and agroforestry (Mitchell, 2002). They regularly and severely attack crops and can cause considerable damage to wooden structures in most tropical countries. In many African countries, a wide range of food and industrial crops are regularly attacked and destroyed by termites (Tano 1996, Han et al., 1998, NDiaye 1998, Akpesse et al., 2008, Tra Bi 2013, Coulibaly et al., 2014). In Côte d'Ivoire, however, there is little work on termite attacks on rubber trees and methods of control. In general, the few studies carried out have taken into account only the inventory of termites and the description of damage on seedlings (Koudou 2004, Tahiri & Mangué 2007). Very little data exists on termites and their impact at different stages of rubber plantation. The general aim of this study is to study the termites responsible for damage in rubber plantations from the nursery to mature plants. The inventory of termite species associated with rubber cultivation is a prerequisite for the control of these pests. The area chosen for our study is the Bandama (SAB) Farm in M'brimbo, a domain located in the south of Côte d'Ivoire.

Materials and Methods

Study Zone

This study was carried out in the Tiassalé region, located in the Lagunes region of southern 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 (Figure 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 (SAB) farm 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 rubber growing, cocoa farming, fruit growing and beekeeping. Three age classes of rubber plantation were sampled. The plots sampled have a pineapple history and are as follows:

✓ **The nursery plot** has an area of one (1) ha with a high density of about 80,000 plants per hectare of nursery. It has been created since 2012. This nursery serves as a reserve of grafts. Indeed, it is from this nursery is born clones known for their agronomic quality and intended for grafting plants in the plantations of society. The removal of these grafts on rubber seedlings leaves many scars on these plants.

✓ **The plot of rubber seedlings** is less than 4 years old. The site has a density of 555 rubber feet/ha with 03 meter spacings between lines and feet. This parcel is characterized by the presence of rubber seedlings with an open canopy. Weeding the plot is done at least once a year using herbicides. The majority of rubber trees was healthy and has no injuries.

✓ **The plot of adult rubber trees** is more than ten (10) years old. The site also has a density of 555 feet of rubber / ha with spacings of 03 meters between the lines and feet. The canopy is closed and the traces of the bleeding are visible on the majority of rubber trees.

Sampling of litter termites

A plot of one hectare was delineated in each area. Termite sampling was conducted using the standardized method for termite harvesting (Jones and Eggleton 2000). Two (2) transects 100m long and 2m wide were delineated on the diagonals of the delimited parcel. Each transect was subdivided into ten (10) sections of 11m x 2m on each diagonal (Figure 1). The search is done by successive section by two people for 30 minutes. These people search the litter, epiged nests and aerial parts of plants up to 1.5 m (if possible) for termite. The termites were then collected in labeled pill containers containing 70 ° ethyl alcohol. Two (3) transects were conducted for termite sampling in each area.

Sampling pest termites

For this evaluation, 100 randomly selected rubber trees were observed in each of the three rubber plantations. Each rubber plant was observed from the base up to 1.5 m in height. The damage caused by termite attacks was photographed. The termites responsible for this damage were then collected in labeled pill containers containing 70 ° ethyl alcohol.

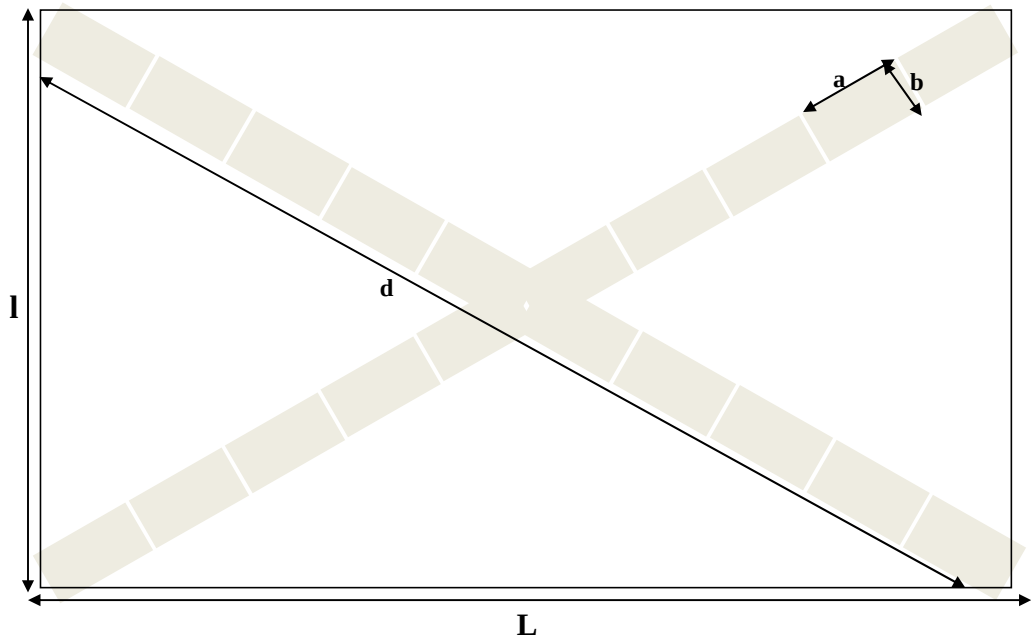

Fig. 1: Experimental device
a: length =11m ; **b** : widths = 2m ; **d** : length of transect 111m ;

Termite identification

Harvested termites were identified in the Laboratory of Biology and Animal Zoology of the University Felix Houphouet-Boigny (Abidjan). Specimens were determined up to the genus and species level using various classification documents such as: Sjöstedt (1926), Hamad (1950), Bouillon and Mathot (1965), Roy-Noel (1966), Sands (1965, 1972, 1998). After identification, each species was classified into one of the feeding group (ie, fungus-growers, soil-feeders and wood-feeders), taking into account the shape of the mandible and intestinal contents for the caste of workers.

Data analysis

Analysis of termite diversity

For the study of termite diversity, species richness (S), Shannon index (H '), equitability (E') and Simpson's index (IS) were calculated for each area. The relative abundance of termites in the transect which is the average number of encounters (occurrences) of a species i harvested in a transect (Magurran 2004) was also calculated for each area. It is based on the incidence (presence = 1 and absence = 0) of the species considered.

Evaluation of termite attacks

The rate of attack of termites was estimated based on the principle of Han and Ndiaye (1996) that the organ was 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 = termite attack rate per plot Npa = Number of feet attacked by termites Ntp = Total number of feet observed per plot.

Results

Diversity of litter termites

Of the plots sampled, twelve (12) termite species belonging to the families of Rhinotermitidae and Termitidae were collected (Table III). These species were divided into five (5) subfamilies and seven (7) genera. The nursery and the mature rubber plantations record the highest specific wealth with 9 and 10 species of termites harvested, respectively. The young plantation, with six species appeared as the least diversified. Harvested termites belong to three feeding group: fungus-growers, wood-feeders and soil-feeders. Two species of wood-feeders were collected only in the mature plantation (*Micocerotermes parvus* and *Nasutitermes arborum*).

Soil-feeders have been observed only in mature patches older than 10 years. The fungus-growers were the most diversified with 5 species whereas the wood-feeders and the soil-feeders were rare on all the plots sampled. The relative abundance of termite species shows that fungus-growers were the most abundant in all areas (Fig 1). *Ancistrotermes cavithorax* was the most common species in all media with abundances greater than 45 occurrences per area (Table III). Wood-feeders were also observed in all plots. Soil-feeders, totally absent in the nursery and young seedlings, were poorly observed in the 10-year-old plots.

Diversity indices varied from one area to another. Plots of mature plants and nursery record the highest Shannon indices with respectively H '= 2.1 and H' = 2.1. This index was relatively low in the immature plantation (H '= 1.65). The index derived from the Simpson index tracks changes in species richness with values between IS = 0.86 and IS = 0.89. Equitability varied in the same direction as these indices (Table III).

Table I: Distribution of termite species according to the age of rubber plantation

Subfamily	Species or morphospecies	Nursery	Young seedlings	Mature plants	TG
Amitermitinae	*Amitermes evuncifer*	25	-	-	w
	Amitermes sp 2	15	-	-	w
Termitinae	*Ancistrotermes crucifer*	5	40	25	f
	Ancistrotermes avithorax	55	55	45	f
	Microcerotermes parvus	15	-	10	w
Macrotermitinae	*Microtermes subhyalinus*	10	-	30	f
	Macrotermes bellicosus	15	20	25	f
	Pseudacanthotermes militaris	15	20	30	f
Nasutitermitinae	*Nasutitermes arborum*	-	-	20	w
Coptotermitinae	*Coptotermes intermedius*	15	20	20	w
	Coptotermes sjoestedti	-	10	10	w
Cubitermitinae					
	Procubitermes sp	-	-	2	s
	Species richness (S)	9	6	10	
	Shannon's index (H')	1,90	1,65	2,10	
	Evenness (E)	0,9	0,96	0,95	
	Simpson's index(IS)	0,86	0,80	0,92	

TG: Feeding group, f: fungus-growers, w: wood-feeders, s: soil-feeders

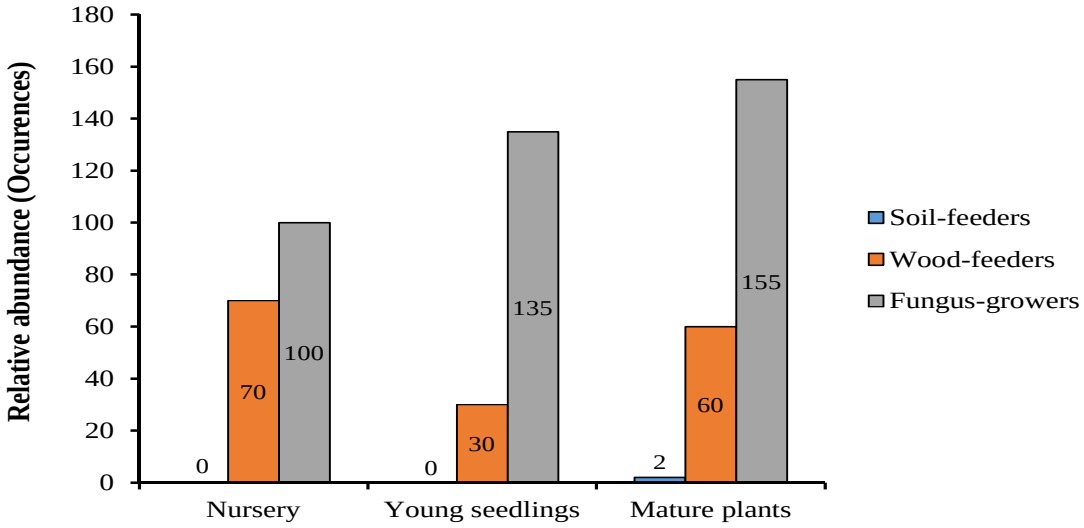

Fig. 1: Relative abundance of feeding groups

Attacks of termites on rubber trees

In total, 6 termite species grouped into 4 genera attack the rubber plants in the plots studied (Fig. 2). These were the *Ancistrotermes*, *Microtermes* and *Pseudacanthotermes* genera for fungus-growers and *Coptotermes* and *Nasutitermes* genera for wood-feeders. On immature plants *Ancistrotermes* and *Pseudacanthotermes* were the two genera of termites collected. At the nursery level, termite pests were all fungus-growers. These were the genera of *Ancistrotermes*, *Microtermes* and *Pseudacanthotermes* genera.

The attack rates of termites vary from one plot to another (Fig. 3). The plot of mature adult plants older than 10 years and the nursery plot, with respectively 88% and 75% termite attack rate, were the plots most attacked by termites. The plot of 4-year-old seedlings, with a 38% attack rate, was relatively less attacked by termites. Termites caused damage to attacked plants. These damages range from a simple prospecting veneer to the decomposition of the trunk of the tree by the action of termites.

However, the major damage, which can affect the development of the plants were very minimal on all the plots sampled. In the mature plants plot, the damage intensification index was 33%. This rate reveals a moderately attacked. On young plants, the damage caused by termites was less important. These were usually veneers (Fig. 4) and the damage intensification index was low (20%). Rubber seedlings in the nursery were infested by termites because of the regular cutting of the grafts. More than 75% of this plot was colonized by termites. The damage ranges from simple tunnel tunnels to wood degradation. No plant died by the action of termites on this plot. The main entry of termites on the seedlings of the nursery was the cut trunk. About 30% of the trees surveyed have more than 1/3 of the trunk replaced by the earth. The degree of attack was often a function of the number of cuts that a plant has undergone during its life.

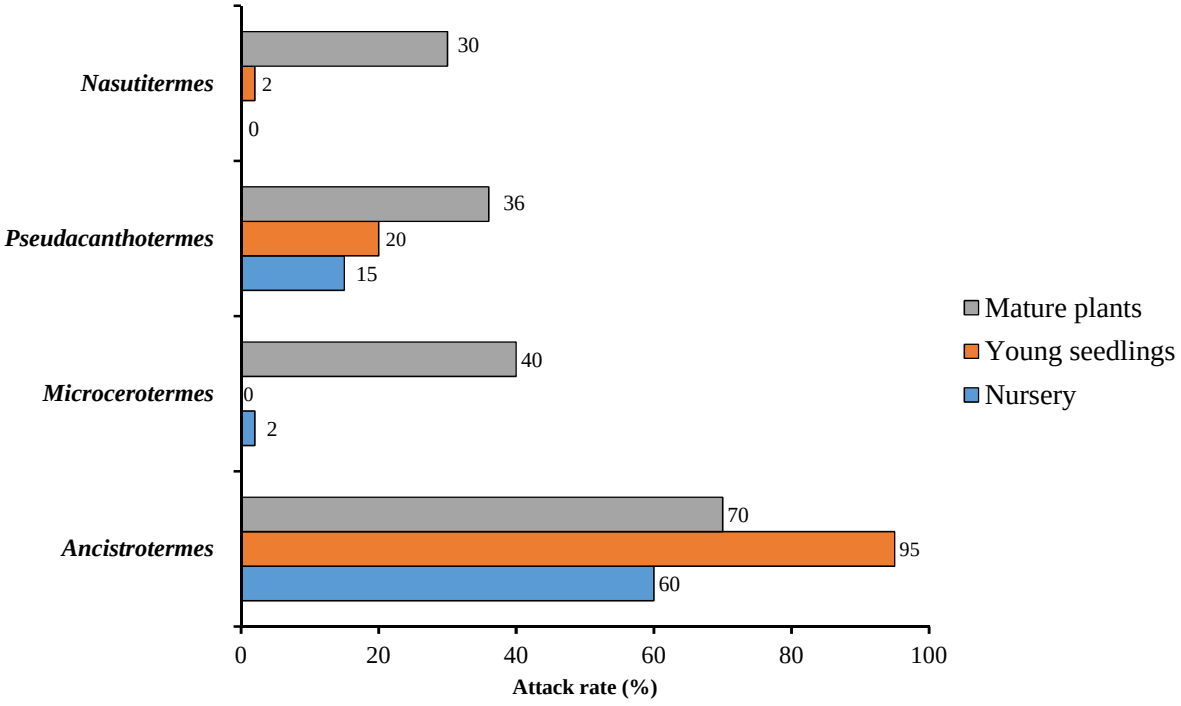

Fig. 2: Attack rate according to termite's genera

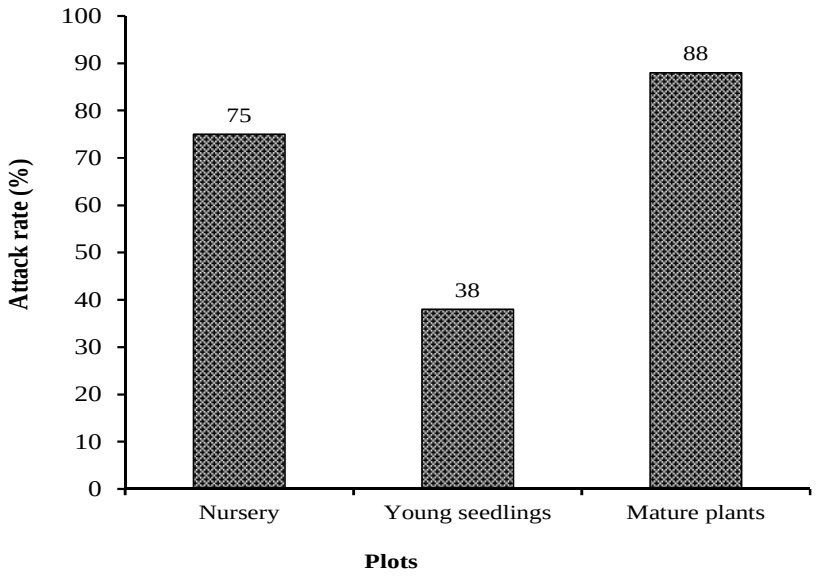

Fig. 3: Attack rate of termite on rubber plants

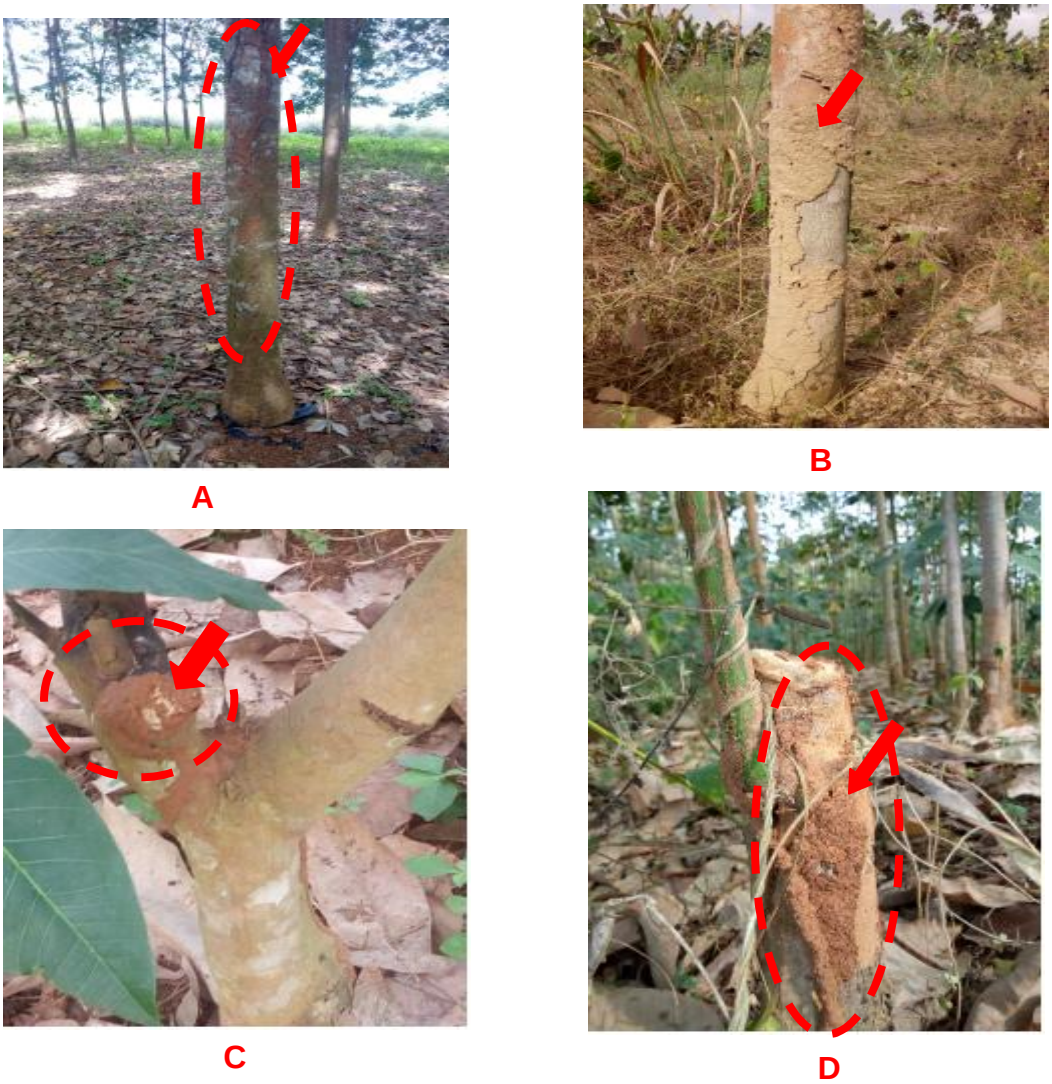

Fig. 4: termites attack and damages on trees
A: Mature plant attacked; B: Young plant attacked; C and D: Nurseries attacked

Discussion

Species richness and species diversity of termites

Of the 3 plots sampled, a total of 11 termite species were collected. This indicates the low specificity of termites of the plantations studied. This low wealth could be related to the plant species planted (rubber) on the plots, that is to say a monoculture. These results are similar to those observed by Gbenyedji et al. (2011). According to these authors, the specific diversity and abundance of the termite fauna was related to the plant species present in the ecosystem. They showed that monoculture disrupts faunal equilibrium in the teak plantations of the classified forest where they collected respectively five and ten species of termites at Eto and Noèpé. Termite sampling took place during the short dry season (December and January). This could also explain the low species richness obtained. According to Sarr (1999), termite densities are strongly influenced by the seasons. Termites would be more abundant at the beginning and end of the rainy season.

The low species richness observed is also linked to the massive use of herbicides used for the maintenance of young plots until the formation of the canopy. Several studies carried out in other area have shown that the use of chemicals affects the trophic structure and species richness of the fauna (Brown et al.2003, Donovan et al., 2007). This is likely to explain the low presence of soil-feeders and wood-feeders in this study. The soil-feeders group eats decomposing organic matter in soil (Brauman, 2000). Plot cultivation combined with the use of herbicides would certainly have had an impact on the availability of dead wood and the quality of soil organic matter as shown by Gillison et al., 2003.

The fungus-growers, less affected by the cultivation of the soil, are abundant in all areas. Their ability to live in these exploited areas is due to their remarkable adaptation, favored by the symbiotic relationship they have with a fungus of the genus Termitomyces (Guedegbe et al., 2008).

Attacks of termites pests on the rubber trees

Of the 11 species collected on the plots, 6 species were responsible for the damage on the plants. These species belong to two feeding group (fungus-growers and wood-feeders). The fungus-growers (*Ancistrotermes*, *Microtermes* and *Pseudacanthotermes*) were the most involved in the attacks on the sampled trees. These attacks were particularly severe on seedlings in the nursery and those on the mature plantation. These observations are very close to those of several authors who worked on rubber plantation. Tahiri and Mangué (2007) who showed that in cultivation of rubber trees young cultivated feet are the most susceptible to termite attacks, especially those of the group of fungus-growers. For its authors, the presence of grafting-related wounds of its seedlings would be responsible for the intensification of termite attacks. Coulibaly et al. (2014) also showed that fungus-growers genera such as *Ancistrotermes*, *Microtermes* and *Amitermes* were the most aggressive on seedlings in mango nurseries.

The evaluation of termite attack rates has shown that attacks were higher in mature planting (88%) while in immature planting this rate is 38%.

The abundance of attacks on mature plants is related to the diameter of the tree. Plants older than 10 years were larger in diameter than 4-year-old plants. This large diameter would facilitate the construction of earth veneers by termites. However, the presence of these veneers does not cause significant damage to the tree. Gbenyedji et al. (2011) showed that the rate of attack due to termites is a function of the age of the trees. Older trees were more attacked than middle-aged trees.

In plantations, the action of termites on trees usually results in veneers. This action does not cause visible damage to trees. However, covering the trunk of the tree with earthy veneers could cause a decrease in the photosynthetic activity of the tree and cause it stress, a source of future termite attacks. Logan and El Bakri (1990) made similar observations in Sudan.

In the nursery, termite attacks were relatively high and 75%. These attacks were responsible for the degradation or death of the plants. Attacks and termite damage in this nursery could be facilitated by injuries caused by graft cutting. The superficial tissues thus broken up widen with the growth of the plant thus producing slits which would facilitate the entry of termites. Many authors agree that wounds or openings on plants are the gateway for many pests (Pollet et al., 1987, Engesser et al., 2000).

Conclusion

This study carried out at S.A.B. (Société Agricole du Bandama) has collected a total of 11 termite species grouped into 7 genera. The results obtained show that in the rubber plantation the diversity and abundance of termites were relatively low. This would be related to the fact that it is a monoculture and the use of herbicides. Six (6) species belonging to fungus-growers and wood-feeders were recognized as aggressive for rubber plants. The fungus-growers were most involved in the attacks on the rubber plants. These termites were responsible for 88%, and 38% of attacks respectively on plants older than 10 years and 4-year-old seedlings. The greatest damage was, however, observed on seedlings in the nursery where 75% attack rate was observed.

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