ORIGINAL ARTICLE

DIVERSITY AND TERMITE DAMAGE ON COCONUT PLOTS (Cocos nucifera L. 1753) AT THE MARC DELORME RESEARCH STATION IN PORT BOUËT OF CÔTE D'IVOIRE

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ABSTRACT

Introduction: Coconut is a perennial plant whose fruits are very useful in many fields. This culture is subject to many pests including termites. **Objective:** evaluate the impact of termites in coconut plantations. **Methods:** In order to identify the termites responsible for damage to coconut palms, a study was carried out at the Marc Delorme research station. Thus, a 3-month-old nursery, a 12-year-old coconut plot considered young and another 51-year-old considered old were the subject of our study. 100 m long and 2 m wide transects subdivided into 20 sections were developed as well as TSBF monoliths and systematic excavations were used for termite collection. Damage was observed on 133 plants on each of the plots and on plants chosen at random from the nursery. **Results**: The results obtained made it possible to identify seven (7) species of termites: *Macrotermes bellicosus*, *Macrotermes subhyalinus*, *Ancistrotermes crucifer*, *Ancistrotermes cavithorax*, *Odontotermes pauperans*, *Odontotermes sp*. and *Amitermes spinifer*. *Macrotermes subhyalinus* is a species common to all three environments. Two trophic groups have been identified. These are the fungus-growers and the wood-feeders with dominance of the fungus-growers. The attack rate varies from plot to plot. Young and old plots have an attack rate of 72.18% and 69.17% respectively. The highest attack rate was recorded on the nursery with 74.64%. **Conclusion:** It emerges from our work that all the studied plots are subject to termite attacks and it is therefore necessary to set up control methods.

Keywords: *Termites, Trophic group, coconut tree, Age gradient, Attack*

1. INTRODUCTION

The coconut palm (*Cocos nucifera* L.) is an oilseed crop of great importance in the tropics [1]. The coconut palm belongs to Arecaceae family and is the only specie of *Cocos* genus [2]. It provides year-round yield and has an economic life of 60–70 years [3]. The area occupied by coconut groves in the world is estimated at more than 12 million hectares for an annual production of 5.2 to 5.8 million tons of copra [4]. In Côte d'Ivoire, the coconut palm constitutes a cash crop for the populations of the coastal regions [5]. This culture is carried out on an area of approximately 50,000 ha for an annual production of more than 70,000 tons of copra [6]. The coconut tree is also involved in the cosmetics, pharmaceutical and energy industries for the production of beauty products, medicines and fuel [7–9]. Fresh almonds are consumed or transformed into milk or cream. It is also used to make grated coconut. Coconut oil obtained from dried almonds is used in industry for making confectionery, margarine and pastries [10–12]. Copra cake or meal can be used in cattle feed, as a food supplement, because of its low protein content [13]. From an agronomic point of view, the copra meal and the shell serve as organic manure [14]. However, this culture is compromised by several diseases and pests including termites. The harmful action of these termites is manifested either by a direct attack on the crops or by their epigeous constructions (termite mounds] which hinder the harvest [15,16], especially when mechanization is used, thus causing a significant drop in yield [17]. Losses due to these pests to crops and plantations are often greater than 15% and can sometimes reach 90% [18]. Despite the many control methods used in Africa, damage still persists and crop losses increase each year. Regarding the termite diversity of coconut groves in Côte d'Ivoire, few studies have been carried out. Thus, the objective of this study is to know the termites responsible for the damage in the coconut orchards of the Marc Delorme station. During this study, the diversity of termites responsible for attacks and their intensity of attacks were evaluated in three classes of coconut orchards.

2. MATERIAL AND METHODS

2.1 Study site

Marc Delorme Research Station (3°14' and 3°15' North latitude and 3°54' and 3°55' West longitude) is located in Port-Bouët. Its total area is 998 ha including 806 ha of area planted with coconut palms. This station was created in 1949 by the Research Institute for Oils and Oilseeds (IRHO). This station houses the international coconut palm collection for Africa and the Indian Ocean, which is classified as "international heritage by the United Nations Food Fund (FAO). The climate of the Marc Delorme station is tropical with two dry seasons and two rainy seasons (April to July and October to November) [1-12]. The average annual rainfall is 1475.88 mm. The average monthly temperature is 26.4 °C [19].

2.2 Sampling of termites in the plots

Experimental device

Termites were sampled in three plots of different ages of coconut trees. These were three-year-old coconut trees, which constitute the nursery; 12-year-old coconut trees, which represent the young plot; and the old plot, which contains 51-year-old plants. The choice of these plots was made in order to compare the degrees of infestation according to the age of the plants. Within the plots (young and old), a sub-plot of 10 m by 100 m was delimited. Within these subplots, three transects of 100 m in length and 2 m in width were made. Then, each transect was divided into 20 sections of 5 m length and 2 m width each. Termite harvesting took place over a two-month period from March to April 2021 using the transect method [20]. At the transect level, litter and biogenic structures such as aboveground and arboreal termite mounds are searched for termites. In addition, termites were collected from tree trunks up to 1.5 m above ground level, especially those within the transect. At the same time the termite mounds located in each transect were counted. Twelve earthen monoliths 12 cm x 12 cm square and 10 cm thick are extracted by section and searched for termites. Each section is sampled by two people for thirty minutes [21,22]. Termites collected using entomological forceps then preserved in alcohol at 70 °C. In the nursery, systematic excavation was used for termite sampling. For these 4 (four) blocks of 29.30 m long and 3 m wide were chosen. Each block was searched for termites.

2.3 Termites identification

The identification of the termites was made in the laboratory using a binocular magnifying glass according to the morphometric parameters of the termites based on the morphology of the soldiers. Qualitative and quantitative characters were observed and measured. The qualitative characters are the shape of the pronotum and the presence of mandibular teeth. The quantitative characters are the number of antennal segments, the length of the head (from the posterior edge of the head to the external base of the mandibles), the median width of the head, the length of the left mandible (from the point of insertion from the mandible to the top of the mandible), the length of the head with mandibles (from the posterior edge of the head to the top of the mandible), the length of the gula, the median width of the gula, the length of the left posterior tibia. The genus and species of each lot is thus determined using the identification keys of [23–25].

2.4 Assessment of attacks and damage by termite pests

Damage was assessed by visual observation according to the principle that the organ is said to be attacked when it bears galleries or veneers with or without termites [26]. In the old and young plots, observation was made on all coconut trees in the subplots studied, i.e. 133 plants per environment. In the nursery, 133 plants chosen at random in 4 defined blocks were the subject of this study. The observation focused on the observation of the trunks and roots of the coconut plants. Galleries and earthen veneers with or without termites, small holes and cavities dug were also searched in order to find the penetration route of the termite inside the plant and the part consumed by the termite. The attack rate is given by the following formula (Eq 1).

$$A_r(\%) = \frac{Na}{Nt} \times 100 \tag{1}$$

With:
Ar: attack rate,
Na: Number of plants attacked,
Nt: Number of Total Plants.

At the end of observations, the damage was classified into four (4) types according to the rating scale (Table 1) (15). To assess the importance of attacks, damage intensification indices were calculated (Eq 2) and ranked (Table 2) [27].

$$I_d = \frac{(P0\times 0\%) + (P1\times 25\%) + (P2\times 50\%) + (P3\times 75\%) + (P4\times 100\%)}{Ps + P1 + P2 + P3 + P4} \tag{2}$$

With Id: intensity index of the damage per plot, P= number of feet and the following values show damage type

Table 1: Rating scale for termite damage to trees [15].

Quote	Definition
DT0	Healthy plant
DT1	Presence of galleries on plants with or without termites
DT2	Plant partially or totally covered with termite veneers
DT3	Presence of termites on the plants
DT4	Plant eaten away by termites

Table 2: Classification of attack intensification indices [27].

Class	Intensity (%)	Qualification
I	0≤ I <20	Low
II	20≤ I <40	Medium
III	40≤ I <50	High
IV	50≤ I <100	Very Strong

2.5 Description of communities

Frequency of occurrence (F%)

The frequency of occurrence expressed as a percentage [28] is the ratio of the number of records containing the species studied (Pi) to the total number of records (P) (Eq 3). Based on the value obtained, a species is classified as rare (F <5%), incidental (5% ≤ F <25%), frequent (25% ≤ F <50%), constant (50% ≤ F <100%) or ubiquitous (F = 100%).

$$F\ (\%) = \frac{Pi}{P} \times 100 \qquad \textbf{(3)}$$

Species richness (S)

Species richness (S) corresponds to the total number of termite species sampled in a given environment [29].

Shannon index

The specific diversity can be evaluated by a diversity index that takes into account both the specific richness and the abundance of the different species (Eq 4). The Shannon index (H') takes into account the number of taxa encountered on a plot. It neglects the rare species present in the environment [30]. It is zero when there is only one taxon and its value is maximum when all the taxa have the same abundance.

$$H' = \sum Pi \times \log 2\ (\text{Pi}) \qquad \textbf{(4)}$$

With:
Pi = probability of encounter of species i,
pi = ni/N,
ni = number of individuals of species i,
N = total number of individuals.

Equity index

Also called evenness index, equitability (E) measures the equitable distribution of species (Eq 4). It makes it possible to compare stands comprising different numbers of taxa [31]. Its objective is to observe the balance of the populations present. E approaches 0 when one taxon largely dominates a stand and is equal to 1 when all taxa have the same abundance.

$$E = \frac{H'}{\log 2(S)} \qquad \textbf{(5)}$$

With:
H' = Shannon diversity index;
S = Specific richness.

Simpson's Index

The Simpson index (D) [29] evaluates the probability that two individuals, randomly drawn from an infinite population of N individuals, belong to the same species (Eq 6). The index "derived" from the Simpson index (IS = 1-D) was used. This index varies between 0 and 1. The diversity is minimum for an index equal to = 1 and maximum for an index equal to 0.

$$D = \sum_{i=1}^{S} Pi^2 \qquad \textbf{(6)}$$

With:
Pi = probability of encounter of species i,
pi= ni/N ;
ni = number of individuals of species i,
N = total number of individuals.

Jaccard Index

The similarity index (Jaccard) or diversity β (Sj) is a measure of biodiversity that makes it possible to compare the diversity of species between ecosystems (eq 7). This implies comparing the number of taxa that are unique to each of the ecosystems [31]. This index varies from 0 (absence of similarity) to 1 (identical environments).

$$Sj = \frac{a}{a+b+c} \qquad \textbf{(7)}$$

With:
a = number of species common to both plots,
b = number of species observed only on plot A,
c = number of species observed only on plot B.

3. RESULTS

3.1 Species of termites harvested in the coconut grove

The observation of the specimens allowed us to identify seven (7) species all belonging to the Termitidae family and divided into two (2) subfamilies. The Macrotermitinae subfamily includes 6 species: *Macrotermes bellicosus*, *Macrotermes subhyalinus*, *Ancistrotermes crucifer*, *Ancistrotermes cavithorax*, *Odontotermes pauperans* and *Odontotermes sp*. Amitermitinae subfamily represented by a single species: *Amitermes spinifer*. One species is common to the three plots, it is *Macrotermes subhyalinus* (Table 3). On all three (3) plots studied, four (4) genus of termites were identified; they are *Macrotermes*, *Ancistrotermes*, *Amitermes* and *Odontotermes* (Figure 1). These entire genuses were listed on the young plot. However, the *Macrotermes* and *Ancistrotermes* were identified on the old plot and only the *Macrotermes* was obtained from the nursery. In this study, the species of termites sampled belong to two (2) trophic groups which are the fungus growers and the wood-feeders. The results of the frequency of occurrence shows that among the termites sampled in the litter, the group of fungus-growers is omnipresent in the nursery while it is constant on the young plot and on the old plot. In addition to fungus-growers, species from the wood-feeders group are rarely encountered on the young plot.

Table 3: Specific diversity and occurrence (%) of termites according to the age of the plots studied using the transect method.

Family	Subfamily	Species	TG	N	Y	O
Termitidae	Termitinae	*Macrotermes bellicosus*	F		9	94
		Macrotermes subhyalinus	F	100	44	6
		Ancistrotermes crucifer	F		40	
		Ancistrotermes cavithorax	F		3	
		Odontotermes pauperans	F		1	
		Odontotermes sp	F		1	
	Amitermitinae	*Amitermes spinifer*	W		1	

TG: Trophic Group, **W**: wood-feeders, **F**: fungus-growers. **N**: Nursery, **Y**: Young plot, **O**: Old plot

Figure 1: Different genus of termites collected (**A**: *Macrotermes*, **B**: *Odontotermes*, **C**: *Ancistrotermes*, **D**: *Amitermes*).

On the different plots sampled, the Shannon index was zero (H'= 0) in the nursery, higher in the young plot (H'=1,31) and lower in the old plot (H'= 0,63). The Simpson's Index (SI) varies from site to site. It is 1 on the nursery and the young plot. On the other hand, it is 0,25 for the old plot. The equitability of termites is 0 on the nursery, E= 0,46 for the young plot and E= 0.39 for the old plot. The similarity index between the different plots (the young plot-old plot, the nursery-old plot and the nursery-young plot) taken two by two is respectively 0.23; 0.2 and 0.11.

3.2 Damage to Coconut termite pests

3.2.1 Quantitative study of termite damage

In total, five (5) species of termites are responsible for damage to coconut palms. These species are grouped into two sub-families which are Macrotermitinae and Amitermitinae. These are *Macrotermes bellicosus*, *Macrotermes subhyalinus*, *Ancistrotermes crucifer*, *Ancistrotermes cavithorax* belonging to the group of fungus-growers and *Amitermes spinifer* for wood-feeders. All these 5 species were harvested from the trees of the young plot with a dominance of fungus-growers. On the old plot, *Macrotermes* and *Ancistrotermes* are the two-genus harvested. In young and old plots, out of a total of

133 coconut trees sampled per plot, the attack rate was 72.18% and 69.17% respectively. As for the nursery, it records an attack rate of 74.64%.

In terms of degree of infestation, at the nursery level, type 2 damage was the most significant (48 plants). Respectively 17 and 16 plants were recorded for DT3 and DT4. On the young plot, 37 healthy plants (DT0) were recorded against 5 plants eaten away by termites DT4. As for the old plot, there were 41 trees with no termite attack (DT0) and 13 plants colonized by termites (DT3). No plants were classified in the DT4 rating in the old plots (Figure 2). The different damage intensification indices obtained show that it differs between the three plots. The young plot and the old plot obtained an average index with respectively 35.33% and 33,45%. The index of intensification of the damage of the nursery is qualified of strong with 43.39%.

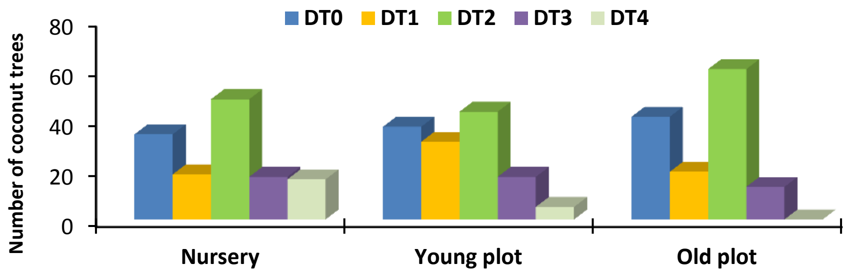

Figure 2: Repartition of coconut trees observed according to the rating scale and age of the plots.

3.2.2 Qualitative study of termite damage

The pest termite species harvested from coconut palm plants have different attack modalities ranging from earthy veneers to trunk consumption (Figure 4). The modes of attack of termites are very varied depending on the species encountered.

- *Macrotermes* present on the three plots are responsible for the four types of damage. The attacks of the latter result in the construction of epigeal nests around the coconut palm. Inside termite mounds, these termites destroy the bark to feed themselves. They gnaw through the bark and attack the wood of the tree leading to the long-term death of the tree. Termites build veneers of soil on the tree and these exposed veneers show *Macrotermes* workers actively moving on the trunks of attacked trees.

- *Ancistrotermes* are present on the young and old plots. The attacks are located on the trunks with the construction of galleries and veneers. These termites puncture the bark and then reach the wood. Once at the heart of the tree, they proceed to stuff the trunk with the earth as it advances. It attacks the roots and trunks of the tree.
- *Amitermes* are the genera encountered only on the young plot. They cause galleries on the trunks of trees and on the feet of coconut palms. These termites consume the trunks of coconut trees from the outside inwards. The attacks of these termites result in the presence of cracks and small holes on the trunks of coconut trees.

Figure 4: Damage of termites on coconut trees.

4. DISCUSSION

In total, seven (7) species of termites were collected from the three (3) plots studied. These results show a low specific richness of termites in the plantations obtained from work carried out by other authors on fruit trees such as those of Ndiaye and Han (2002) in an orchard in Casamance (23 species of termites), Tra Bi (2013) in cocoa trees (25 species of termites) and Coulibaly *et al.,* (2014) in mango tree nurseries (12 species of termites) [22-26-32]. This low species richness could be linked to the cleaning that the plots underwent and the use of insecticides and other inputs during these interviews in the nursery. Observations made by Lavelle (1997) showed that regular cleaning and maintenance would affect the physical structure of the soil, which could be a cause of the low species richness observed in plantations [33]. This argument is consistent with that of Donovan *et al.,* (2007) who reported that soil exploitation would affect the trophic structure and species richness of termites [34]. In addition, the low specific richness of termites is often linked to the plant species planted (coconut palm) on the plots. According to Gbenyedji *et al.,* (2011) the specific diversity and abundance of termite fauna would be linked to the plant species present in the ecosystem [35]. Indeed, man considerably modifies the characteristics of natural ecosystems through his agricultural activities: the preparation of the soil, the destruction of woody plants, the replacement of a diversified flora by a crop. A monoculture disrupts the faunal balance. Harmful species of termites harvested mainly belong to the group of fungus growers and wood-feeders with dominance of fungus growers. These two trophic groups are recognized as the main pests of rubber trees and mango trees [16-36]. They attack trees because of their mainly cellulose-based diet and their need for water. Han *et al.,* (1998) and Tahiri *et al.,* (2010) also showed that in perennial crops (oil palm and rubber), young cultivated plants were the most prone to termite attacks, especially those in the fungus-growers group [37]. The observations of Anani *et al.,* (2010) showed that most of the species of termites responsible for the damage caused to trees on the Lomé campus belong to the group of xylophages and fungus growers [38]. The low number of xylophage individuals collected would be due to the feeding of these trophic groups. Indeed, cultivation would have an impact on the trophic groups. However, fungus-growers are less affected by soil cultivation, which would explain their abundance in the study environments. Their ability to live in these exploited environments would be linked to their remarkable adaptation, favored by the symbiotic relationship they maintain with certain fungi of the genus Termitomyces which would facilitate the digestion of complex molecules such as cellulose, lignin and tannins [39,40]. In our studies we note that the damage observed is essentially of the DT2 type (plants totally or partially covered with termite veneer) with an average of 68 plants. This high number is due to the mode of attack of the different species of termites encountered. Indeed, most termites, more specifically those of the genus *Macrotermes*, build galleries and earth platings on the trunks of plants. These veneers serve as protection for attacking the plant. Akpesse et al., (2008) stipulates that the attack of termites is from the outside to the inside with successive consumption of the outer cortex of the stem, the inner parenchyma and the cambium of the stem [41]. The deleterious (harmful) action of termites on the trees observed results in food recognition veneers, the destruction of the tree. However, this action can result in another way in the tree by the decrease in photosynthetic activity due to the covering of the trunk of the tree by earthy veneers. Logan and El Bakri (1990) showed that the presence of galleries and crop veneers on the tree can reduce its photosynthetic capacity and cause it stress (the state of a plant when one of the factors of its growth runs out), source of future termite attacks [42]. This damage observed during our work is caused by termites from two trophic groups, namely fungus-growers and xylophages. Fungus-growers were the most numerous on the plants sampled in the plots. This group was observed by N'Diaye (1998) during his work on fruit trees in Senegal. Indeed, they attack fruit trees by making veneers that can cover the entire trunk [43]. Also, these termites can attack trees from the underground parts, i.e. the roots and the collar (sapwood and heartwood) [40]. Fungus-growers termites in general have been reported as pests of food crops [41]. The attack rate of termites on the plots depends on the age of plots. The attack rates in the young and old plot are respectively 72.18% and 69.17%. According to Gbenyedji *et al.,* (2011) the attack rate due to termites depends on the age of the trees [35]. The highest attack rate was obtained in the nursery with 74.64%. This high rate shows that the plants in this nursery are more attractive because of their softer constituents which are easily digested by termites. Also, the strong presence of dry plant matter (coconut husk, dead wood and branches) strewing the ground attracts these termites. These results are similar to those of Tondoh (1992). According to this author, the presence of crop residues and dead wood in newly created plots is a real source of food that can attract termites [44]. The infestation rates recorded on the plots could be linked to the nature of the soil (ferralitic soil) which would favor the installation of termite mounds, sources of plant infestations. Anani *et al.,* (2010) showed that the incidence and intensity of termite attacks vary according to species, locality and soil conditions [38].

5. CONCLUSION

This study allowed us to know the termitic sanitary state of three parcels of coconut palms of the Marc Delorme station according to an age gradient. It shows seven (7) species of termites divided into 4 genera: *Macrotermes*, *Ancistrotermes*, *Odontotermes* and *Amitermes* belonging to the Termitidae family. These species belong to two trophic groups, fungus growers and wood-feeders. Fungus-growers are the most diverse group with dominance of the genus *Macrotermes*. Thus the diversity is higher in the young plantation and is low in the seedbed nursery. The results obtained show that all these plots studied are subject to termite attacks with a maximum rate recorded on the young plot and the nursery in germoir with respectively 72.18% and 74.64%. The modes of attack of termites vary greatly depending on the species and generally relate to the consumption of bark, the construction of galleries and veneers on the trunks.

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6. REFERENCES

1. Koffi EBZ, Yao SDM, Doh F, Koffi Y, Sié RS, Konan KJL. Évaluation de la tolérance des descendances hybrides de cocotier (*Cocos nucifera* L.) NJM x GVT vis-à-vis des attaques de la punaise Pseudotheraptus devastans Distant (Heteroptera: Coreidae) en Côte d'Ivoire. *Afr Sci.* 2017;13(3):364-76.
2. Batugal P, Jayashree K. COGENT's multi-site International Coconut Genebank. Coconut Genet Resour. 2005;106.
3. Anilkumar KS, Wahid PA. Effet d'une fertilization inorganique à long terme sur la disponibilité des elements nutritifs du soil et sur la nutrition du cocotier. Ol Paris. 1989;44(6):281-6.
4. CNUCED, Conférence des Nations Unies sur le Commerce et le Developpement. Noix de coco, un profil de produit de base par INFOCOMM Fonds de la CNUCED pour l'information sur les marchés des produits de base agricoles. [Internet]. 2016. Disponible sur: unctad.org/commodities
5. Ouvrier M, Zakra N, Sangaré A, N'Cho YP. Inventaire de la cocoteraie ivoirienne. Abidjan: IDEFOR; 1995 p. 33.
6. CNRA. La maladie du jaunissement mortel gagne du terrain [Internet]. GrandLahou: Centre National de Recherche Agronomique; 2014 [cité 7 août 2022] p. 30. Disponible sur: https://www.google.com/cnra/La maladiedujaunissementmorteld cocotier
7. Rouzière A. Quelles technologies le CIRAD peut-il proposer pour redynamiser la filière cocotier? Ol Paris. 1994;49(3):115-24.

8. Assa RRA. Diagnostic de la cocoteraie du littoral ivoirien: étude physico-chimique, microbiologique et organoleptique de l'eau et de l'amande des fruits de quatre cultivars du cocotier (*Cocos nucifera* L.) selon les stades de maturité [PhD Thesis]. Thèse de doctorat unique de l'Université de Cocody (Abidjan, Côte d'Ivoire); 2007.
9. Van der Vossen H, Chipungahelo G. Cocos nucifera L. In: Végétable oils/Oléagineux. Van DerVossen HAM, Mkamilo GS. 2007. p. [CD-ROM].
10. Graille J. Usages alimentaires et oléochimiques du complexe laurique. *Oléagineux*. 1993;48(12):515-26.
11. Konan BR, Konan JL, Assa RR, Oulé M, Amani G. The physicochemical characteristics of coconut (*Cocos nucifera* L.) kernel in germination. *Seed Sci Biotechnol*. 2009;3(1):1-7.
12. Assa RR, Konan JK, Prades A, Nemlin J, Koffi E. Physicochemical characteristics of kernel during fruit maturation of four coconut cultivars (*Cocos nucifera* L.). Afr J Biotechnol. 2010;9(14):2136-44.
13. Bourdeix R, Konan Konan JL, N'Cho YP. Cocotier: guide des variétés traditionnelles et améliorées. Barcelone, Espagne: *Diversiflora*; 2005. 104 p.
14. Lekadou TT, N'Goran A, Konan JL, Allou K, Zakra N, Assa A. Décomposition des tourteaux de coprah et de palmiste et effets sur la croissance des cocotiers (*Cocos nucifera* L.) en pépinière et la nutrition minérale des cocotiers adultes en Côte d'Ivoire. *Sci Nat*. 2008;5(2):155-66.
15. Gbenyedji JNB, Kasseney BD, Nyamador SW, Sanbena BB, Kokutsè AD, Kokou K, et al. Evaluation Des Attaques De Termites (Isoptera Brulle, 1832) Sur Quatre Essences Forestieres D'importance Economique Au Togo (Afrique De L'ouest). *Eur Sci J*. 2016;12(9).
16. Coulibaly T, Akpesse AAM, Yapi A, Zihiri GN, Kouassi KP. Dégâts des termites dans les pépinières de manguiers du nord de la Côte d'Ivoire (Korhogo) et essai de lutte par utilisation d'extraits aqueux de plantes. *J Anim Plant Sci*. 2014;22(3):3455-68.
17. Iroko AF. L'homme et les termitières en Afrique. KARTHALA Editions; 1996.
18. Wood TG. Termites in Africa: the environmental impact of control measures and damage to crops, trees, rangeland and rural buildings. *Sociobiology*. 1991;19(1):221-34.
19. Doh F, Yao MDS, Issali AE. Incidence des attaques de la punaise *Pseudotheraptus devastans* (Distant) (Heteroptera: coreidae) sur trois varietes hybrides de cocotier, PB 113+, PB 121+ ET NVS x GVT en Côte D'Ivoire. *Int J Biol Chem Sci*. 2014;8(6):2650-8.
20. Jones DT, Eggleton P. Sampling termite assemblages in tropical forests: testing a rapid biodiversity assessment protocol. *J Appl Ecol*. 2000;37(1):191-203.
21. Akpesse AAM, Kissi TAP, Coulibaly T, Dilby YKS, Kouassi KP, Koua HK. Termite assemblages and infestation in rubber plantations of M'Brimbo in Southern Côte d'Ivoire. *Intl J Adv Res Biol Sci.* 2019;6(4):21-9.
22. Coulibaly T, Akpesse AA, Boga J pierre, Yapi A, Kouassi KP, Roisin Y. Change in termite communities along a chronosequence of mango tree orchards in the north of Côte d'Ivoire. *J Insect Conserv*. 2016;20(6):1011-9.
23. Bouillon A, Mathot G. Quel est ce termite africain? Ed. de l'Université; 1965.
24. Ruelle JE. Revision of the termites of the genus *Macrotermes* from the Ethiopian region (Isoptera: Termitidae). *Brit Mus Nat Hist Bull Entomol*. 1970;
25. Sands WA. The termite genus *Amitermes* in Africa and the Middle East. *Bull-Nat Resour Inst*. 1992;(51).
26. Han SH, Ndiaye AB. Dégâts causés par les termites (Isoptera) sur les arbres fruitiers dans la région de Dakar (Sénégal). In: Actes du Colloque sur les Insectes Sociaux. 1996. p. 111-7.
27. Aléné DC, Messi J, Quilici S. Influence de l'ombrage sur la sensibilité des plantules de *Ricinodendron heudelotii* (Baill.) aux attaques de *Diclidophlebia xuani* (Messi *et al.*) en milieu naturel au Cameroun. Fruits. 2006;61(4):273-80.
28. Dajoz R. Précis D'ecologie, 8 e Edition. Dunod Paris. 2006;631.
29. Morin A, Findlay S. Biodiversité: Tendance et Processus—Biologie de la Conservation des Espèces. Univ D'Ottawa Ott Can. 2001;
30. Magurran A. Measuring Biological Diversity. (Blackwell Publishing: Malden, MA.). 2004;
31. Dajoz R. Précis d'écologie. Ecologie fondamentale et appliquée. Ed Gauthier-Villars Paris. 1982;1-503.
32. Tra Bi CS. Diversité spécifique et dégâts des termites dans les cacaoyères (*Theobroma cacao* l., 1759) de la région d'Oumé en Côte d'Ivoire. These Dr Univ Félix Houphouët-Boigny. 2013;
33. Lavelle P. Faunal activities and soil processes: adaptive strategies that determine ecosystem function. In: Advances in ecological research. Elsevier; 1997. p. 93-132.
34. Donovan SE, Griffiths GJ, Homathevi R, Winder L. The spatial pattern of soil-dwelling termites in primary and logged forest in Sabah, Malaysia. *Ecol Entomol*. 2007;32(1):1-10.
35. Gbenyedji JNBK, Kotoklo EA, Amevoin K, Glitho IA. Diversité spécifique des termites (Isoptera) dans deux plantations de tecks (*Tectona grandis* L.) au sud du Togo. *Int J Biol Chem Sci*. 2011;5(2):755-65.
36. Koudou GB, Wahounou PJ, Tano Y. Évaluation des antécédants culturaux dans les plantations d'Hévéa en basse Côte d'Ivoire. *Bioterre*. 2004;4:128-41.
37. Han SH, Tokro GP, Tano Y, Lepage M. Dégâts des termites dans les plantations de palmiers à huile en Côte d'Ivoire: évaluation et méthodes de lutte. *Plant Rech Dév*. 1998;5(2):119-26.
38. Kotoklo EA, Kasseney BD, Nyamador W, Ketoh K, Glitho I. Attaques des arbres par les termites sur le campus de l ' Université de Lomé. *Int J Biol Chem Sci*. 2010;4(1):61-8.
39. Guedegbe H, Houngnandan P, Roman J, Rouland-Lefevre C. Patterns of substrate degradation by some microfungi from fungus-growing termite combs (Isoptera: Termitidae: Macrotermitinae). *Sociobiology*. 2008;52(3):525.
40. Tra Bi CS, Akpesse AAM, Boga JP, Yapi A, Kouassi KP, Konaté S, et al. Diversity and abundance of Hypogenous termites (Insecta : Isoptera) in cocoa plantation (*Theobroma cacao* L .) in semi- deciduous forest zone (Oumé , Côte d'Ivoire). 2014;76(1):138-46.
41. Akpesse AA, Kouassi PK, Tano Y, Lepage M. Impact des termites dans les champs paysans de riz et de mais en savane sub-soudanienne (Booro-Borotou, Côte d'Ivoire). Sci Nat. 2008;5(2):121-31.
42. Logan J, Cowie R, Wood T. Termite (Isoptera) control in agriculture and forestry by non-chemical methods: a review. Bull Entomol Res. 1990;80:309-30.
43. Ndiaye AB. Contribution à l'étude des termites ravageurs d'arbres fruitiers au Sénégal: Inventaire systématique, études écologiques et dégâts [PhD Thesis]. Thèse Doctorat 3 cycle, Université de Dakar; 1998.
44. Tondoh EJ. Influence de la mise en culture sur les peuplements de la macrofaune du sol en moyenne Côte d'Ivoire. Mém DEA Univ Cocody Abidj. 1992;

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