



**Research Paper**

**DIVERSITY AND IMPACT OF TERMITES (ISOPTERA BRULLÉ) PESTS ON THE MANGO TREE (*Mangifera indica* L.) IN ORCHARDS OF THE DIASS PLATEAU AND THE NIAYES OF BAYAKH (SENEGAL)**

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**Abstract**

This study provides a reference situation for the diversity of termites in mango orchards, emphasizing i) the diversity of the species present, ii) the assessment of the stand and iii) the frequency of the species in each orchard. In all, 9 orchards chosen along a transect from Sindia (Diass plateau) to Bayakh (Niayes area) were studied. One hectare was measured in each orchard. Observations and collection of termites were made on all the mango trees of the chosen hectare. The 14 species of pest termites listed are divided between mushroom growers (6) and lignivores (8). The most common mushroom growers in *Microtermes grassei* and *Odontotermes spp.* and the lignivores are *Microcerotermes spp.* and *Amitermes evuncifer*. However, *Microtermes grassei* and *Amitermes evuncifer* remain the most frequent. The attack rate recorded on the mango tree is greater than 89%. The distribution of termites is strongly correlated with the characteristics of the environment, the nature of the soil in particular.

Key words: Termites, Mango tree, Diass, Niayes, Senegal.

**INTRODUCTION**

Global mango production is 38.6 million tones [1]. In 2010, West Africa produced nearly 1,374,000 tones [2]. The leading West African countries in mango production are: Nigeria (54%), Guinea (13%), Niger (13%), Mali (6%), Senegal (5%), and Ivory Coast

(3%) [3]. Mango accounts for 60% of fruit production in Senegal [4] with an annual quantity of 118 950 tones [5]. The country's soil conditions and land heritage offer great potential for expanding mango production [6]. The production areas are Dakar, Thies, Saint-Louis, Fatick, Kolda, Ziguinchor and Sedhiou [7]. The *Niayes* area, on the other hand, accounts for 80% of export production [8].

Despite a positive record in recent years, mango production is affected by many constraints, including phytosanitary problems. According to [9], mango cultivation is altered by bioaggressors such as termites, fruit flies, mealybugs, diaspines, thrips, plant bugs, locusts and plant pathogen-related diseases (anthracnose, powdery mildew and mango peduncles).

For several years, termites have been seen as a scourge for tropical agriculture [10];[11]. Termites are commonly found in the Mastotermitidae, Kalotermitidae, Rhinotermitidae, Termitidae and Hodotermitidae families [12].

Economic losses from these insects on crops and plantations can range from 15% to 90% [13]. In Senegal, studies on termites pests of market crops [14], fruit trees [15]; [16]; [17]; [18]; [19] and cassava [20]; [21]; [22] carried out in different regions made it possible to list the pests termites, assess attack rates and describe the damage. This study is part of this general framework to study the diversity and impact of termite's pests in mango ecosystems at the level of the plateau of Thies and *Niayes*. Specifically, it consists of: i) inventories the Mango Moth pests and ii) studies the distribution and frequency of these species and iii) the assessment of attacks.

## MATERIAL AND METHODS

### Study environment

The study area is on the Diass plateau (part of the Thies region) and in the Bayakh *Niayes*. The region of Thies is an important driver of the country's economy. Three sites, located along a south-north transect from Sindia (Diass Plateau) to Bayakh (*Niayes* area), were studied (Fig. 1). At each site, three orchards were retained. Site I include the orchards of Sindia, Diass and Boukhou. Site II includes the orchards of Sébikhotane, Khodoba and Keur Moussa. Site III includes orchards in the Bayakh area named Bayakh 1, Bayakh 2 and Bayakh 3. In total, 9 orchards were surveyed.

## METHODS

### Sampling of termites

In each orchard, an area of 1 ha was measured using the decameter. All mango trees in the sampling area were examined. Termites are sought after under veneers on the trunk and branches, in the outer galleries built on the trunk and branches, in the galleries and nests built, in the trunk and branches of the trees. Termites are collected using the flexible clamp and placed in tubes containing 95° ethanol with a label that includes information about the date of collection, the collector's identity and a reference number. The harvests of each orchard are put in a collection box. The name of the locality, the date and the orchard number are shown on each box.

### Identification of termite species

The collected samples were taken back to the Terrestrial Invertebrate Zoology Laboratory (ZIT) of the Fundamental Institute of Black Africa Sheikh Anta Diop in Dakar (Senegal) for identification and collection.

For identification, we used Bouillon and Mathot [23] and Ndiaye's thesis [24]. The specimens are observed under the binocular magnifying glass equipped with a camera and connected to a computer allowing, if necessary, the acquisition of images.

### Studied parameters

#### Consistency of termites

The consistency (C) of a species, based on Dajoz [25], is the number of surveys containing the species from the total number of surveys conducted. In this work, orchards are treated as surveys. Consistency is obtained by the formula:

$$C = \frac{\text{Number of orchards containing the species}}{\text{Total number of orchards}} \times 100$$

According to the classes defined by Dajoz [25]: the species will be classified in constant species ( $C > 50\%$ ), accessory species ( $25 < C < 50\%$ ) and accidental species ( $C < 25\%$ ).

#### Frequency of a species

Frequency (F) is defined by Dajoz [25] as "the percentage of individuals of a species relative to the total number of individuals". By adapting the formula to the case of termites which are social insects, the number of individuals of the species is replaced by the number termites [26]. samples of the species and the total number of individuals by

the total number of samples collected. The samples are assimilated to colonies which are considered to be super-individuals in

$$F = \frac{\text{Number of samples containing the species}}{\text{Total number of samples}} \times 100$$

A species is said to be infrequent if  $F < 25\%$ , moderately frequent for  $25 \leq F < 50\%$  and frequent for values of  $F \geq 50\%$ .

## RESULTS

### Inventory of species

The identification of 792 samples from the transect orchards identified 18 termite species from 3 families (Tab. 1). These are the Kalotermitidae, the Rhinotermitidae and the Termitidae. The less diverse Kalotermitidae include a subfamily (Kalotermitinae) and a species. Rhinotermitidae consist of two subfamilies, Psammotermitinae and Coptotermitinae, each with a species. Termitidae are more diverse and include two subfamilies: Termitinae (09 species) and Macrotermitinae (06 species).

According to the diet, species are divided into lignivorous, fungus and humivorous termites. Representatives of the latter group of pest-free termites are not considered in the remainder of the study.

The pests termites, 14 species in total, belong to the food groups of lignivorous and fungi. Lignivorous pests include 8 species belonging to the genera *Cryptotermes* (01 species), *Psammotermes* (01 species), *Coptotermes* (01 species), *Amitermes* (01 species) and *Microcerotermes* (04 species). As for fungal pests, they include 6 species belonging to genera six (0 *Macrotermes* (01 species), *Microtermes* (02 species) and *Odontotermes* (03 species).

### Consistency of species following transect

Based on consistency (Fig. 2), the species found in the 9 orchards fall into the 3 classes defined by Dajoz [25]. The constant species are *Microtermes grassei*, *Amitermes evuncifer*, *Microtermes lepidus*, *Odontotermes* spp. and *Microcerotermes* spp. Among these constant species, *Microtermes grassei* and *Odontotermes* spp. were encountered in all the orchards visited. The ancillary species are *Macrotermes subhyalinus* and *Coptotermes intermedius*. The accidental species are *Microcerotermes fuscotibialis*, *Psammotermes hybostoma* and *Cryptotermes havilandi*.

### Frequency of species at all sites visited

At site I level, frequency results (Tab. 2) show that *Microtermes grassei* and *Microcerotermes* spp are the most common pests in this area. Par contre les espèces comme *Psammotermes hybostoma*, *Amitermes evuncifer*, *Coptotermes intermedius*, *Microcerotermes fuscotibialis*, *Microtermes lepidus* et *Macrotermes subhyalinus* sont peu fréquentes. In Site II the data (Tab. 3) also show that *Microtermes grassei* and *Microcerotermes* spp remain the frequent species of the environment. In Site III, however, these species are infrequent and moderately frequent, respectively (Tab. 4). *Psammotermes hybostoma* is moderately frequent.

### Evaluation of termite's attacks on mango trees

Attack rates were assessed at the transect, site and orchard scale (Fig. 3). The average attack rate at each site is very high; 93.2% for Site I, 89.8% for Site II and 89.2% for Site III. No significant differences were noted between these sites at the 5% threshold with  $p = 0.73$ .

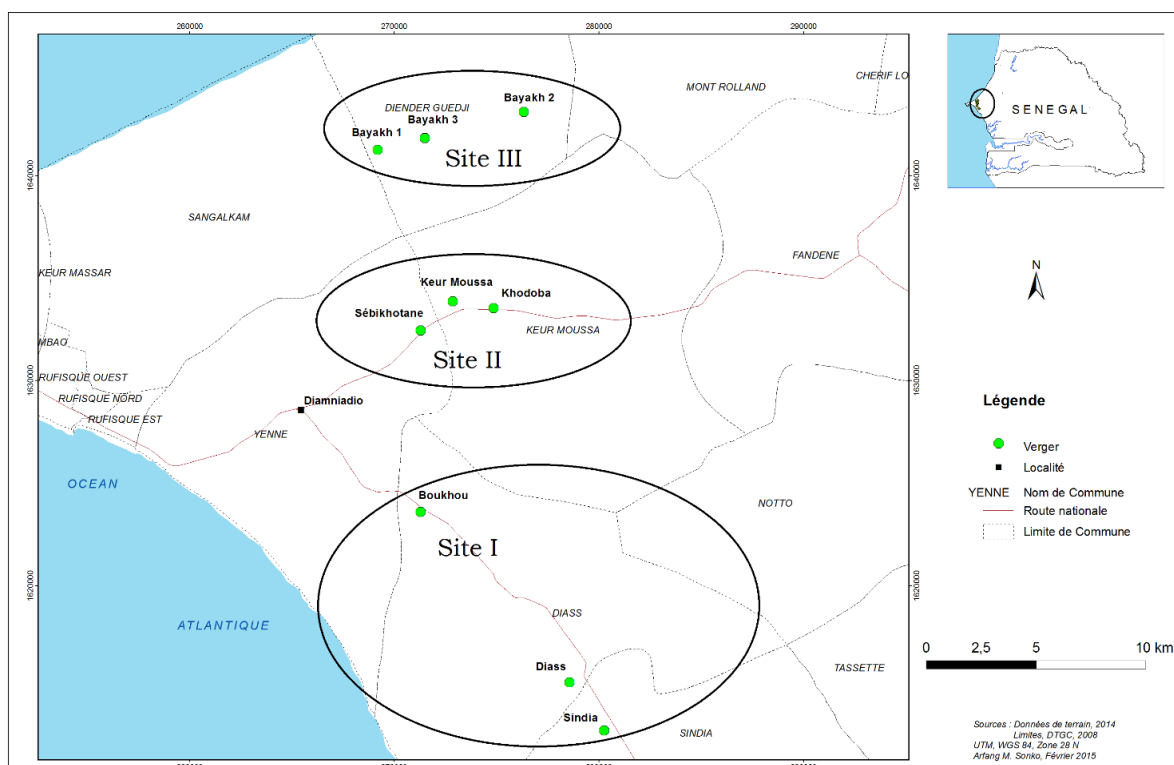
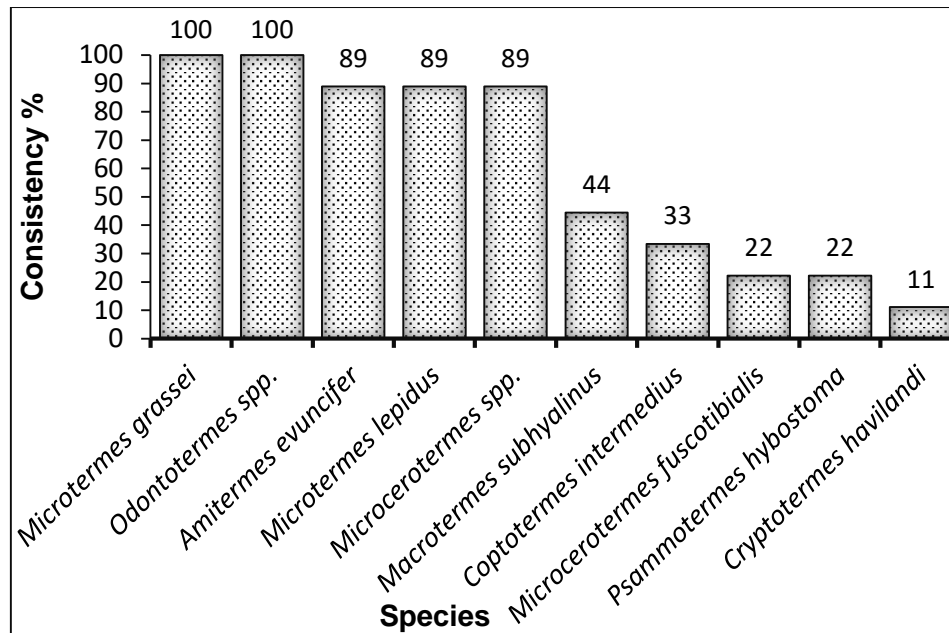


Figure 1. Geographical location of the study sites and orchards

Tableau 1: List of species surveyed

Family	Subfamily	Species
KALOTERMITIDAE Froggatt, 1897	KALOTERMITINAE Froggatt, 1897	<i>Cryptotermes havilandi</i> Sjöstedt, 1897
RHINOTERMITIDAE Froggatt, 1897	PSAMMOTERMITINAE Holmgren, 1911	<i>Psammotermes hybostoma</i> Desneux, 1902
	COPTOTERMITINAE Holmgren, 1910	<i>Coptotermes intermedius</i> Silvestri, 1912
TERMITIDAE Latreille, 1802	TERMITINAE Latreille, 1802	<i>Amitermes evuncifer</i> Silvestri, 1901
		<i>Angulitermes nilensis</i> Harris, 1962
		<i>Microcerotermes fuscotibialis</i> Sjöstedt, 1896
		<i>Microcerotermes aff. solidus</i> Silvestri, 1912
		<i>Microcerotermes parvulus</i> Sjöstedt, 1911
		<i>Microcerotermes aff. parvus</i> Haviland, 1898
		<i>Pericapritermes urgens</i> Silvestri, 1914
		<i>Promirotermes holmgreni</i> infera Silvestri, 1914
	MACROTERMITINEA Kemner, 1934	<i>Macrotermes subhyalinus</i> Rambur, 1842
		<i>Microtermes grassei</i> Grassé, 1937
		<i>Microtermes lepidus</i> Sjöstedt, 1925
		<i>Odontotermes eraticus</i> Grassé, 1944
		<i>Odontotermes</i> Sp. 1
		<i>Odontotermes</i> Sp. 2



**Figure 2. Consistency of termites along the transect**

Tableau 2. Frequency of species (%) at Site I

Species	Frequency of species in % at SITE I	Classes
<i>Amitermes evuncifer</i>	18,9	Infrequent
<i>Coptotermes intermedius</i>	5,8	Infrequent
<i>Cryptotermes havilandi</i>	2,1	Infrequent
<i>Macrotermes subhyalinus</i>	4,6	Infrequent
<i>Microcerotermes fuscotibialis</i>	10,7	Infrequent
<i>Microcerotermes spp.</i>	64,6	Frequent
<i>Microtermes grassei</i>	84,4	Frequent
<i>Microtermes lepidus</i>	8,7	Infrequent
<i>Odontotermes spp.</i>	33,4	Medium frequency

Tableau 3. Frequency of species (%) at Site II

Species	Frequency of species in % at SITE II	Classes
<i>Amitermes evuncifer</i>	29,8	Medium frequency
<i>Coptotermes intermedius</i>	1,2	Infrequent
<i>Macrotermes subhyalinus</i>	2,1	Infrequent
<i>Microcerotermes fuscotibialis</i>	1,8	Infrequent
<i>Microcerotermes spp.</i>	59,4	Frequent
<i>Microtermes grassei</i>	58,8	Frequent
<i>Microtermes lepidus</i>	31,5	Medium

		frequency
<i>Odontotermes</i> spp.	29,1	Medium frequency

Tableau 4. Frequency of species (%) at Site III

Species	Frequency of species in % at SITE III	Classes
<i>Amitermes evuncifer</i>	98,6	Infrequent
<i>Microcerotermes</i> spp.	49,9	Medium frequency
<i>Microtermes grassei</i>	23,6	Infrequent
<i>Microtermes lepidus</i>	23,2	Infrequent
<i>Odontotermes</i> spp.	11,8	Infrequent
<i>Psammotermes hybostoma</i>	26,3	Medium frequency

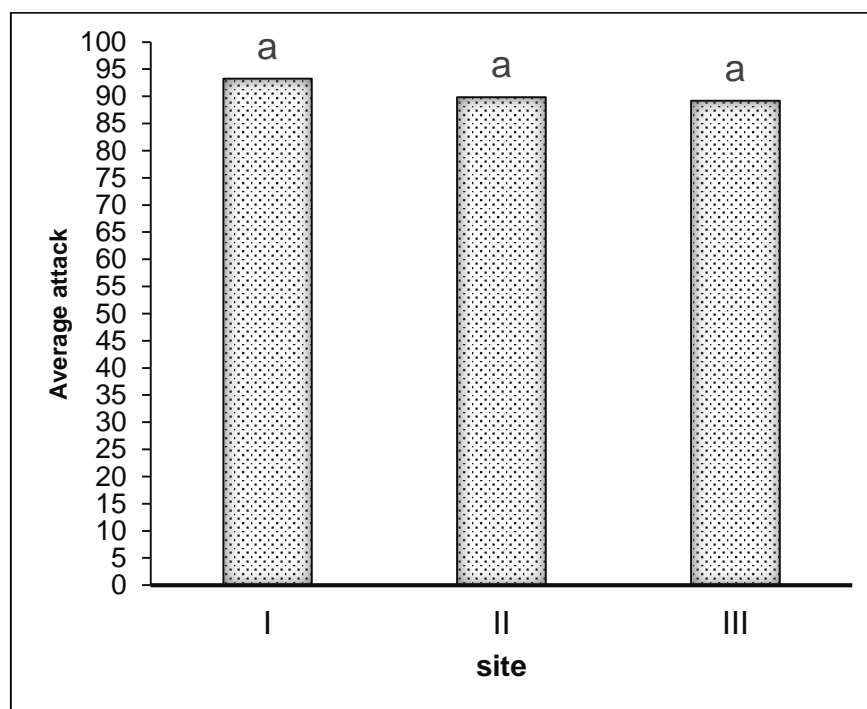


Figure 3. Average attack rate (%) at all three site

## DISCUSSION

The 14 species of termites found on mango trees were reported by [18] in Thies orchards. Termites recognized as pests of the mango tree, encountered during the study, belong to the trophic groups of xylophages (lignivorous and fungi). On the campus of the University of Lome, [27] only recognize termites with this trophic diet as tree pests.

By their distribution, the species show differences that would be explained by the ecological valence of each species and by environmental factors. Thus, *Microtermes grassei* found in all orchards would be the most plastic species. This ecological performance of *M. grassei* is also noted by [28] in his study on termites on the Cape Verde peninsula. *Amitermes evuncifer* is also a constant species, absent only in the Khodoba orchard. The absence of the species in this orchard could be related to the young age of the plants and to field work, in particular the weeding that eliminates certain species as pointed out by [28]. According to this author, the species is closely linked to the presence of trees and moisture. The Khodoba orchard is made up of young mango trees associated with sorghum, which does not offer favourable conditions for the distribution of *Amitermes evuncifer*.

Small *Microcerotermes* are a complex of several species that are very difficult to discriminate [24] and are absent from the Sébikhotane orchard. This absence could be linked to the good condition of the orchard. *Macroterm subhyalinus* is present at sites I and II that have soils rich in clay necessary for the construction of termites of this fungal termite [29]. This would justify its absence in the *Niayes* of Bayakh where the sandy soil is poor in clay. [30] and [31] also observed the absence of *Macrotermes* in the sandy dunes of the Mbao and Malika reforestations. The distribution of the termite psammophile, *Psammotermes hybostoma* is also related to the soil nature of biotopes [32]; [28]. This is what justifies his absence in Sites I and II.

The restriction of *Microcerotermes fuscotibialis*, species with arboreal nest, in the two oldest orchards, in Sindia and Boukhou is related to the age of the orchards. Its establishment and the construction of an inaccessible nest on a tree takes some time.

*Cryptotermes havilandi*, a lignivorous species that nests in trees [32], is recorded only in Boukhou. This orchard has the oldest mango trees that are better suited to host colonies of this termite.

The *Microtermes grassei* fungal termite has a higher frequency at sites I and II where the soil is rich in clay. According to [28], *Microtermes* are more abundant in biotopes with soft vegetation and containing clay.

In the sandy biotopes of the *Niayes*, *Amitermes evuncifer*, a lignivorous species, is dominant by its frequency of occurrence. *Amitermes evuncifer* prefers sandy soils with treed vegetation [28].

The average attack rates of mango trees observed at the 3 sites studied are more than 89%. These rates are very high compared to the rates observed in Dakar by Han and Ndiaye [15], Casamance, Thies, and Kaolack by [16; 18; 19]. Mango tree attack rates are still the highest, according to the authors.

## CONCLUSION

The study identified 18 species of termites on mango trees in orchards in the Diass Plateau and Bayakh Niayes, 14 of which are recognized as pests. The variable distribution of the species is related to the age of the trees but also to the type of soil. The dominant species by their distribution and frequency of occurrence are *Microtermes grassei*, mushroom species and *Amitermes evuncifer*, lignivorous species. Attack rates on the Mango Tree are high. The description of the attacks of the termite's pests encountered differs from one species to another.

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## BIBLIOGRAPHIC REFERENCES

- [01] Gautam AK., 2014, A study on mango (*Mangifera indica* L.) trunk decay by *Phellinus gilvus* (Schw.) Pat. from Himachal Pradesh, India. *International Letters of Natural Sciences*, (6) : 9-15.
- [02] Strebelle J., 2013, Analyse et propositions sur la construction des marchés locaux nationaux régionaux en Afrique analyse complémentaire : Position des op dans la filière mangue en Afrique de l'ouest et au Sénégal ; Partenariat Afrique/Europe pour des Politiques Agricoles et Agroalimentaires plus Durables et Solidaires. Bruxelles, 23 p.
- [03] International Trade Center (ITC)/Economic Community of West Africa States-Trade and Enterprise Experts Network (ECOWAS TEN), 2011, *Mangue service des nouvelles des marchés (Mns)*; Bulletin mensuel, 26 p.

- [04] Diédhiou PM, Diop SAG, Mbaye N, Diédhiou I, Diallo Y, Djiba S, Faye R, Samb PI., 2014, Mango rotting in southern Senegal a big phytosanitary challenge. *International Journal of Biosciences*, 5, (5): 183-188.
- [05] ASEPEX, 2012., Bilan de la campagne 2012 d'exportation mangue au Sénégal. (1), décembre, Dakar, 4 p.
- [06] USAID., 2006, La chaîne de valeurs mangue au Sénégal : analyse et cadre stratégique d'initiatives pour la croissance de la filière. Programme USAID / Croissance Economique, (685), 91 p.
- [08] Diédhiou PM, Mbaye N, Faye R and Samb PI., 2014, Field tests of fungicides against post harvest rot of mangoes in Senegal. *International Journal of Science, Environment and Technology*, 3, (2) : 597-606.
- [09] Rey JY., 2011, La production fruitière sénégalaise. *CIRAD/UPR HortSys*, Thiès, 3 p.
- [10] Stansly PA, Nan-Yao Su, Conner JM., 2001, Management of subterranean termites, *Reticulitermes* spp. (Isoptera: Rhinotermitidae) in a citrus orchard with hexaflumuron bait. *Crop Protection*, (20) : 199-206.
- [11] Duboisset A & Seignobos C., 2005, Petite histoire des connaissances acquises sur les termites et leur rôle agroécologique. *Étude et Gestion des Sols*, 12, (2) : 153-164.
- [12] Rouland-Lefèvre C., 2011, Termites as Pests of Agriculture. in *Biology of Termites: A Modern Synthesis*. David Edward Bignell, Yves Roisin, Nathan Lo, Ed : 499-517. Springer, 592 p.
- [13] Wood TG & Pearce MJ., 1991, Termites in Africa: The environmental impact of control measures and damage to crops, trees, rangeland and rural buildings. *Sociobiology*, **19** (1) : 221-234.
- [14] Han SH, & Ndiaye AB., 1998, L'attaque des cultures maraîchères par les termites (Isoptera) dans la région de Dakar (Sénégal). *Actes Coll. Insectes Sociaux*, (11) : 37-43.
- [15] Han SH, & Ndiaye AB., 1996, Dégâts causés par les termites (Isoptera) sur les arbres fruitiers dans la région de Dakar (Sénégal). *Actes Coll. Insectes Sociaux*, (10) : 111-117.
- [16] Ndiaye AB & Han SH., 2000, L'attaque des arbres fruitiers par les termites dans les vergers de Saint-Louis et de Thiès (Sénégal). *Actes Coll. Insectes Sociaux*, (13) : 127-132.

- [17] Ndiaye AB & Han SH., 2002, Attaque des arbres fruitiers par les termites en Casamance (Sénégal) (Isoptera). *Bulletin de la société entomologique de France*, 107 (2) : 193-199.
- [18] Ndiaye AB & Han SH., 2006, L'attaque des arbres fruitiers par les termites dans la région de Thiès (Sénégal) (Isoptera). *Bulletin de la société entomologique de France*, 111 (1) : 59-64.
- [19] Ndiaye AB & Han SH., 2007, Les termites (Isoptera) des arbres fruitiers de la région de Kaolack (Sénégal). *Bulletin de l'IFAN Cheikh Anta Diop, Dakar, TLII, série. A*, (1-2) : 147-161.
- [20] Faye A, Kane PD, Mbaye DF, Sall Sy D, Sané D., 2014, Study of the cassava varietal sensitivity to termites ravaging cuttings planted in farms in the department of Tivaouane (Senegal). *International Journal of Science and Advanced Technology*, 4(6): 6-16.
- [21] Sonko AM, Sall D et Ndiaye A B. Les termites (*Termitoidae* Latreille 1802) ravageurs du manioc (*Manihot esculenta* Crantz 1766) dans la zone de Tivaouane (Sénégal)., 2019, *International Journal of Biological and Chemical Science* 13(4): 2005-2020. DOI : <https://dx.doi.org/10.4314/ijbcs.v13i4.8>.
- [22] Sonko AM., 2020, Evaluation de l'efficacité de *Metarhizium anisopliae* (Metchnikoff, 1880) dans le contrôle gestion des termites (*Termitoidae* Latreille 1802) ravageurs du Manioc (*Manihot esculenta*, Crantz) à Tivaouane (Sénégal). Thèse de doctorat ès-sciences, université Cheikh Anta Diop de Dakar, Faculté des Sciences et Techniques, 116 p.
- [23] Bouillon A. & Mathot G., 1965, Quel est ce termite africain. *Zooleo*, 1, 1-115.
- [24] Ndiaye AB., 2014, Contribution à la connaissance des termites (*Isoptera* Brullé, 1832) du Sénégal : Systématique et Ecologie. Thèse de doctorat ès-sciences, université Cheikh Anta Diop de Dakar, Faculté des Sciences et Techniques, 257 p.
- [25] Dajoz R., 1971. *Précis d'écologie*. Ed. Dunod, Paris, 434 p.
- [26] Mathot G., 1964, Description d'une nouvelle espèce de *Cubitermes* du CONGO (*Isoptera*, *Termitinae*). *Cubitermes exiguus* n. sp. In *Études sur les Termites Africains*, A. Bouillon ed. : 15-21.
- [27] Kotoklo EA, Kasseney BD, Nyamador W, Ketoh GK. et Glitho AI., 2010, Attaques des arbres par les termites sur le campus de l'Université de Lomé (Togo).

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- International Journal of Biological and Chemical Science*, 4, (1): 61-68. DOI: <http://dx.doi.org/10.4314/ijbcs.v4i1.54231>.
- [28] Roy-Noël J., 1974, Recherche sur l'écologie des Isoptères de la presqu'île du Cap-Vert (Sénégal). *Bulletin de l'Institut Fondamental d'Afrique Noire*, Tome XXXVI, série A, (2-3) : 609 p.
- [29] Grasse P. P., 1984, *Anatomie-Physiologie Biologie-Systématique des termites*. Tome II, fondation des sociétés-construction. Ed. Masson, Paris, France ; 613 p.
- [30] Roy-Noël J., 1982, L'attaque des arbres par les Termites dans la presqu'île du Cap-vert (Sénégal). Tome II. Cas du reboisement sur dunes fixées de Mbao. *Bulletin de l'Institut fondamental d'Afrique noire sér. A*, 44 (1-2) : 115-145.
- [31] Roy-Noël J & Wane C., 1977, L'attaque des arbres par les Termites dans la presqu'île du Cap-vert (Sénégal). Tome 1. Cas du reboisement sur dunes vives de Malika. *Bulletin de l'Institut fondamental d'Afrique noire, sér. A*, 39 (1) : 124-141.
- [32] Ndiaye AB., 1998, Contribution à l'étude des termites ravageurs d'arbres fruitiers au Sénégal : inventaire systématique, études écologiques et dégâts. Thèse de Doctorat de 3e cycle, Biologie Animale, Faculté des Sciences et Techniques, UCAD, 113 p. DOI: <http://dx.doi.org/10.4314/ijbcs.v10i1.10>.