International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

DIVERSITY AND ABUNDANCE OF LITTER TERMITES IN COCOA PLANTATIONS (*Theobroma cocoa* L) OF S.A.B FROM M'BRIMBO STATION (SOUTHERN COTE D'IVOIRE)

Alexandre A. M. AKPESSE[1], Tenon COULIBALY[2]*, N'Guessan G. R. YAO[1], Yao K. S. DIBY[1], Hervé K. KOUA[1]

[1]Laboratory of Zoology and Animal Biology, UFR-Biosciences, Félix Houphouët-Boigny University of Abidjan, Côte d'Ivoire.

[2]Deparment of Animal Biology, UFR Sciences Biologiques, Université Péléforo Gon Coulibaly, BP 1328, Korhogo, Côte d'Ivoire.

*Corresponding Author

ABSTRACT

Termites are the major component of soil macrofauna and influence soil structure in tropical regions. This study aims to evaluate their assemblage in the cocoa plantations of the S.A.B. station. (Agricultural Society of Bandama). Using a standardized method of rapid biodiversity estimation, termites were collected, from an 8-year-old plot of cocoa in comparison with primary forest. A total of 19 species of termite grouped into 12 genera were collected in these two areas. The results obtained show that the species richness is relatively low in the cocoa plantation compared to the primary forest (18 species). The Shannon index was high in the forest (H '= 2.05) while the cocoa plantation has a low Shannon index (1.59). A higher relative abundance of termites was observed in the forest with an average of 1.93 ind./sections versus 1.23ind / section for the cocoa plantation. Termites harvested in the cocoa plantation were dominated by fungus-growers who account for 86% of the total abundance of termite. This study showed that despite the previous pineapple, with the massive use of chemical inputs, the cocoa plot records more than half of the species observed in the forest. The cocoa plantation would contribute to the regeneration of the termite diversity in this area heavily disturbed by the pineapple crop.

Keywords: Cocoa, termite's diversity, species richness, abundance

1. INTRODUCTION

Habitat destruction is recognized as one of the major threats to global biodiversity (Fahrig 2002, Brooks et al., 2002, Tscharntke et al., 2002). Overall, the degradation of natural habitats is

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

mainly due to human activities. Agricultural practices are a major contributor to habitat alteration in many tropical countries. According to Stiling (1999), shifting cultivation has been identified as the leading cause (70%) of forest loss in Africa. The consequence of this conversion is a simplification of natural communities with the elimination of sensitive species (Boren et al., 1999, Hansen and Rotella, 2002). However, these claims do not take into account the ability of many species to survive in disturbed or converted habitats for agricultural purposes (Lugo 1988). Given the vast expanses of land that are used for agriculture around the world, it is imperative that conservation biologists understand how agroecosystems could be used to sustain biodiversity (Perfecto et al., 1997). With the continued loss of tropical forests, researchers have begun to examine the contribution of cultivated areas to biodiversity conservation (Bawa et al., 2004, McNeely, 2004, Schroth et al 2004). Many studies have shown that agro-forests can withstand high levels of species richness, often resembling even undisturbed forests (Schulze et al., 2004, Tylianakis et al., 2006). Recently in Côte d'Ivoire, Coulibaly et al. (2016) have shown that mangoes orchards harbor a diversity of termites close to that of the natural area. However, very little work has linked cocoa plantations and termite communities in Côte d'Ivoire. Yet termites are one of the major biotic components of tropical ecosystems where they represent, with earthworms and ants, true ecosystem engineers (Lavelle et al., 1997, Dangerfield et al., 1998). The ecological importance of termites is observed in particular through their role (1) in the food webs where they act as main decomposers and are the prey of many other organisms, (2) in the soil structure as well as storage and decomposition of organic matter of plant origin (Bignell et al., 1983, Konaté et al., 2003) and finally (3) as the main bioturbator in some soils. Given the particular influence of termites in the soil process in the tropics, it is important to understand how certain agricultural activities such as cocoa affect their assemblage. Here we examine termite diversity in forest and cocoa plantations to explore the question of the role of agroecosystems in biodiversity conservation. The area chosen for our study is the Bandama farm in M'brimbo (SAB), a domain located in the south of Côte d'Ivoire.

2. MATERIAL AND METHODS

2.1. Study zone

This study was carried out in the region of Tiassalé, is located in the region of Lagunes, in the south of Côte d'Ivoire (5 ° 50 'N and 4 ° 50'W). It is about 120 km north-west of Abidjan and about 117 km southeast of Yamoussoukro (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 Farm (SAB) in M'brimbo is an area of the former African canning company (SAFCO). The site was acquired by SAB in 2004 and development work began in 2007. It has a total area of 1012 hectares. Today this farm is intended for cocoa farming, rubber growing, fruit growing and beekeeping. The plots sampled are as follows:

- **Cacao plantation**: The 8-years old plot of 10 hectares was randomly selected from the 100 ha site. The chosen plot counts on approximately 1200 cacao tree/ha with spacings of 03 meters between the lines and the feet (Figure 2a). The cultural background of this parcel is pineapple.

- **The primary forest** plot chosen was a control is adjacent to that of cocoa. This forest has never been exploited for agricultural purposes (Figure 2b). The canopy was dense and the soil was humid. Fallen trees were rare, while litter was thick and mostly composed of tree leaves.

Figure 1: Geographic location of the study environment

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

Figure 2: Plots of cocoa (a) and primary forest (b) sampled

2.2. Termite sampling

Termite sampling was performed using the standardized method for termite collecting (Jones and Eggleton, 2000). It consists in delimiting, in each parcel, 20 sections of 10 m2 (5 m × 2 m) of surface along a transect 100 m long and 2 m wide. The search is done in two stages by two people for 30 minutes. The first is to search litter, epigeic nests and the aerial part of plants up to 1.5 m tall (if possible) in search of termites. The second, after careful excavation of each section, the termites are collected in labeled pill containers containing 70 ° ethyl alcohol. Three (3) transects were conducted for termite sampling in each medium. In total, three transects of 100 m length were made in each medium.

2.3. Termite identification

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

2.4. Data analysis

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

Sampling efficiency was tested by constructing species accumulation curves using EstimateS software (version 7.0) (Colwell, 2004). The non-parametric first-order estimator, jackknife 1, was chosen for wealth estimation expected (Brose et al., 2003). The species richness (S), the Shannon index (H '), the equitability (E') and the Simpson index (IS) were calculated for each medium. As we used presence-absence data, the relative abundance was defined as the number of encounters per transect, where the presence of one species in a section represented one encounter (Magurran, 2004). The similarity between the different area (A and B) was calculated according to the following formula: S = c / (a + b + c); c = species common to both plots, a = number of species observed only on plot A; b = number of species observed only on plot B.

3. RESULTS

3.1. Sampling efficiency

The species richness in litter termite sampling is relatively high with coverage rates greater than 80% for both media. The accumulation curves, of the observed (Sobs) and expected (Jack 1) specific richness, all approach the asymptote, thus indicating a high efficiency of the sampling method used in these environments (Figure 3).

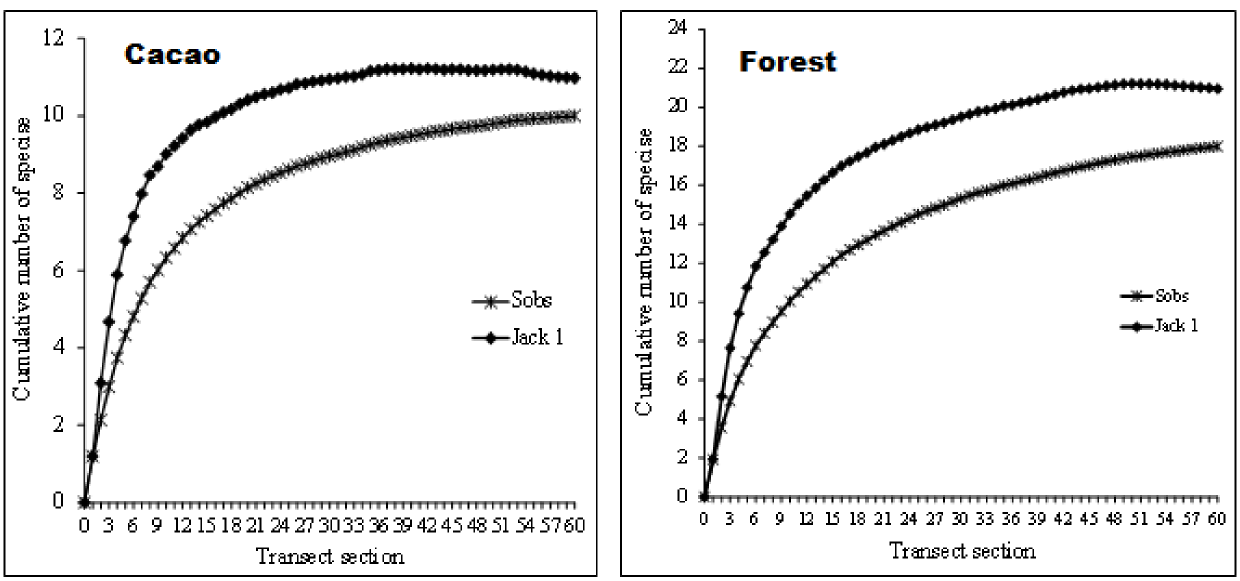

Figure 3: Sample-based accumulation curves of observed (Sobs) and estimated (Jack 1) species richness of termites in each habitat type.

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

3.2. Taxonomic structure of collected species

A total of 19 termite species belonging to 12 genera were collected from both plots (Table I). These genera were divided into seven (7) subfamilies and grouped into the two major families of Rhinotermitidae and Termitidae. The Macrotermitinae was the most diverse subfamily, with 9 species. It was followed by those of Cubitermitinae and Termitinae, which each recorded 3 species. The subfamilies of Rhinotermitinae, Apicotermitinae, Nasutitermitinae and Coptotermitinae were least represented with one species each. The species richness obtained in the primary forest (18 species) was much higher than that observed in the cocoa plot which recorded 10 species. All the species observed on the cocoa plot were also present in the primary forest with the exception of *Microtermes toumodiensis*.

The Shannon index was high in the forest (H '= 2.05) while the cocoa plantation has a low index of 1.59 (Table 2). The Simpson index (IS) and the equitability (E) evolved in the same direction as that of Shannon. The Simpson index was 0.97 for the forest while it is 0.72 for the cocoa plantation. The equitability (E) was maximum in the forest with a value of 0.84 however its value was relatively lower for the cultivated plot (0.51). The similarity index between the two media was low (0.53).

Table I: List of termite species harvested in the plots studied

Subfamilies	Species/ morphospecies	Cocoa	Forest	Trophic group
Coptotermitinae				
	Coptotermes intermedius		2	Wood-feeders
Rhinitermitinae				
	Shedorhinotermes amanianus		6	Wood-feeders
Macrotermitinae				
	Ancistrotermes cavithorax	9	21	Fungus growers
	Ancistrotermes guineensis	15	8	Fungus growers
	Acanthotermes acanthothorax		2	Fungus growers
	Macrotermes bellicosus	4	6	Fungus growers
	Macrotermes subhyalinus		1	Fungus growers
	Microtermes thoracalis	11		Fungus growers
	Microtermes toumodiensis	13	5	Fungus growers
	Odontotermes sp	2	16	Fungus growers
	Pseudacanthotermes militaris	10	15	Fungus growers
Cubitermitinae				
	Basidentitermes potens		6	Soil-feeders
	Cubitermes fungifaber		3	Soil-feeders
	Procubitermes sp	10	6	Soil-feeders

Termitinae				
	Microcerotermes fuscotibialis	1	1	Wood-feeders
	Microcerotermes sp		13	Wood-feeders
	Amitermes evuncifer	2	2	Wood-feeders
Apicotermitinae				
	Astalotermes sp		2	Soil-feeders
Nasutitermitinae				
	Nasutitermes arborum		1	Wood-feeders

Table 2: Metrics of termite diversity in the two habitats

Habitats	Species richness	Estimated species richness (Jack 1)	Sample coverage (%)	Shannon's index	Simpson's index	Evenness	Similarity	Uniques	Total relative abundance (occurrences)
Forest	18	20.95	85.91	2.05	0.97	0.84	0.53	3	116
Cacao	10	10.98	91.07	1.59	0.72	0.51		1	74

The relative abundance of termites varied from one habitat to another. The forest has the highest abundance of termites with a total abundance of 116 occurrences, ie an average abundance of 1.93 ind./ sections. The cocoa plantation, with a relative abundance of 74 occurrences, recorded the lowest abundance of termites, ie 1.23 ind./section (Table: 2).

3.3. Variation in the proportion of termite feeding groups

Three trophic groups were collected in these two environments. They are: fungus-growers, soil-feeders and wood-feeders (Figure 4). In the forest, fungus-growers and wood-feeders, with respectively 64% and 22% were the most abundant groups. However, in the cocoa plantation, fungus-growers dominated termite settlement and account for 86% of the total termite abundance in this habitat. Soil-feeders, with 5% of the total abundance, were very weakly present in the plantation.

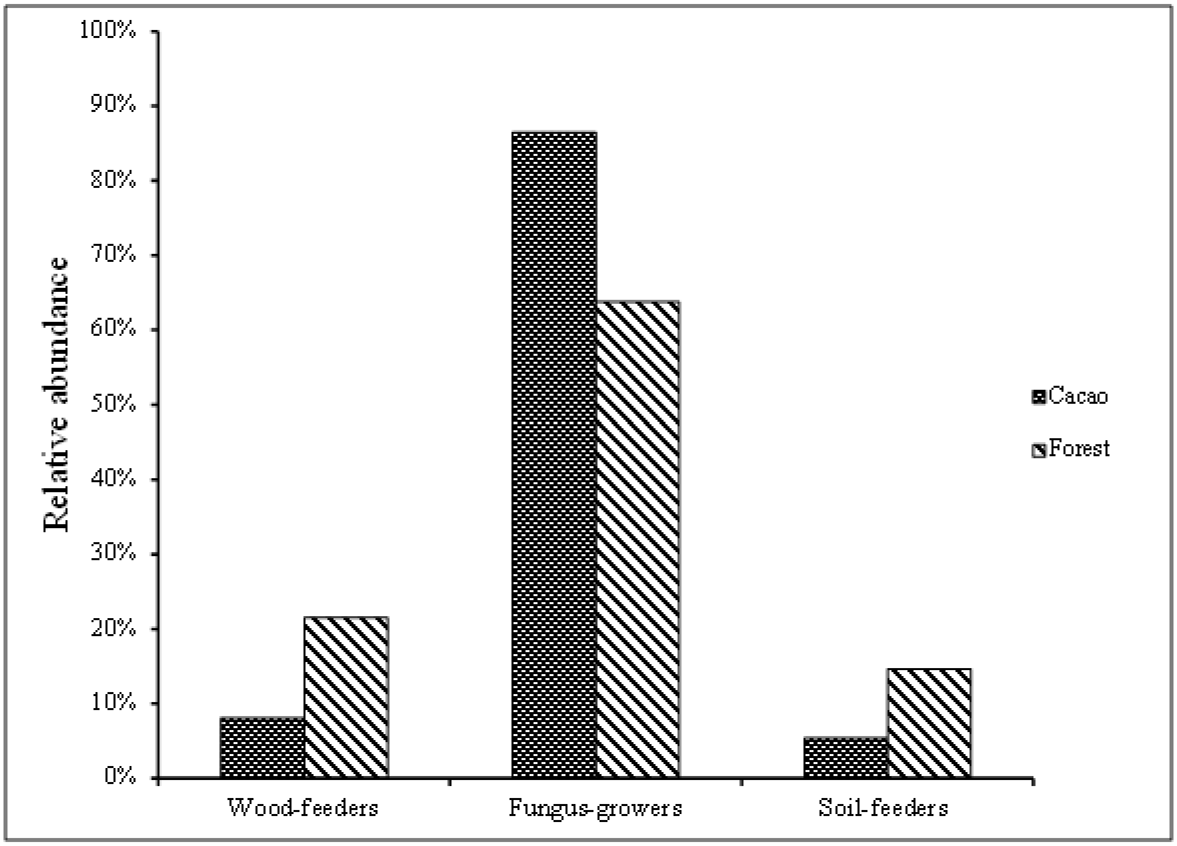

Figure 4: Variation of the proportion of trophic groups in different media

4. DISCUSSION

4.1. Sampling efficiency

We evaluated sampling efficacy with sample-based rarefaction curves. The termite species richness was efficiently assessed in the two areas. This fact was illustrated on the one hand by the plateau asymptote attained by the observed rarefaction curves. Moreover, our results agreed with Chao et al., 2005 about the link between the rarefaction curves and the number of unique species. According to these authors, the observed species accumulation curves level off when the number of unique species decreasing. Such a trend was observed in the present study for the two areas were few unique species were found. However, our sampling provided a good picture of termite species composition in the two habitats, with 88.49% of the expected termite species sampled. The sampling method was successfully applied, implying that our objective of examining the termite assemblage structure across habitat type could be addressed.

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

4.2. The termite assemblage

A total of 19 termite species belonging to 12 genera were collected from the cocoa plantation and forest. These results werz very different from those obtained in other studies carried out in similar habitats. Tra Bi et al. (2012) collected, in Oumé in west-central Côte d'Ivoire, 34 species belonging to 18 genera in cocoa plantations and in the forest using the transect method. This difference in the results would be related to the fact that these authors sampled in different age classes of cocoa plantations with a larger number of transects. Increasing the sampling effort would increase the efficiency of the transect method used by these authors, with a larger number of species harvested.

Ten (10) termite species were harvested from the cocoa plantation. This species richness is relatively low compared to that obtained by Tra Bi et al., (2012), in cocoa plantations of the same age (8 years). Indeed, these authors harvested 18 species of termites in cocoa plantation of 6-10 year old class. This difference would be related to the cultural antecedent of each plantation. In the case of the Tra Bi et al. study, the plantation was set up from the primary forest plots. This antecedent forest would be at the origin of the great diversity observed by these authors. The cocoa plantation sampled in this study was set up from old plots of pineapple. In order to obtain quality pineapples, pineapple producers used many chemicals such as insecticides, nematicides, herbicides and fungicides applied at least four times a year. Massive use of chemicals (insecticides, herbicides and fertilizers) and tillage have certainly contributed to the loss of diversity of soil fauna in general and termites in particular before the establishment of the plantation cocoa trees. To this cultural background, it should be added that the cacoculture, set up to replace the pineapple crop, also uses pesticides that are applied once or twice a year. Several studies in other settings have linked the use of chemical inputs with the diversity of soil macrofauna (Eggleton et al., 2002, Brown et al., 2003, Donovan et al., 2007). This work has shown that the exploitation of the soil and the use of chemicals affect the trophic structure and species richness of the fauna. This is probably what would explain the low presence of humivores in the cocoa plantation. Indeed humivores are organisms exclusively related to organic particles decomposing in the humic fraction of the soil (Tayasu et al., 1998, Brauman, 2000). They are most affected by land use and the use of chemical inputs (Donovan et al., 2001 and Gillison et al., 2003).

However, the results show a high diversity and abundance of termites mushroom and a low presence of humivores. This could be explained by the fact that these mushroom termites have a symbiotic extra-digestive relationship with a superior fungus (Basidiomycetes) of the genus Termitomyces. This fungus degrades wood fragments that become digestive for termites

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

(Matoub, 1993, Guedegbe et al., 2008). This would facilitate their installation in the most hostile environments (Konaté et al., 2005).

5. CONCLUSION

This study carried out at S.A.B. (Société Agricole du Bandama) has collected a total of 19 termite species grouped into 12 genera in this region of Côte d'Ivoire. The results obtained show that in the cocoa plantation the diversity and abundance of termites are relatively low compared to those obtained in the primary forest. This would be linked to the farming history of this farm, which used to be a piece of pineapple. The high use of chemical inputs for pineapple farming would have led to a decline in diversity. This diversity would be in full reconstitution in the cocoa plantation which replaced the plots of pineapple. From the trophic point of view, there is a strong dominance of fungus-growers in the cocoa plantation.

REFERENCES

Ahmad M. (1950). The phylogeny of termite genera based on imago-worker mandibles. *B Am Nat Hist Entomol* 95:36-86.

Bawa S.S., Kress W.J., Nadkarni N.M., Lele S. (2004). Beyond paradise meeting the challenges in tropical biology in the 21st century. *Biotropica* 36:437–446.

Bignell D.E., Oskarsson H., Anderson J.M., Jneson J.B. and Wood T.J. (1983). Structure, microbial associations and function of the so-called « mixed segment » of the gut in two soil-feeding termites, *Procubitermes aburiensis* and *Cubitermes severus*. *J. Zoot. Lond.*, 201,445-150.

Boren J.C., Engle M.D., Palmer W.M., Masters E.R. and Criner T. (1999). Land use change effects on breeding birds community composition. *Journal of Range Management* 52: 420-430.

Bouillon A. and Mathot G. (1965). Quel est ce termite Africain ? *Zooleo* n°1, Leopoldville Univ, Leopoldville.

Brauman A. (2000). Effect of gut transit and mound deposit on soil organic matter transformations in the soil feeding termite: a review. *European Journal of Soil Biology*, 36: 117-125.

Brooks T., Mittermeier A.R., Mittermeier G.C., Da Fonseca B.A.G., Rylands B.A., Konstant R.W., Flik P., Pilgrim J., Oldfield S., Magin G. and Hilton-Taylor C. (2002). Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology* 16 (4): 909-923.

Brown G.G., Benito N.P., Pasini A, Sautter K.S., Guimarães M.F., Torres E. (2003) No- tillage greatly increases earthworm populations in Paraná state, Brazil. *Pedobiologia* 47:764-771.

Colwell R.K. (2004). EstimateS: statistical estimation of species richness and shared species from samples. Ver. 7.5. – Persistent URL <purl.oclc.org/estimates/>. Accessed 12 April 2014.

Coulibaly T., Akpesse A.A.M., Boga J-P., Yapi A., Kouassi K.P., ROISIN Y. (2016). Change in termite communities along a chronosequence of mango tree orchards in the north of Côte d'Ivoire, *Journal of Insect Conservation* 20: 1011-1019.

Dangerfield JM, McCarthy TS, Ellery WM. (1988). The mound-building termite *Macrotermes michaelseni* as an ecosystem engineer. *J Trop Ecol* 14:507-520.

Donovan, S. E., Eggleton, P., Dubbin, W. E., Batchelder, M and Dibog, L. (2001). The effect of a soil-feeding termite, Cubitermes fungifaber (Isoptera: Termitidae) on Soil properties: termites may be an important source of soil microhabitat heterogeneity in tropical forest. *Pedobiologia*, 45: 1-11.

Donovan SE, Griffiths GJK, Homathevi R, Winder L. (2007). The spatial pattern of soil-dwelling termites in primary and logged forest in Sabah, Malaysia. *Ecol Entomol* 32:1-10 .

Eggleton P, Bignell DE, Hauser S, Dibog L, Norgrove L Madong B. (2002). Termite diversity across an anthropogenic disturbance gradient in the humid forest zone of West Africa. *Agr Ecosyst Environ* 90:189-202.

Fahrig L. (2002). Effects of habitat fragmentation on the extinction threshold: A synthesis. *Ecological applications* 12(2): 346-353.

Gillison, A. N., Jones, D. T., Susilo, F. X and Bignell, D. E. (2003). Vegetation indicates diversity of soil macroinvertebrates: a case study with termites along a land-use intensification gradient in lowland Sumatra. *Organisms Diversity Evolution* 3: 111-126.

Guedegbe, H., Houngnandan, P., Roman, J and Rouland-Lefevre, C. (2008). Paterns of substrate degradation by some microfungi from fungus-growing termites combs (Isoptera: Termitidae: Macrotermitinae). *Sociobiology* 52 (3): 51-65.

Hansen A. J. R. and Rottella J. J. (2002). Biophysical factors, land use and species viability in and around nature reserves. *Conservation Biology* 16: 1112-1122.

Jones D. T and Eggleton P. (2000). Sampling termite assemblage in tropical forest: testing a rapid biodiversity assessment protocol. *Journal of applied Ecology* 37: 191-203.

Konaté S., Le Roux Verdier B and Lepage M. (2003). Effect of underground fungus-growing termites on carbon dioxide emission at the point-and landscape-scales in an African savanna. *British Ecology Society* 17: 305-314.

Konaté S., Yeo K., Yeboue L., Alonso L.F. and Kouassi K. (2005). Évaluations 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, 27 p.

Lavelle P, Bignell D, Lepage M, Wolters V, Roger P, Ineson P, Heal OW, Dhillion S. (1997). Soil function in a changing world: the role of invertebrate ecosystem engineers. *Eur J Soil Biol* 33:159–193.

Lugo AE (1988) Estimating reductions in diversity of tropical forest species. In: Wilson EO (ed) Biodiversity. National Academy Press, Washington, pp 58–70.

Magurran A.E. (2004). Measuring Biological Diversity. Blackwell Publishing, Oxford, UK, 256 p.

Matoub M. (1993). La symbiose termite-champignon chez *Macrotermes bellicosus* Termitidae: Macrotermitinae): rôle des enzymes acquises dans la xylanolyse. Thèse de Doctorat, Université Paris XII, Val de Marne, 187 p.

McNeely J.A. (2004). Nature vs. nurture: managing relationships between forests, agroforestry and wild biodiversity. *Agrofor Syst* 61:155–165.

Perfecto I., Vandermeer J., Hanson P., Cartin V. (1997). Arthropod biodiversity loss and the transformation of a tropical agroecosystem. *Biodivers Conserv* 6:935–945.

Roy V, Demanche C, Livet A, Harry M. (2006). Genetic differentiation in the soil-feeding termite *Cubitermes* sp. *affinis subarquatus*: occurrence of cryptic species revealed by nuclear and mitochondrial markers. BMC Evol Biol 6:102.

Sands WA. (1965). A revision of the termite family Nasutitermitinae (Isoptera, Termitidae) from the Ethiopian Region. *Bull Br Mus (Nat Hist) Entomol Suppl* 4:1–172

Sands WA. (1972). The soldierless termites of Africa (Isoptera: Termitidae). *Bull Br Mus (Nat Hist) Entomol Suppl* 18:244 p.

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

Sands WA. (1998). The Identification of Worker Castes of Termite Genera from Soils of Africa and the Middle East. CAB International and Natural Resources International, Wallingford, UK, 500 p.

Sjöstedt Y. (1926). Revision der Termiten Afrikas. 3. Monographie. Kungliga Svenska Vetenskapsakademiens Handlingar (3) 3:1-415.

Schulze CH, Waltert M, Kessler PJA, Pitopang R, Veddeler D, Muhlenberg M, Gradstein SR, Leuschner C, Steffan-Dewenter I, Tscharntke T. (2004). Biodiversity indicator groups of tropical land use systems: comparing plants, birds and insects. *Ecol Appl* 14:1321–1333.

Schroth G., Fonseca G.A.B., Harvey C.A., Gascon C., Vasconcelos H.L. (2004). Agroforestry and biodiversity conservation in tropical landscapes. Island Press, Washington Stiling P. (1999). Ecology: Theories and Applications. Third edition. Prentice-Hall. New Jersey.

Tayasu, I., Inoue, T., Miller, R. L., Sugimoto, A., Takeichi, S and Abe T. (1998). Confirmation of soil-feeding termites (Isopera ; Termitidae; Termitinae) in Australia using stable isotope ratios. *Functional Ecology* 12: 536-542.

Tra-Bi C. S., Boga J.-P., Akpesse A. A. M., Konaté S., Kouassi P. and Tano Y. (2012). 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* 79(4): 519-530.

Tscharntke T., Steffan-Dewenter I., Kruess A. and Thies C. (2002). Contribution of small habitat fragments to conservation of insect communities of grassland-cropland landscapes. *Ecological applications* 12(2): 354-363.

Tylianakis J.M., Klein A.M., Lozada T., Tscharntke T. (2006). Spatial scale of observation affects alpha, beta and diversity of cavity-nesting bees and wasps across a tropical land-use gradient. *J Biogeogr* 33:1295–1304.

