



Diversity and damage of termites in urban zones: the case of the campus of University Péléforo Gon Coulibaly of Korhogo (Côte d'Ivoire)

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Abstract

Termites are one of the most abundant invertebrate groups in tropical ecosystems. Despite their important role, termites can cause considerable damage to wooden structures in most tropical countries. This study aim is to evaluate the termite diversity on the campus of the University Péléforo Gon Coulibaly of Korhogo and to show their attacks on trees and buildings. According to the standardized rapid estimation method (RAP) of biodiversity, a total of 12 species of termite were collected. Fungus-growers group with 68% of termite total abundance were the mostly abundant group. The study of termite attacks showed that plants were strongly attacked by termites. Out of 294 trees visited, 274 trees showed traces of termite attacks, a rate of 93%. Termite damage caused leaf drop, dieback and / or death of the plant. Concerning buildings and woodwork, termites caused significant damage on these structures. The results of our study are a preliminary study to draw the special attention of university officials to take action to combat these termites.

Keywords: damage, termite diversity, university, urban building

Introduction

Termites make up more than 10% of all animal biomass in the tropics and 95% of the soil insects' biomass ^[10]. Their role in the functioning of ecosystems is important. Termites are very active agents. They are true decomposers of the litter ^[20] and constitute prey of certain organisms ^[24]. They are also involved in improving the physicochemical properties of soils ^[23, 15, 37]. However, in several African countries, cultivated plants are regularly attacked and destroyed by termites ^[13]. Termite damage to crops and plantations is often greater than 15% and sometimes up to 90% ^[41]. Logan *et al.* ^[25] reported that about 10% of termite species described are known to be harmful to living plants and buildings. In recent decades, particular attention has been paid to the study of termites, given their economic interest. Once entering a structure, termite damage unprotected cellulosic materials such as timber, electrical cables and farming equipment ^[41, 39]. For homeowners this is a serious problem as a termite colony can structurally compromise a building's integrity resulting in permanent damage and loss of value. The annual economic cost of termite damage and termite prevention, worldwide is estimated in the billions ^[2].

In Côte d'Ivoire, most of the termite studies have focused on the biological assessment of habitats ^[16, 9, 38, 6] and the demonstration of their ecological role in the functioning of ecosystems ^[19, 21]. Studies of termite damage on ornamental trees and structures built in urban areas are almost non-existent. In the domain of newly built University Péléforo Gon

Coulibaly of Korhogo (UPGC) in northern Côte d'Ivoire, termite mounds are proliferating rapidly. This proliferation of termites and their mounds is not without harmful consequences on the development of transplanted trees in gardens and on buildings. In general, termite mounds are the source of termite infestation of buildings ^[3]. It is therefore urgent, for the protection of buildings and ornamental species transplanted in the gardens, to list the pest species and to quantify in the university site their damage for a planned fight. The present work aims to (1) know the diversity of termites on the campus of the UPGC and (2) to show the impact of the pest species on the trees and buildings.

Material and method

Study area

This study took place in October 2016 at Péléforo Gbon Coulibaly University of Korhogo (9°34'N, 5°37'W). Korhogo is located in the north Côte d'Ivoire, a West Africa country (Fig 1). The climate is of the dry Sudanese tropical type with two contrasted seasons: the rainy season (monthly rains >50 mm) extends from April to October and the dry season from November to March. The annual average rainfall varies between 1000 and 1600 mm. Rainfall constitutes the most influential climatic factor. The average humidity is 65–70% and the annual average temperature varies between 24 and 36 °C. The natural vegetation is a savanna, with an almost complete cover of high grass dominated by *Panicum* sp. Granites and schists are the main rocks characterizing the

substratum of the region and soils are generally average fertility.

Sampling design

Two separate blocks were delineated in the university courtyard. In each block, The sampling of termites was done by using a standardized method designed for rapid estimation of termite biodiversity, along transects 100 m long by 2 m wide [16]. Each transect was subdivided into 20 contiguous quadrats of 10 m (5 m x 2 m) each in order to standardize the sampling effort. In all quadrats, microhabitats (litter, stumps, twigs, nests, fallen sheeting, fallen branches, etc.) were hand-searched up to a height of 2 m above ground level. As the method was designed for use in forests, modifications were

made for its application in urban areas by searching on trees, buildings and in gardens. The soil was hand-sorted in situ, and a representative sample of termites (around 10 individuals of each caste present) was sorted and put into 70% ethyl alcohol. Termites collected were both of the soldier and worker castes. Samplings were based on the occurrence of individuals (presence-absence) rather than their number, with respect to the social habit of termites. The fieldwork took place at the end of the rainy season, as these periods were especially favourable for sampling. During this period, termite foraging activities are more evident in the study area because the termites consume preferentially dry plant matter. The evident foraging activities enabled an easy collection of a great number of species.

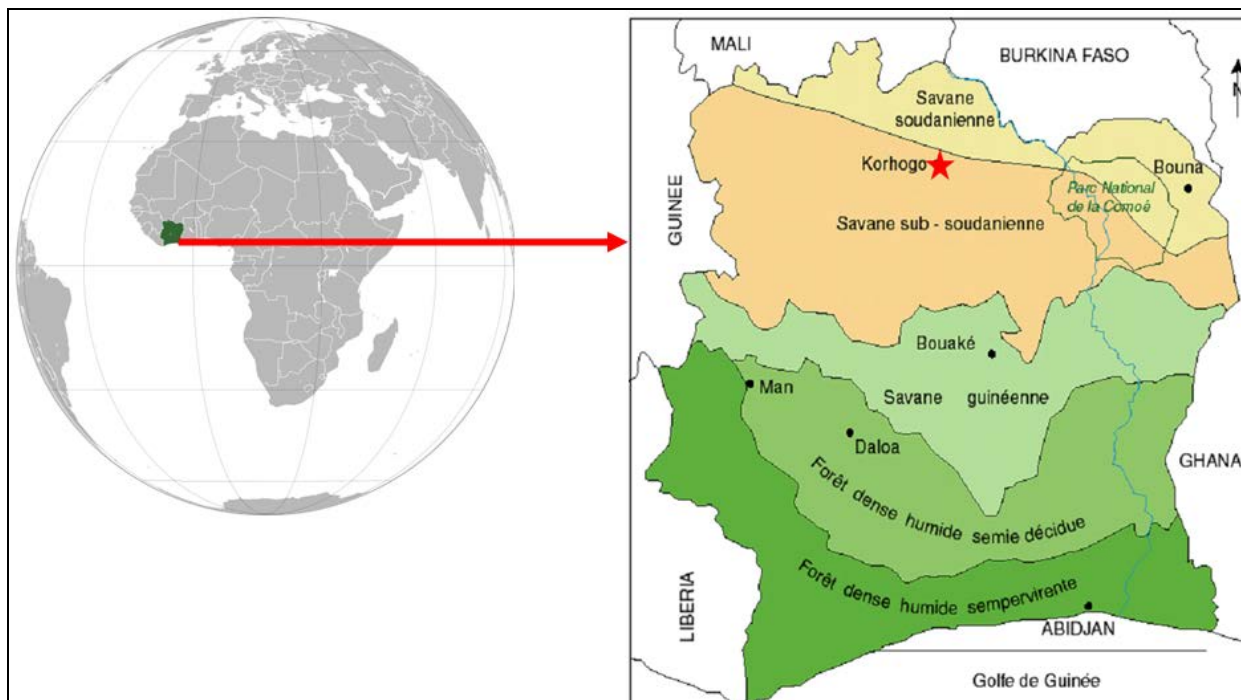


Fig 1: Geographical location of the study area (Echelle= 1/ 5.000. 000 è)

Study of termite attacks on trees

Surveys were conducted in four sections (100 mx 100), taking into account the abundance of plant species on campus [22]. In this study, the structure is said to be attacked when it carries galleries or veneers with or without termites [13]. Termites have been found in galleries and veneers, on the trunk, the branches and on apparent roots. A total of 294 trees were observed including 112 natural trees and 182 ornamental plants.

Study of termite attacks on buildings

The walls, wooden cupboards and ceilings of buildings and all the wood supports were inspected for the presence of attacks and termite damage. This damage was then photographed. Termites were collected to determine the species involved in the observed damage.

Identification of collected termites

The collected termites were identified at the Biology and Animal laboratory (Université Péléfro Gon Coulibaly of

Korhogo). Specimens were identified to the level of species or morphospecies using standard determination keys such as: [1, 5, 31, 32, 33, 12, 34]. We were aware that morphological identification alone may lead to the confusion of sibling species [30, 14], e.g. in *Odontotermes* or *Microtermes*, but a molecular characterization of all samples to sort out complexes of morphologically indistinguishable, closely related species was beyond the scope of this study. After identification, each species was classified in one feeding group (i.e. fungus-growers, soil-feeders, wood-feeders and grass-feeders).

Data analysis

Diversity data

The species richness of termites was determined by enumerating the number of species observed over the whole transect. Because presence-absence data was used, the relative abundance was defined as the number of encounters per transect, where the presence of one species in a quadrat represented one encounter [26]. Thus, occurrences were preferred because the number of individuals could be

misleading when dealing with social animals such as termites that are patchily distributed [42].

Evaluation of termite damage

Termite’s presence on the trees does not necessarily cause major damage to the tree. Rating scale termite damage on trees has been established (Table I).

Table 1: Rating scale termite damage on trees

Scale	Définition of scale
D0	No galleries, no earthy veneers, no termite presence on the tree: healthy tree
D1	Minor damage: characterized by the presence of earthy galleries and veneers on the bark of trees.
D2	Major damage: characterized by the presence of termites in the wood of the tree, often death of the tree.

The proportions of the observed attack categories were

calculated using the following formula:

$$Ta = Na/No \quad (2)$$

Where;

Ta = Attack rate

Na = Number of plants attacked

No = Number of plants observed.

Results

Specific richness and abundance of termites harvested

The general inventory of termites allowed collecting 12 species belonging to 2 families (the Rhinotermitidae and the termitidae) (Table 2). These species were divided into 11 genera and 5 sub-families. The Macrotermitinae were most diverse with 6 species. The Termitinae and the Nasutitermitinae record 2 species each. Apicotermitinae and Coptotermitinae with 1 species each were the least diverse families.

Table 2: Taxonomic structure of termites collected on the campus of UPGC

Families	Subfamily/	Species or morphospecies	Feeding group;	Occurrence	
Rhinotermitidae	Coptotermitinae	<i>Coptotermes intermedius</i>	x	2	
		<i>Ancistrotermes cavithorax</i>	f	32	
		<i>Ancistrotermes crucifer</i>	f	8	
Termitidae	Macrotermitinae	<i>Macrotermes subhyalinus</i>	f	2	
		<i>Microtermes</i> sp.	f	14	
			<i>Odontotermes pauperans</i>	f	18
			<i>Pseudacanthotermes militaris</i>	f	10
		Apicotermitinae	<i>Adaiphrotermes</i> sp.	s	4
		Nasutitermitinae	<i>Fulleritermes tenebricus</i>	w	12
	<i>Trinervitermes geminatus</i>		g	14	
	Termitinae	<i>Amitermes evuncifer</i>	w	4	
		<i>Microcerotermes</i> sp.	w	2	

* f=fungus-growers, s= soil-feeders, w= wood-feeders and g= grass-feeders

The species collected were classified into four feeding groups (fungus-growers, soil-feeders, wood-feeders and grass-feeders). The fungus-growers were the most abundant group

in the area investigated. They totaled 68 % of the total abundance of termites. However, the soil-feeders group was very weakly present with 3% of total termite (Fig. 2).

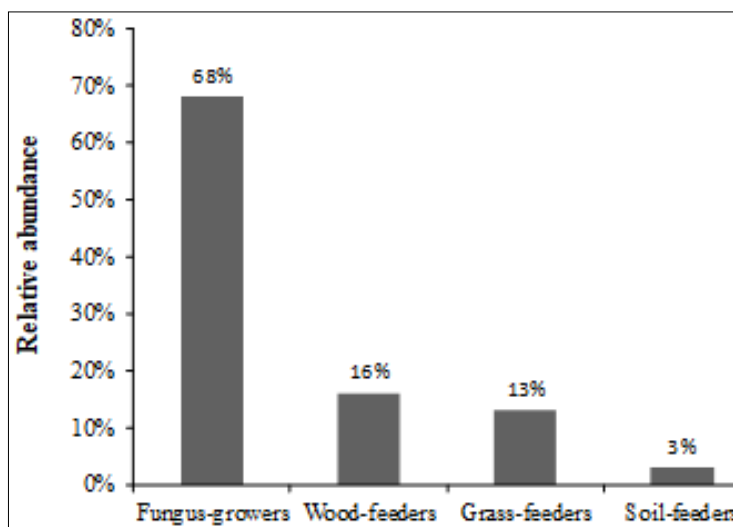


Fig 2: Relative abundance of termites feeding groups

Termite attack on plants or trees

A total 10 species of pest termites were sampled on trees (Fig

3) and were responsible for 94% of attacks on these trees. Traces of activities of termites were observed on different

trees (294 feet) from the university site including ornamental plants. *Ancistrotermes cavitox* was the most aggressive species because it caused 48% of attacks. Species such as *Ancistrotermes crucifer*, *Amitermes evuncifer*, *Odontotermes pauperans* and *Microtermes sp* recorded attack rates above 10%. *Fulleritermes tenebricus*, *Pseudacanthotermes militaris*,

Microcerotermes sp, *Macrotermes subhyalinus* and *Coptotermes intermedius* were the least aggressive species because they were responsible for attack rates of less than 10%. The pest termites sampled were essentially fungus-grower and wood-feeders. Fungus-growers were observed on 207 trees and wood-feeders were observed on 67 trees.

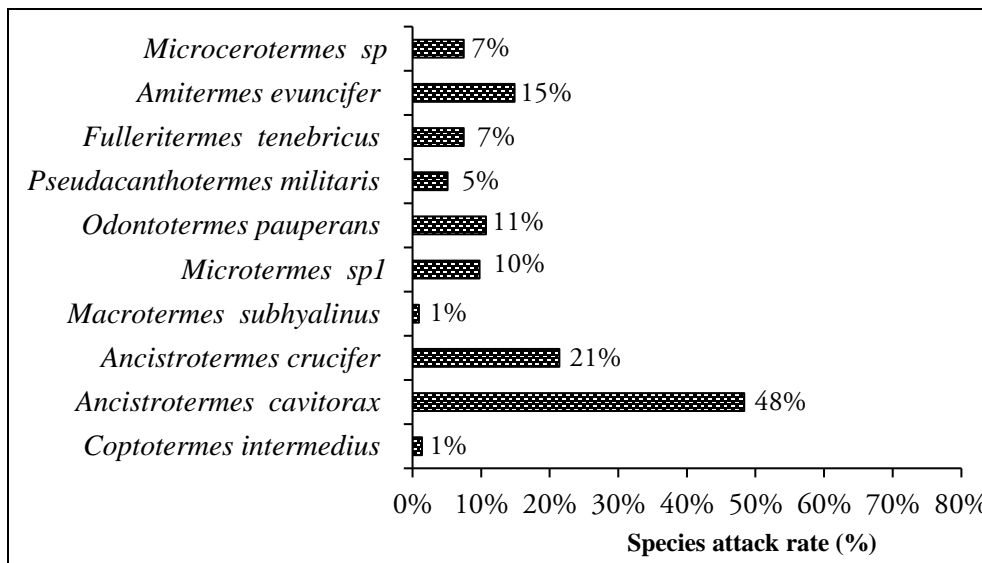


Fig 3: Attack caused by termite species (%)

Two categories (D1 and D2) of damage were observed on the trees (Fig. 5 and 5). Minor damage (D1) with a rate of 66% was the largest on the trees sampled. 27% of the observed trees showed ajor damage (D2). The species responsible for minor damage (D1) were *Ancistrotermes crucifer*, *Macrotermes subhyalinus*, *Microtermes sp1*, *Odontotermes pauperans* and *Fulleritermes tenebricus*. On the other hand, species such as *Ancistrotermes cavitox*, *Pseudacanthotermes militaris*, *Amitermes evuncifer*, *Coptotermes intermedius* and *Microcerotermes sp* were observed in the major damage (D2).

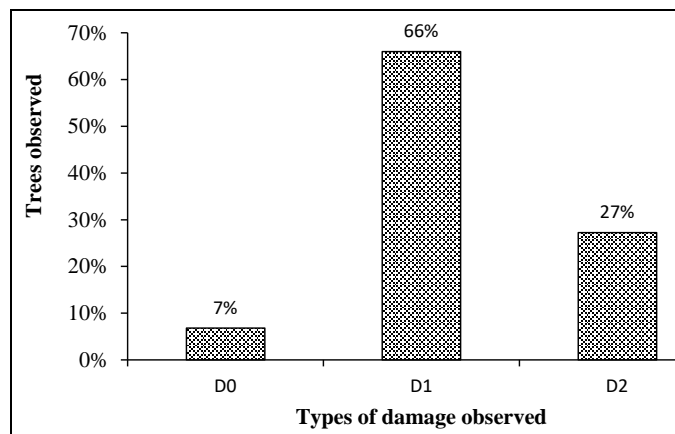


Fig 4: Type of damage observed on the trees



Fig 5: Termite damage on trees in the university area (A & B: minor damage; C & D: major damage)

Termite damage on buildings

Termites attack and cause damage to office electrical outlet,

Ceilings of buildings, the walls of building, cardboard packaging materials, the billboards and to the supports of hangars (Fig. 6). Termites caused degradation of the wooden structures, electrical cables and painting of walls. Species such as *Ancistrotermes crucifer*, *Odontotermes pauperans* and *Pseudacanthotermes militaris* were responsible for these damages.



Fig 6: Termite damage on buildings A: ceiling, B: Electrical outlet, C: storage carton, D: wall of a building, E: bulletin board, F: Hangar support.

Discussion

In this study, 12 species grouped into 11 genera of termites were identified on the campus of Korhogo University. This species richness was higher than that of Shaikh *et al.*,^[35]. These authors collected 4 species of termites divided into 3 genera on the Swami Ramanand Teerth Marathwada University campus in India. This difference in the results would be related to the sampling methods. Indeed, these authors collected termites only on trees, while our study took into account the termites of the soil by the transect method. The number of species collected in this study is relatively small compared to that obtained in the natural area of the region. Coulibaly *et al.*,^[6] collected 28 species of termites in a savanna region. The number of species harvested in our study was low because of anthropogenic activities on campus. Indeed, the campus courtyard is regularly cleaned by machines and new lawns are under construction. However, several studies have shown that the exploitation of the environment has an impact on the diversity of termites^[17, 8]. This human activity would explain the total absence of soil-feeders of the Cubitermitinae subfamily. This group of termites is considered a real habitat stability indicator^[4, 7]. Several termite species have been harvested from the trees on

the campus. These species were responsible for many damages to the trees. Some authors showed that most domesticated African plants are attacked by termites^[29, 27]. In India also, between 1975 and 1977, more than 40 species of ornamental plants, fruit trees and forest species were attacked by termites^[28] on the Bangalore campus alone. The termite species observed on trees belong to the groups of wood-feeders and fungus-growers, which was well in relation with their diet. On the campus of Lomé, Kotoklo *et al.*^[22] also found that termites responsible for the damages on tree belong to the group of wood-feeders and fungus-growers. However, *Ancistrotermes cavitox* (fungus-growers) with 48% of the attacks on trees was the most aggressive species. The high proportion of trees infested (93%) by termites may be related to the nature of the campus soil (ferrallitic red soil). This type of soil would favor the installation of termite mounds that are the source of plant infestations. Thakur *et al.*^[36] observed in India that termite attacks on trees vary with soil types. Termite damage has also been observed on campus buildings. This damage is caused by fungus-growers termites of the *Ancistrotermes*, *Odontotermes* and *Pseudacanthotermes* genera. The damage of termites on built structures has been observed in several studies. In Southern Africa, Uys,^[40] recorded 165 termite species with 54 genera, of which 10 species are known to cause extensive damage to wood and cellulosic products in building. Worldwide, damage caused by termites is estimated at U.S \$22 billion per annum in terms of damage to wooden structures^[11].

Conclusion

A total of 12 termite species were harvested from the UPGC campus. Many of these species attack trees, buildings and wooden structures. All species sampled on trees belong to wood-feeders and fungus-growers. *Ancistrotermes cavitox* responsible for 48% of attacks on trees was the most dangerous species on trees. Of the buildings, the species responsible for damage were essentially fungus-growers. The damage to the buildings and plants of this university deserves the special attention of university officials to take action to combat these termites. Indeed, with the construction of new buildings and the establishment of new green spaces, termite damage could be an obstacle for these projects.

Références

1. Ahmad M. The phylogeny of termite genera based on imago worker mandibles. Bulletin of the American Museum of Natural History (Entomology). 1950; 95(2):36-86.
2. Ahmed BM, French JRJ. Report and recommendations of the national termite workshop, Melbourne. Int. Biodeterioration Biodegradation. 2005; 56:69-74. DOI: 0.1016/j.ibiod.2005.05.001
3. Aisagbonhi CI. A survey of the destruction effect of *Macrotermes bellicosus* Smeathman (Isoptera: Termitidae-Macrotermitinae) on coconut seednuts at NIFOR, Benin, Nigeria. Trop. Pest. Manag. 1989; 35(4):380-381.
4. Bandeira AG, Vasconcellos A, Silva MP, Constantino R. Effects of habitat disturbance on the termite fauna in a Highland Humid Forest in the Caatinga Domain, Brazil. Sociobiology. 2003; 42:117-127.

5. Bouillon A, Mathot G. Quel est ce termite Africain ? Zooleo n°1, Leopoldville Univ, 1965, 115.
6. Coulibaly T, Akpesse AAM, Boga JP, Yapi A, Kouassi KP, Roisin Y. Change in termite communities along a chronosequence of mango tree orchards in the north of Côte d'Ivoire. *Journal of Insect Conservation*. 2016; 20:1011-1019.
7. De Souza OFF, Brown VB. Effects of habitat fragmentation on Amazonian termite communities. *Journal of Tropical Ecology*. 1994; 10:197-206.
8. Donovan SE, Griffiths GJK, Homathevi R, Winder L. The spatial pattern of soil-dwelling termites in primary and logged forest in Sabah, Malaysia. *Ecological Entomology*. 2007; 32:1-10.
9. Dosso K, Konaté S, Aidara D, Linsenmair KE. Termite diversity and abundance across fire-induced habitat variability in a tropical moist savanna (Lamto, Central Côte d'Ivoire). *Journal of Tropical Ecology*. 2010; 26:323-334.
10. Eggleton P, Bignell DE. Monitoring the response of tropical insect to changes in the environment: troubles with termites, In: *Insects in a changing environment*. (Eds.), HARRINGTON R. and STORK NE. Academic press London, 1995, 473-497.
11. Fage JPL, La Fage JP, Houghton DR, Smith RN, Eggins HOW. "Termite control: changing attitudes and technologies. *Biodeterioration 7* Cambridge: UK, 1988, 1721-1726.
12. Harris WV. On the genus *Coptotermes* in Africa. *Proc R Ent Soc. Lond (B)*. 1966; 35:161-171.
13. Han SH, Ndiaye AB. L'attaque des cultures maraîchères par les termites (Isoptera) dans la région de Dakar (Sénégal). *Insectes Sociaux*. 1998; 11(3):37-43.
14. Hausberger B, Kimpel D, Van Neer A, Korb J. Uncovering cryptic species diversity of a termite community in a West African savanna. *Mol Phylogenet Evol*. 2011; 61:964-969.
15. Jouquet P. De la structure biogénique au phénotype étendu. Les termites champignonnistes comme ingénieurs de l'écosystème. Thèse de Doctorat, Université Paris VI, 2002, 141.
16. Josens G. Étude biologique et écologique des termites (Isoptera) de la savane de Lamto-Pakobo (Côte d'Ivoire). Thèse de Doctorat d'État, Université Libre de Bruxelles, 1972, 262.
17. Jones DT, Susilo FX, Bignell DE, Hardiwinoto S, Gillison AN, Eggleton P. Termite assemblage collapse along a land-use intensification gradient in lowland central Sumatra, Indonesia. *Journal of Applied Ecology*. 2003; 40:380-391.
18. Jones DT, Eggleton P. Sampling termite assemblage in tropical forest: testing a rapid biodiversity assessment protocol. *Journal of applied Ecology*. 2000; 37:191-203.
19. Konaté S. Structure et rôle des buttes termitiques dans le fonctionnement d'une savane préforestière (Lamto, Côte d'Ivoire): Le termite champignonniste *Odontotermes* comme ingénieur de l'écosystème. Thèse de Doctorat, Université Paris VI, 1998, 252.
20. Konaté S, Le Roux, Verdier B, Lepage M. Effect of underground fungus-growing termites on carbon dioxide emission at the point-and landscape-scales in an African savanna. *British Ecology Society*. 2003; 17:305-314.
21. Konaté S, Yéo K, Yeboué L, Alonso LF, Kouassi K. Evaluation rapide de la diversité des insectes des forêts classées de la Haute Dodo et du Cavally (Côte d'Ivoire). *RAP Bulletin of Biological Assessment, C I. Washington DC*, 2005, 27.
22. Kotoklo AE, Kasseney DB, Nyamador W, Ketoh KG, Glitho IA. Attaques des arbres par les termites sur le campus de l'Université de Lomé (Togo). *Int. J Biol. Chem. Sci*. 2010; 4(1):61-68.
23. Lavelle P. Faunal Activities and Soil Processes: Adaptive Strategies That Determine Ecosystem Function. *Advances in ecological research*, 1997; 21:1-40.
24. Lepage MG. Étude de la prédation de *Megaponera foetens* (F.) sur les populations récoltantes de Macrotermitinae dans un écosystème semi-aride (Kajiado-Kenya). *Ins. Soc*. 1981; 28:247-262.
25. Logan JMW, Cowie RH, Wood TG. Termites (Isoptera) control in agriculture and forestry by non-chemical methods: a review, *Bulletin of Entomological Research*. 1990; 80:309-330.
26. Magurran AE. *Measuring Biological Diversity*. Blackwell Publishing, Oxford, 2004, 256.
27. Malako SLO. Economic importance of termites. Six cases studies in Nigeria and Ghana. *The Nigeria Field*. 1983; 47(4):222-230.
28. Parihar Dr. Some observations on distribution and pest status of termites attacking forestry plantations in the Rajasthan desert. *Indian Journal Forestry*. 1981; 4:22-25.
29. Renoux J. Les termites et l'homme. *Laboratoire EBENA Université Paris XII Val de Marne*. Paris, 1997, 133-146.
30. Roy V, Demanche C, Livet A, Harry M. Genetic differentiation in the soil-feeding termite *Cubitermes* sp. *ainis subarquatus*: occurrence of cryptic species revealed by nuclear and mitochondrial markers. *BMC Evol Biol*. 2006; 6:102.
31. Sands WA. A revision of the termite family Nasutitermitinae (Isoptera, Termitidae) from the Ethiopian Region. *Bull. Br. Mus (Nat Hist) Entomol. Suppl*. 1965; 4:1-172.
32. Sands W. A. The soldierless termites of Africa (Isoptera: Termitidae). *Bull. Br. Mus. (Nat Hist) Entomol. Sup*. 1972; 18:244.
33. Sands WA. The Identification of Worker Castes of Termite Genera from Soils 329 of Africa and the Middle East. *CAB International & Natural Resources International*, Wallingford, UK, 1998, 500.
34. Sjöstedt Y, Sjöstedt Y. *Revision der Termiten Afrikas*. 3. Monographie. *Kungliga Svenska Vetenskapsakademiens Handlingar*. 1926; 3(3):1-415.
35. Shaikh Y, Shaikh G, Chavan S. Diversity of subterranean termites and their associated fungi on infected four plant species in Swami Ramanand Teerth Marathwada University Campus Nanded. *International Journal of Entomology Research*. 2018; 3(1):49-51.
36. Thakur ML, Kumar S, Negi A, Rawat DS. Chemical control of termites in Eucalyptus Hybrid. *Indian Forester*, 1989, 733-742.
37. Tano Y, Yapi A, Kouassi KP. Diversité biologique et

- importance des termites (Isoptères) dans les écosystèmes de savane et de forêt de Côte d'Ivoire. *Bioterre*. 2005; 5(1):44-64.
38. Tra-Bi CS, Boga JP, Akpessa AAM, Konaté S, Kouassi P, Tano Y. Diversité et effet de la litière sur l'assemblage des termites (Insecta: Isoptera) épigés le long d'un gradient d'âge de la cacaoculture (*Theobroma Cacao* L.) en Moyenne Côte d'Ivoire, Oumé. *European Journal of Scientific Research*. 2012; 79(4):519-530.
39. Tsunoda K. Improved management of termites to protect Japanese homes. Proceedings of the 5th International Conference on Urban Pests, Perniagaan Ph'ng, Malaysia, <http://www.icup.org.uk/reports%5CICUP005.pdf>, 2005, 33-37.
40. Uys V. A Guide to the Termite Genera of Southern Africa. 1st Edn. Plant Protection Research Institute Agricultural Research Council, Pretoria, ISBN: 1-86849-216-8, 2002, 116.
41. Wood TG, Pearce MJ. Termites in Africa: the environmental impact of control measures and damage to crops, trees, rangeland and rural buildings. *Sociobiology*. 1991; 19(1):221-234.
42. Yéo K, Konaté S, Tiho S, Camara SK. Impacts of land use types on ant communities in a tropical forest margin (Oumé, Côte d'Ivoire). *African Journal of Agricultural Research*. 2011; 6(2): 60-274.