Journal of Applied Biosciences 29: 1809 - 1827
ISSN 1997–5902

Diversity and abundance of terrestrial ants along a gradient of land use intensification in a transitional forest-savannah zone of Côte d'Ivoire

Mouhamadou KONE[12§], Souleymane KONATE[2], Kolo YEO[2], Philippe Kouassi KOUASSI[1] and K. E. LINSENMAIR[3]

[1]Unité de Formation et de Recherches en Biosciences, Université de Cocody, Abidjan, Côte d'Ivoire ; [2]Station d'écologie de Lamto, Université d'Abobo-Adjamé, Abidjan, Côte d'Ivoire ; [3]Department of Animal Ecology and Tropical Biology, University of Würzburg, Germany;

[§]Corresponding author address: kmouhamadou2@yahoo.fr
Original submitted in 6th April 2010. Published online at www.biosciences.elewa.org on May 11, 2010.

ABSTRACT

Objective: In the transitional forest-savannah zone, human pressure on natural resources occurs mainly through converting forests into diverse land use systems. Land use management has an important impact on soil and its functional role in maintaining ecosystem processes; it generally results in dramatic and rapid changes in vegetation that are likely to affect soil invertebrate communities significantly. In the context of the sustainable use of natural resources in tropical countries an investigation was conducted in Cote d'Ivoire to study the impacts of land use type on biodiversity.

Methodology and results: Data were collected on ant diversity and relative abundance in five land use types: (i) forest in Lamto reserve, (ii) rural forest, (iii) food crop plantations, (iv) cocoa and (v) pineapple plantations, with the aim of characterizing ant assemblage in response to land use change. Standard sampling methods (Winkler leaf litter extraction, pitfall trapping and soil monolith extraction) were used to collect ants along three transects of 200 m length per land use type. A total of one hundred and eighteen ant species were found in all habitats combined. The rural forest was the most species rich habitat (75 species), followed in decreasing order by the Lamto forest (73 species), food crop plantations (61 species), cocoa plantations (45 species) and pineapple plantations (19 species).

Conclusions and application of findings: Three main conclusions were drawn from this study: (i) a decrease in terrestrial ant diversity occurred with increasing land use intensification; (ii) food crop lands had levels of ant diversity comparable to those of the forests; however, there were dramatic changes in the community structure; (iii) the rural forests are near natural and may serve as refuges for ant diversity. These findings encourage sustainable types of land use, involving agro-forestry practices to allow natural recovery processes after agricultural disturbance. This approach will help in the conservation of biodiversity.

Key words: Ants, forest, human pressure, land use intensification, refuge.

INTRODUCTION

Biodiversity is threatened globally and the last decade has been characterized by an increase in environmental problems at the local and global scale. These problems are mainly due to habitat conversion and fragmentation, human land use practices and climate change. Agriculture is one of the most destructive forms of land conversion in the tropics. It causes more prominent changes to land and vegetation characteristics on shorter temporal scale and at a large spatial scale than most natural processes (Jepsen *et* *al*., 2005). In recent years, tropical forests that are home to over 50% of the world's terrestrial species while covering only 7% of the global land mass, have suffered considerable loss of their biodiversity (Achard *et al*., 2002; Barbault *et al*., 2002; Darkoh, 2003; Wright, 2005). Most of the resources of Côte d'Ivoire come from rural areas where human populations continue to expand. This situation led to loss of more than 75% of forested areas in fewer than 30 years (Lévêque, 1994). This vast loss of natural habitat could lead to reduction in biodiversity. As yet, there is not much direct evidence on which agricultural practices affect biodiversity more.

Ants are abundant and diverse in almost all terrestrial habitats, easy to collect and sensitive to environmental changes. They are one of the most important arthropod groups in tropical forests in terms of biomass and impact as the prime predators of the other invertebrates (Fittkau & Klinge, 1973; Wilson, 1987). As efficient predators ants may limit herbivore populations including potential insect pests in agroecosystems (Philpott & Armbrecht, 2006; Armbrecht & Gallego, 2007; Van Mele, 2008). Several ant species have been used as agents of biological control (Majer, 1976; Kenne, 1999). Ants also have important influences on soils (Lobry de Bruyn & Conacher, 1994; Lobry de Bruyn, 1999), vegetation (Buckley, 1982) and other faunal groups through their involvement in a wide range of key ecological processes. Because of this importance, they are widely used as bioindicators and are included in monitoring programmes focusing on the ecological effects of human impacts (Andersen, 1993).

Several studies have focused on ant communities throughout the world. It has been demonstrated that ant communities respond predictably to disturbance (Andersen, 1990, 1997a, b; Bestelmeyer & Wiens, 1996; Majer & Nichols, 1998; Peck *et al*., 1998; Bisevac & Majer, 1999; Agosti *et al*., 2000; Floren *et al*., 2001; Mitchell *et al*., 2002; Schonberg *et al*., 2004). Therefore, it is expected that replacing forests with farms should have strong impact on ants and other soil invertebrates (Andersen, 1995; Vasconcelos, 1999). Forest disturbance effects on ant communities have been studied because they dominate the ground and arboreal arthropod fauna in tropical forests (Belshaw & Bolton, 1993; Floren & Linsenmair, 1997).

In Côte d'Ivoire, most studies conducted since 1965 have focused on ant biology and ecology. For the Lamto wet savanna, Lévieux (1973) showed that the spatial distribution of ants is not strongly affected by the vegetation structure but considerably by soil type. Diomandé (1981) showed that ant diversity declines with increasing agricultural activities in forest zones of Southern Côte d'Ivoire. Investigation by Yéo et al. (*in press*) indicates that land use types affects the soil and leaf-litter ant communities in Oumé (central Côte d'Ivoire).

In the rural zone around Lamto Scientific Reserve, intensive agricultural practices occur. We therefore hypothesis that ant communities would change following the gradient of land use types. In this study, we analyzed changes in terrestrial ant diversity and abundance across five land use types representative of this rural domain in comparison to the protected area at Lamto. This study provides much needed information to understand the impacts of land use change on biodiversity.

MATERIALS AND METHODS

Study site: The study was carried out in the Lamto reserve (6°13'N, 5°02'W) and the surrounding rural zone during the long rainy season (April to October 2005). This region is located in the forest-savannah transitional zone. The average annual rainfall and temperature are 1053 mm and 28.6° C, respectively. Three sites were selected for sampling in each of five land use types: (i) Lamto forest, (ii) rural forest, (iii) food crop plantations, (iv) cocoa plantations and (v) pineapple plantations. Sites were within 0.15 – 21 km of each another. A 200 m transect was established inside all sites with a total of 15 transects of 200 m for all land use types.

The land use types selected for investigation were chosen according to the level of disturbance as follows:

1. The Lamto forest (strictly protected): Located within the Lamto reserve, this forest is protected against fire which represents the major threat and cause of disturbance in this protected area. All forms of human impact have been excluded from this land use type for more than 40 years (since 1962). The tree canopy is dense and little light reaches the ground, which is highly humid. Dead fallen trees are rare while the litter is thick and essentially composed of leaves from trees. Within this forest, the regeneration was undisturbed. As for vegetation structure, the dominant plant species were *Dialium guineensis* (7500 individuals ha^{-1}), *Olax subscorpioidea* (5100 individuals ha^{-1}), *Lecaniodiscus cupanioides* (3850 individuals ha^{-1}), *Eryxthroxylon emarginatum* (3325 individuals ha^{-1}), *Celtis philippensis* (1450 individuals ha-¹) and *Triplochiton scleroxylon* (950 individuals ha-¹). A floristic assessment has been completed by Koulibaly (2008).

2. The rural forest: Three fragments of forest located within the rural domain were investigated. These forests had canopies more opened than the protected forest in Lamto. A great number of dead fallen trees were found mainly due to cutting by the farmers (or to wind damage). This damage was also due to selective logging, hunting and medicinal plants harvesting. The dominant plant species were *Dialium guineensis* (4375 individuals ha-¹), *Olax subscorpioidea* (3600 individuals ha-¹), *Trichilia prieureana* (2975 individuals ha-¹), *Pouteria alnifolia* (2650 individuals ha-¹) and *Lecaniodiscus cupanioides* (2500 individuals ha-¹).

3. Food crop plantations: The food crop plantations investigated were composed of mixtures of different plants e.g. yam, taro, plantain banana, cassava, maize and eggplant. Farmers used machetes to remove ground vegetation and some small trees. Other trees were felled using a chainsaw. Pesticides were not used in this land use type; the ground was covered by dead leaves of the cultivated crops. Plantain banana trees provided relatively shady conditions to the undergrowth.

4. Cocoa plantations: The cocoa plantations investigated were about 20 years old. The floor cover was mainly composed of dead cocoa tree leaves. Pesticides were applied once or twice per year in these plantations. The most common pesticide used was Imidaclopride 200 g/l (trade name Confidor 200SL) at a dose rate of 0.5l ha^{-1}.

5. Pineapple plantations: The pineapple plantations investigated belonged to an agriculture company (Société de Culture Bananière (SCB)). Pineapples, like any agricultural crop are affected by pests and diseases that require chemical control to prevent crop losses, to maintain quality standards for the consumer market, and to meet phytosanitary requirements of importing countries. Among the crop products applied are insecticides, nematicides herbicides and fungicides. Before cropping, the area was mechanically cleared by felling trees using chain saws. The remaining vegetation and dead woods were then completely bulldozed; so that there was no tree. Here, pesticides were applied at least four times per year but the number of treatments could be increased if pest attacks reach a set threshold. This is the predominant land use type within our gradient. (Figures 5A, 5B, 5C, 5D and 5E)

Sampling method: Ants were sampled by combining a modified version of the A.L.L. (Ants of Leaf Litter) protocol (Agosti *et al*., 2000), modified version of monolith method as described in Yéo (2006) and Yéo et al. (*in press*) and non standardized hand collections. Fifteen samples were taken at 12 m intervals along a 200 m transect line against twenty samples in the standard protocol. At each sampling point the leaf litter present inside a 1 m² quadrat was collected and sifted in order to extract big leaves and twigs (Martin, 1983). The shifted litter containing the small invertebrate fauna was poured into the sample bag for transportation to the field station. Ants were extracted from this litter using a mini-Winkler apparatus (Fisher, 1998). The litter in each sample bag was poured within a mesh inlet sack (mesh size: 4 mm), which was suspended inside the Winkler bag. As the litter in the inlet sacks dries, ants migrate in a receptacle on the bottom of the Winkler bag. The receptacle was a cup partially filled with a 70% ethanol solution. The Winkler extraction is conducted during 48 hours. In the field, after collecting the leaf litter for the Winkler bags, a pitfall trap containing alcohol and glycerin were placed one meter apart from each quadrat. The pitfall traps remained at the sampling point for 48 hours (Bestelmeyer *et al*., 2000).

Endogaeic ants were sampled by extracting soil monolith referred to as “soil digging” by Fisher & Robertson (2002). For this method, 15 monoliths of 27 000 cm³ (30×30×30 cm) were dug out, 12 m apart from one another and running parallel to the litter transect (in a distance of 10m). The soil monoliths were cut into two slices (0 to 15 cm and 15 to 30 cm). Each slice was sorted separately and constitutes a distinct sample (Yéo, 2006).

Finally, hand collection was done for 20 minutes along both transects (the modified ALL and soil monolith transects). This allowed the sampling of additional species from special microhabitats where ants may be nesting (under stones, dead wood and trunks, among others.).

Identification of ant specimens: All ants collected were identified at genera level using the key of Bolton (1994). The species were identified using keys from Bolton (1973, 1974, 1975a, 1975b, 1976, 1981, 1982, 1983, 1986, 1987, 1994, 1995, 2000, 2003); Bolton *et al.* (1976); Bolton et Brown (2002).Then some species were compared with reference collections in the Natural History Museum at London and the Museum of Comparative Zoology at Harvard University. When species-level identifications were not possible, distinct specimens were structured into morphospecies.

Data analysis: Workers were the only caste examined as their presence provides evidence of an established colony (Longino *et al*., 2002). Data from pitfall traps, Winkler bags and monoliths were combined to determine the total ant species richness and relative abundance in land use types. To obtain a measurement of sampling success, species richness in land use types was estimated using the species richness estimators (Chao2) included in the EstimateS software (Colwell, 2005). The process of species richness estimation is explained in detail on line (http://purl.oclc.org/estimates). This second order estimator is based on the incidence of species rather than their abundance. It is based on the relationship of uniques to duplicates (Chao, 1987). The observed and estimated species richness allowed estimation of the sampling coverage according to the formula:

Sampling efficiency (%) = (species richness observed / species richness estimated) x 100

The completeness of our sampling method was tested by constructing sample-based species accumulation curves for each land use type. Number of unique species was also calculated to explain the trend of the species accumulation curve.

The Simpson index calculated with the program Ecological Methodology (Krebs, 2002), was used as diversity measure of ant communities. The evenness, i.e. the equitability of the distribution of species abundance was also calculated with this software.

An analysis of variance (ANOVA) was performed to assess the variation of species relative abundances and richness across land use types using the software Statistica version 6 (www.statsoft.com). Differences between land use types were detected by applying LSD (Least Significant Differences) post hoc comparison tests.

The relative abundance of ant species' and subfamilies' was calculated. We termed as "common" species, those totaling at least 15 occurrences when combining data from all land use types. Their variation was assessed across land use types using the one-way Anova of the software Statistica. To better visualize the similarity of transects and land use types, the Unweighted Pair-Group clustering method using arithmetic Averages (UPGMA) was performed with the software Statistica.

RESULTS

Sampling efficiency: Observed species accumulation curves were close to those of estimated species in all land use types except for the pineapple plantation where there is intense land use (Fig.1). In the latter type of land use, the trends indicated that additional samplings were required to provide an accurate picture of the pool of local species richness. The observed species richness represented only 45% of the expected species richness in pineapple whereas this corresponded to at least 75 % in the other land use types (Table 1). The pineapple plantations were observed to contain less unique species (with 12 species) than the other land use types. The rural forest possessed the most number of unique species with 24 species.

Table 1: Sampling statistics for ants in different land use types in Cote d'Ivoire.

Parameter	Land use type				
	Lamto forest	Rural forest	Food crop Plantations	Cocoa plantations	Pineapple plantations
Number of samples	45	45	45	45	45
Number of species observed (Sobs)	73	75	61	45	19
Estimated species richness (Chao2)	84	99	69	56	43
Sample coverage (%)	87	76	88	80	45
Unique species	24	16	14	13	12

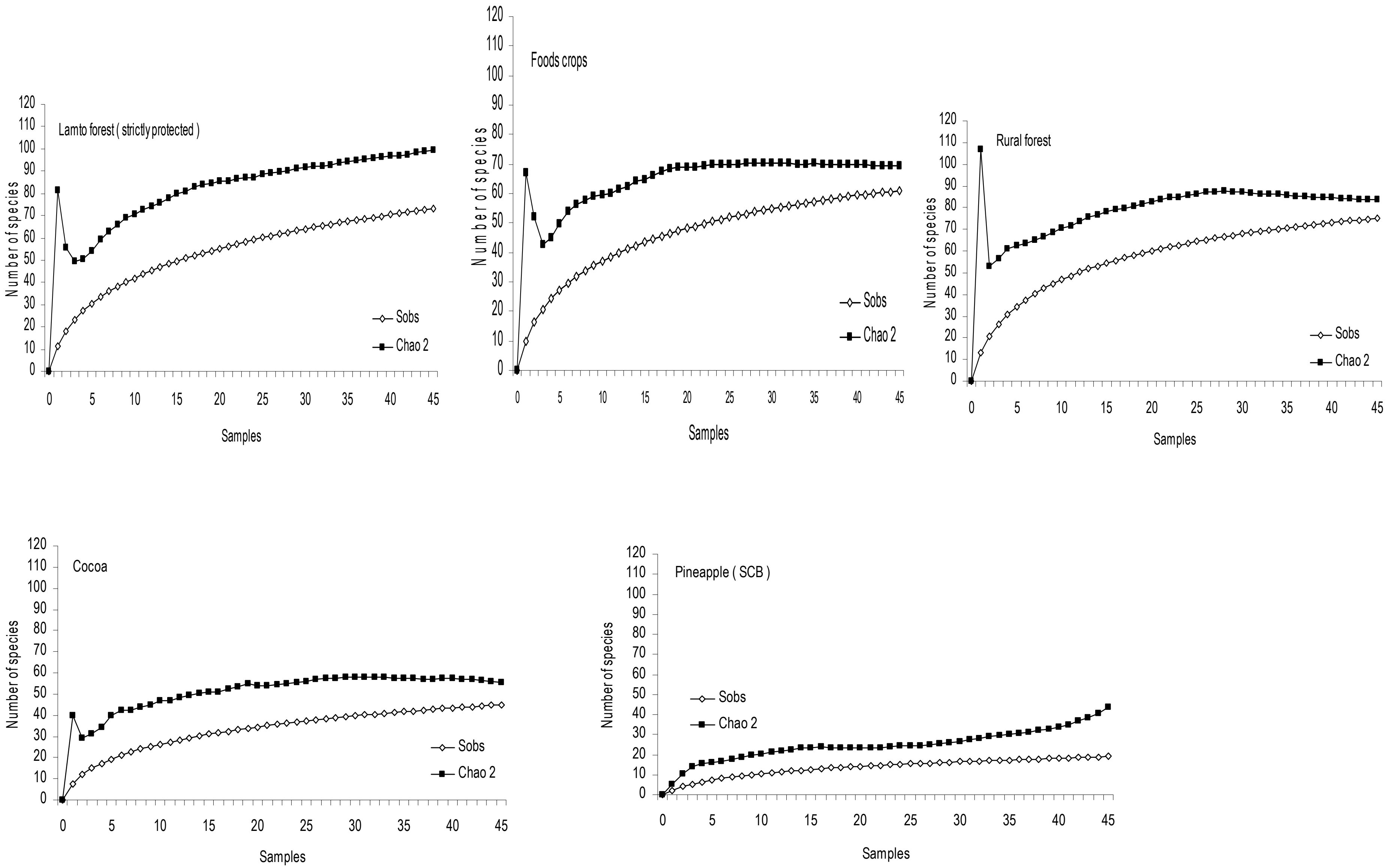

Figure 1: Sample-based species accumulation curves of ant species richness in the land use types (Sobs: species richness observed; Chao2: species richness estimated)

Species diversity and composition: A total of 118 species belonging to 41 genera and 10 subfamilies were recorded in all land use types (Table 2). The rural forest had the most species among the land use types (75 species) whereas pineapple plantations were the least species rich (19 species). The mean number of species varied significantly across land use types (One-way Anova: $F = 13.03$, $P < 0.001$). However, no significant difference was found between the Lamto forest and the rural forest but both differed significantly from the cocoa plantations (LSD test, $n = 3$, $P < 0.05$ and $P < 0.01$, respectively) and the pineapple plantations (LSD test, $n = 3$, $P < 0.001$) (Fig. 2). Generally, the Simpson index of diversity was high for all land use types along the gradient (Table 3).

Table 3: Metrics of ant diversity in different land use types in Cote d'Ivoire.

Parameter	Land use type				
	Lamto forest	**Rural Forest**	**Food crop plantations**	**Cocoa plantations**	**Pineapple plantations**
Mean species richness (± SE, n = 3)	44 ± 6.8	46.33 ± 3.92	38 ± 2.64	27 ± 2.96	10.33 ± 2.33
Simpson index (D)	0.97	0.97	0.97	0.94	0.9
Evenness (E)	0.4	0.4	0.44	0.37	0.47

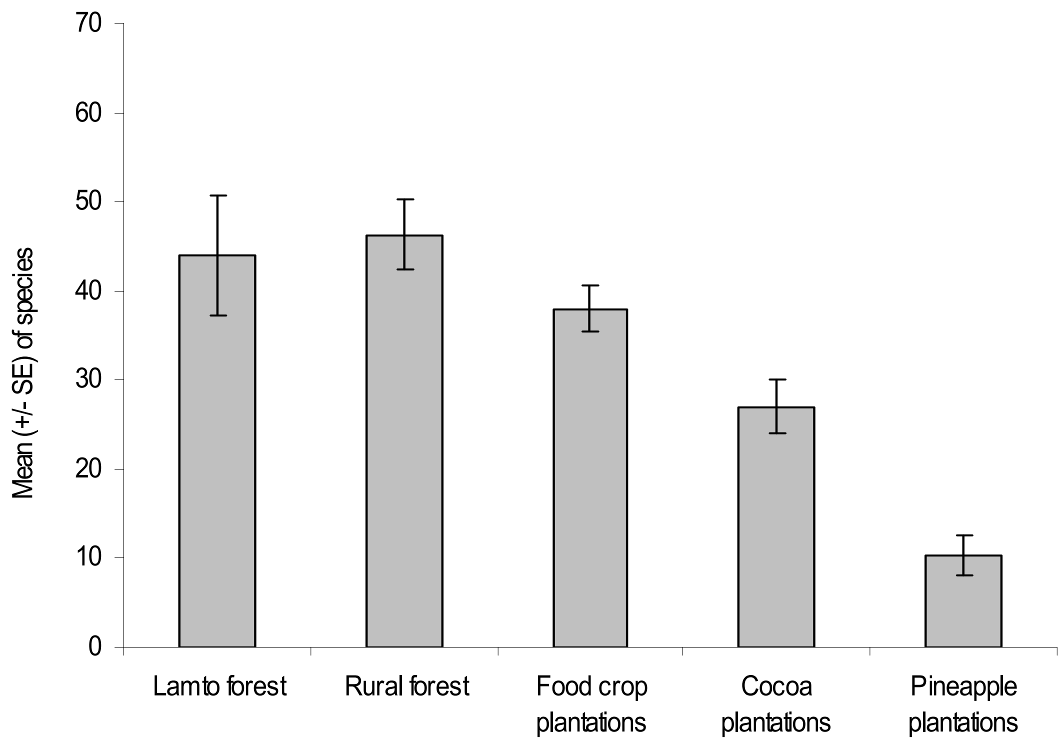

Figure 2: Mean number of ant species (+/- SE) collected in different land use types.

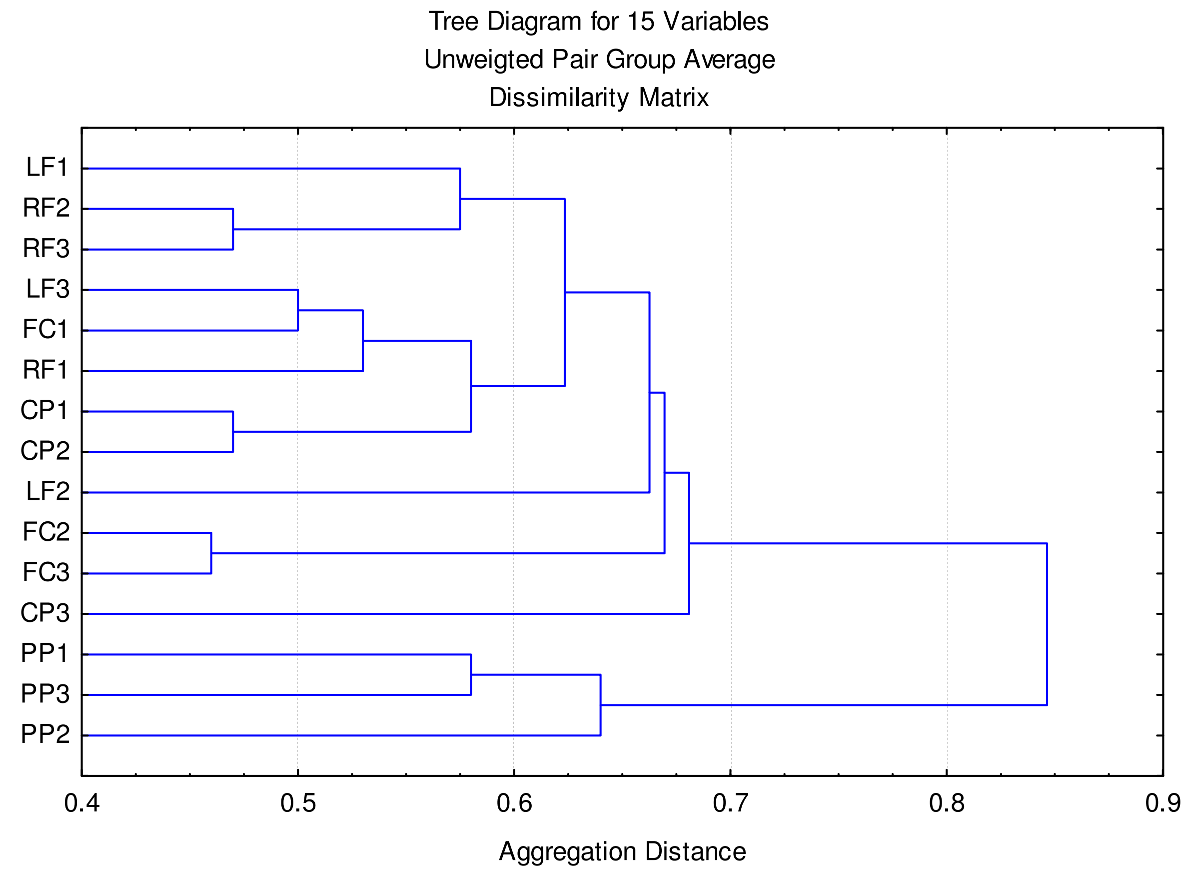

Figure 3: Comparison of species composition between transects in different land use type by means of UPGMA (Unweighted Pair-Group Method using arithmetic Average) dendrogram using 1- Jaccard index of similarity as distance between groups. LF, RF, FC, CP and PP are code for Lamto forest, Rural forest, Food crops, Cocoa plantations and Pineapple plantations. 1, 2, 3 are transects number.

The cluster analysis showed that species composition was not affected by land use change at transect level. There was no evidence of separate clusters for the different land use types except the pineapple plantations (Fig. 3).

Land use types are grouped according to the similarity of their ant community composition in Figure 4. Cluster analysis suggested that land use had an influence on species composition since tree distinct clusters were formed. The two forests formed one cluster; the food crops and cocoa plantations were grouped together; while the pineapple plantations formed a separate group. The cluster analysis was amended by the calculation of community complementarity. The two forests that were grouped together had relatively similar species compositions, sharing 51% of their species. Also, the ant communities in food crop plantations were relatively similar to those in cocoa plantations, sharing 51% of their species. The ant species composition in the food crop plantations was dissimilar to those of the Lamto forest, rural forest and pineapple plantations. Pineapple plantations were dissimilar to the other land use types. The assessment of community complementarity confirms the patterns observed in the clustering method (Table 4).

Table 4: Assessment of community complementarity of ants in varying land use types in Cote d'Ivoire.

Habitat 1	Habitat 2	No. of total species	No. of shared species	Complementarity (β-diversity)
Lamto forest	Rural forest	98	50	0.49
Lamto forest	Food crop plantation	96	38	0.6
Lamto forest	Cocoa plantation	83	35	0.58
Lamto forest	Pineapple plantation	78	14	0.82
Rural forest	Food crop plantation	97	39	0.55
Rural forest	Cocoa plantation	82	38	0.54
Rural forest	Pineapple plantation	80	14	0.81
Food crop plantation	Cocoa plantation	71	34	0.49
Food crop plantation	Pineapple plantation	64	16	0.75
Cocoa plantation	Pineapple plantation	53	11	0.79

Relative abundance of ants across habitats: Differences in the ant community structure were detected by analyzing the relative abundance of subfamilies and "common" species. Of the 10 subfamilies identified (Table 5), five were most represented (Myrmicinae, Ponerinae, Formicinae, Dorylinae and Dolichoderinae) in the diverse land use types. The relative abundance of Myrmicinae and Ponerinae varied significantly across land use types contrary to the other subfamilies. They were well represented in the Lamto forest, the rural forest and the cocoa plantations but poorly encountered in the pineapple plantations.

Of the 38 common species, only seventeen seemed to react clearly to land use intensification (Table 2). The abundance of *Camponotus maculatus*, *Crematogaster africana*, *Hypoponera* sp.3, *Pachycondyla caffraria*, *Pheidole buchholzi*, *Pyramica marginata* and *Tetramorium intonsum* decreased with increasing land use intensification (i.e. from forests to agricultural systems). *Pheidole* sp.3 increased despite land use intensification. *Monomorium* sp.1, *Oligomyrmex thoracicus*, *Pachycondyla tarsata*, *Strumigenys rufobrunea* and *Tetramorium zambezium* were abundant in all habitats except the pineapple plantations. *Camponotus acvapimensis* was mostly collected in food crop and pineapple plantations. *Tetramorium sericeiventre* was found only in food crop plantations. *Anochetus* sp.1 was restricted to the Lamto forest. As for *Pheidole* sp.4, it was abundant in the two forests, food crop and pineapple plantations but absent in the cocoa plantation.

Table 5: Comparison (using one-way ANOVA) of the relative abundance of ant subfamilies along the land use gradient in Cote d'Ivoire.

Subfamily	Land use types						
	LF	RF	FC	CP	PP	F	P-values
Myrmicinae*	343	343	283	227	65	11.15	**0.001**
Ponerinae	112	167	87	65	5	11.18	**0.02**
Formicinae	20	41	56	34	25	1.61	0.25
Dorylinae	3	5	23	2	5	5.80	0.21
Dolichoderinae	12	19	14	13	0	6.56	0.16
Cerapachyinae	10	7	3	0	0	8.17	0.08
Pseudomyrmicinae	0	1	0	0	0	4	0.41
Aenictinae	1	0	1	0	0	3.23	0.52
Amblyoponinae	0	3	1	0	0	6.43	0.17
Proceratinae	2	0	0	0	0	4	0.41

*Subfamilies with abundance differing significantly along the gradient (P < 0.05) are in bold.

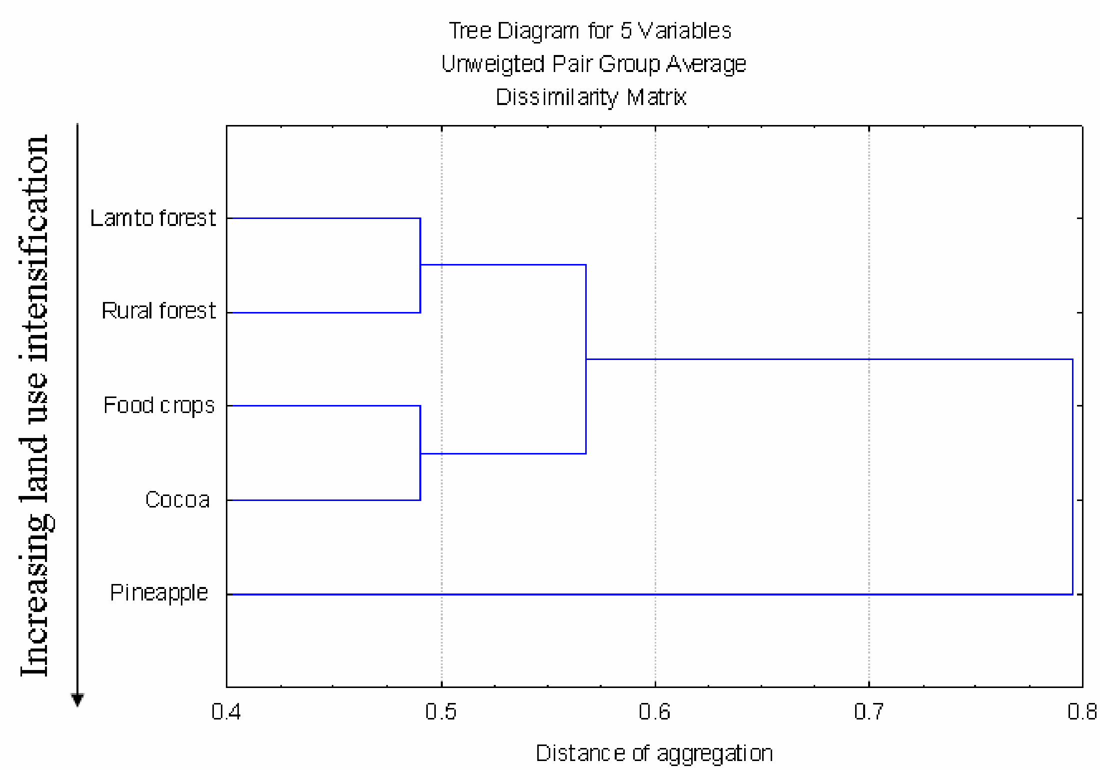

Figure 4: Comparison of ant species composition between land use types with UPGMA (Unweighted Pair-Group Method using arithmetic Average) dendrogram using 1- Jaccard index of similarity as distance between groups.

Figure 5A: Cocoa plantation

Figure 5B: Food crops

Figure 5C: Lamto forest

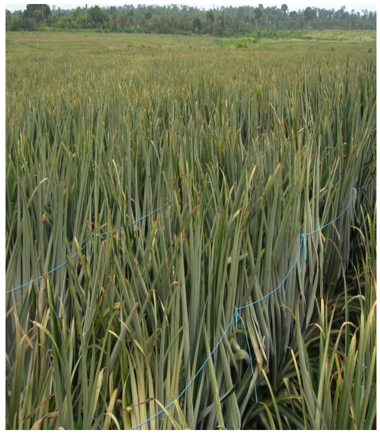

Figure 5D: Pineapple

Figure 5E: Rural Forest

DISCUSSION

Sampling efficiency: With at least 75% as sample coverage, the observed species richness was close to estimated species richness in Lamto forest, rural forest, food crop plantations and cocoa plantations. This pattern indicated a high efficiency of our sampling method in land use types except for the pineapple plantations where only 45 % of the expected species were collected. The low number of ant species estimated in this intensively disturbed area was illustrated by the trend of sample-based species accumulation curves (S_{obs} and Chao2). This result suggested that more than three transects needed to be sampled in land use type. Overall, the efficiency of the sampling method was successfully tested. Thus, our objective of assessing changes in ant diversity and abundance along a gradient of land use intensification could be addressed.

Species diversity and relative abundance across habitats: We collected 118 species belonging to 41 genera and 10 subfamilies in all land use types. These findings were close to those of Yéo (2006) who found 143 species belonging to 45 genera and 10 subfamilies after investigating three major habitats within the Lamto reserve i.e. the gallery forest, the forest island and the savanna. The elevated species richness found in the previous study could be explained on the one hand by the fact that the study investigated only natural habitats, and on the other hand by the number of transects sampled per habitat (5 transects instead of 3).

Ant species richness was lower in agricultural areas than in forests. It decreased from the rural forest to the pineapple plantations, probably due to the modification of original habitats replaced by cultivated areas. The destruction of original habitats leads to the elimination of native plants and the establishment of invasive plants causing partial changes of abiotic conditions. These findings agreed with Altieri *et al*. (2003) who noticed that the simplification of local environmental structure by reducing the number of native plant species and increasing the number of cultivated species has a negative impact on biodiversity.

Agricultural activities seem to have affected ant diversity which is positively correlated with increasing structural complexity of vegetation with regard to nesting site availability and food supply (Roth *et al*., 1994; Perfecto & Snelling, 1995; Bestelmeyer & Wiens, 1996; New, 2000). In other respects, habitat changes might directly impact ant communities, their preys and even other species interacting with them. This idea is supported by Lavelle (1987) who showed that cultivation may quickly lead to destruction or decrease of some soil communities responsible for fertility maintenance. For instance, Kouassi (1999) reported a decrease of soil macrofauna density in cultivated areas where soil is bare and ploughed for agriculture.

Food crop plantations were richer than cocoa and pineapple plantations. The former land use type was made up of a mixture of crops and some remaining forest plant species which probably favoured the maintenance of some forest ant species. In contrast, the latter two habitats (cocoa and pineapple plantations) were monoculture with frequent application of pesticides causing the accumulation of toxic residues. This fact had consequences of polluting the habitats and subsequently ant communities were strongly affected. According to Lévêque & Mounolou (2001), treatments with fungicides or insecticides can lead to pollution with toxic organic components or heavy metals. While pesticides probably are involved in the decrease of ant diversity, factors such as microhabitat loss contribute to the disappearance of those species dependent on such niches.

Five main subfamilies appeared to be present along the gradient, the Myrmicinae, the Ponerinae, the Formicinae, the Dorylinae and the Dolichoderinae. Among them, three were abundantly collected in all land use types except in pineapple plantations (Myrmicinae, Ponerinae and Formicinae). Within each land use type, Myrmicinae were abundant than all other subfamilies. Their dominance matches their numerical importance within the world fauna (Hölldobler & Wilson, 1990; Bolton, 1994). However, this abundance varied significantly across most disturbed land use types notably in the pineapple plantations where it dropped significantly.

Most Myrmicinae species are characterized as typical leaf litter inhabitants. Therefore the reduction in leaf litter with changed land use could lead to greater reduction of their species. The abundance of common Myrmicinae species varied across land use types, indicating that these species react differently to disturbance. Of the 23 species sampled, 11 varied significantly from one land use type to another; 4 were restricted to forests (*Pheidole buchholzi*, *Crematogaster africana*, *Pyramica marginata* and *Tetramorium intonsum*). One species was frequently observed in cocoa and pineapple plantations (*Pheidole* sp.3). This species perhaps prefers open ground as nesting sites. Four species (*Monomorium* sp1, *Tetramorium zambezium*, *Oligomyrmex thoracicus* and *Strumigenys rufobrunea*) were present in all land use types except the pineapple plantations. These species are leaf litter inhabitants; and the drastic reduction of litter in pineapple plantations might have been responsible of their absence. *Tetramorium sericeiventre* was found only in the food crop plantations. This species might be an opportunistic explorer of human associated habitats. It is known to prefer open habitats with higher temperatures (Yéo, 2006).

The second group in dominance was the Ponerinae. Their relative abundance varied across land use types as their species were restricted to forests and food crop plantations (*Hypoponera* sp.3, *Anochetus* sp.1 and *Pachycondyla caffraria)*. Many species of this subfamily are generalist predators. The higher prey diversity in forests and food crop plantations could explain their preference for these habitats. Ponerinae species are also known to be susceptible to microclimate changes (Hölldobler & Wilson, 1990).

Another dominant subfamily was Formicinae which seemed to be favoured by disturbance. This was the case with *Camponotus acvapimensis* which was abundant in food crop and pineapple plantations. This finding pointed to good adaptability of this species to disturbed areas, in agreement with Diomandé (1981).

Structural modification along the gradient investigated: Comparison of species composition between transects in the land use types showed no effect of land use on ant composition except for pineapple plantations where transects were grouped together. This is due to the fact that pineapple plantations were intensive land use type with the relatively similar treatments in all sampling sites (i.e. pesticide use and complete mechanical clearance with loss of top soil and compaction leading to great change in the ant composition).

Comparing land use types in relation to species richness and composition, we found that agricultural systems possess lower species richness and a strongly different species composition compared to forests. Ant species richness in the rural forest was slightly higher than in the protected forest, but this difference was not significant. The ant species compositions of these two forests were similar; they shared only 50 species out of a total of 98 (with 0.49 as complementarity). The rural forest land use was probably less disturbed than one can expect. This low intensity of disturbance due to selective logging and harvesting of medicinal plants did not significantly affect ant fauna.

Species richness in the Lamto forest was higher than in food crop plantations, but not significantly. However their communities' composition was different, sharing 38 out of a total of 96 species (with 0.6 as complementarity).This change in the composition was probably linked to the disappearance of native forest species and the colonization of the space by the most adapted species. In central Amazonia, Vasconcelos *et al*., (2000) found that although logging did not affect species richness and abundance, it affected species composition.

The communities living in the food crop plantations were relatively similar to those found in the cocoa plantations sharing 36 species out of a total of 71 (with 0.49 as complementary). The cocoa plantations had started as a mixture with food crops during the early stages. So it could maintain a pool of ant species during the early stages. The composition of ant communities in pineapple plantations was dissimilar to all the other land use types. This could be explained by the uniformity of the culture without trees and its very limited spectrum of nest site availability, probably due to the high use of pesticides and machinery. According to Armbrecht & Perfecto (2003), Philpott & Foster (2005), Armbrecht et al. (2006) and Philpott & Armbrecht (2006) the removal of shade trees and higher frequency of weeding accompanying intensification of tropical agricultural systems may increase nest-site limitation of many ant species

Our investigations have demonstrated the overall negative influence of land use intensification on ant diversity. The results showed that ant species richness and composition changes according to land use type. The food crop area, where traditional farming practices are used, supported high levels of ant diversity comparable to that of the forests but with a very different community of ant species . Importantly, the rural forests may continue to provide a refuge for the original forest ant as long as they remain in near-natural state in regard to structure and biological diversity. Thus sustainable land use type should be encouraged, involving agro-forestry practices to allow natural recovery processes after agricultural disturbance. This approach will help to conserve biodiversity in the area around Lamto Scientific Reserve.

ACKNOWLEDGMENTS:

Authors thank Dr. Gary Alpert for his help with identifications of some ants, Mr.Firmin and Drissa for their assistance in the field of Lamto Tropical Ecology research station (Côte d'Ivoire); Prof. André Francoeur and Dr. Corrie Moreau for reading and commenting on the manuscript; management of SCB (Société de Culture Bananière) for allowing access to their land and the German Ministry of Education and Research (BMBF) for financial support through the BIOTA West project.

REFERENCES

Achard F, Eva, HD, Stibig HJ, Moyaux P, Gallego J, Richards T, Malingreau JP, 2002. Determination of deforestation rates of the world's humid tropical forests. Science 297: 999-1002.

Agosti D, Majer JD, Alonso LE and Schultz TR, 2000. Ants: standard methods for measuring and monitoring biodiversity. Smithsonian Institution Press, Washington D C. 280 pp.

Altieri MA, Silva EN, Nicholls CI, 2003. A biodiversidade e seu papel ecológico na agricultura. In: Altieri M. A., Silva, E. N., Nicholls C. I. (Ed.). O papel da biodiversidade no manejo de pragas. Ribeirão Preto: Holos.p17-23.

Andersen AN, 1990. The use of ant communities to evaluate change in Australian terrestrial ecosystems: a review and a recipe. - Proceedings of the Ecological Society of Australia 16: 347–357.

Andersen AN, 1993. Ants as indicators of restoration success at uranium mine in tropical Australia. Restoration Ecology 1: 156-167

Andersen AN, 1995. A classification of Australian ant communities, based on functional groups which parallel plant life-forms in relation to stress and disturbance. Journal of Biogeography 22: 15-29.

Andersen AN, 1997a. Functional groups and patterns of organization in North American ant communities: a comparison with Australia. Journal of Biogeography 24: 433-460.

Andersen AN, 1997b. Using ants as bioindicators: multiscale issues in ant community ecology. Conservation Ecology 1, 8. Available online at: http://www.consecol.org/vol1/iss1/art8.

Armbrecht I, Perfecto I, 2003. Litter-twig dwelling ant species richness and predation potential within a forest fragment and neighboring coffee plantations of contrasting habitat quality in Mexico. Agriculture, Ecosystems and Environment 97: 107-115.

Armbrecht I, Rivera L, Perfecto I, 2005. Reduced diversity and complexicity in the leaf-litter ant assemblage of Colombian coffee plantations. Conservation Biology 19: 897- 907.

Armbrecht I, Perfecto I, Silverman E, 2006. Limitation of nesting resources for ants in Colombian forests and coffee plantations. Ecological Entomology 31: 403-410.

Armbrecht I, Gallego MC, 2007. Testing ant predation on the coffee berry borer in shaded and sun coffee plantations in Colombia. Entomologia Experimentalis et Applicata 124 : 261- 267.

Barbault R, Cotnet C, Jouzel J, Mégie G, Sachs I, Weber J, 2002. Johannesburg, Sommet Mondial du Développement durable: quels enjeux? Quelle contribution scientifique ? Ministère des Affaires Etrangères Français- adapf. 205 p

Belshaw R and Bolton B, 1993. The effect of forest disturbance on leaf-litter ant fauna in Ghana. Biodiversity and Conservation 2: 656-666.

Bestelmeyer BT and Wiens JA, 1996. The effects of land use on the structure of ground-foraging ant communities in the Argentine chaco. Ecological Applications 6: 1225-1240.

Bestelmeyer BT, Agosti D, Alonso L, Brandão CRF, JR Brown LW, Delabie JH C et Silvestre R, 2000. Field techniques for the study of ground-dwelling ants. - In: Agosti D, Majer J, Alonso LE, Schultz TR. (Eds.), Ants. Standard Methods for Measuring and Monitoring Biodiversity. Washington D.C.: Smithsonian institution Press. pp. 122-144.

Bisevac L and Majer JD, 1999. Comparative study of ant communities of rehabilitated mineral sand mines and heathland, Western Australia. Restoration Ecology 7: 117–126

Bolton B, 1973. The ant genus *Polyrhachis* F. Smith in the Ethiopian region (Hymenoptera: Formicidae). Bulletin of the British Museum (Natural History,) Entomology **28**: 285-369.

Bolton, B, 1974. A revision of the Ponerine Ant genus *Plectroctena* F. Smith (Hymenoptera: Formicidae. Bulletin of the British Museum (Natural History,) Entomolog*y* 30: 311-338.

Bolton B, 1975a. A revision of the Ant Genus *Leptogenys* Roger (Hymenoptera: Formicidae) in the Ethiopian region with a review of the Malagasy species. Bulletin of the British Museum (Natural History), Entomology **31**: 237-305.

Bolton B, 1975b. A revision of the African ponerine ant genus *Psalidomyrmex* André (Hymenoptera: Formicidae). Bulletin of the British Museum (Natural History), Entomology **32**: 3-16.

Bolton B,1976. The Ant tribe Tetramoriini (Hymenoptera: Formicidae). Constituent genera, review of smaller genera and review of *Triglyphothrix* Forel. Bulletin of the British Museum (Natural History), *Entomology* **34**: 283-379.

Bolton B, Gotwald W H Jr and Leroux J-M, 1976. A new west African ant of the genus *Plectroctena* with ecological notes (Hymenotera: Formicidae). Annales de l'Université d'Abidjan, Série E (Ecologie) **9**: 371-381.

Bolton B, 1981. A revision of the ant genera *Meranoplus* F. Smith, *Dicroaspis* Emery and *Calyptomyrmex* Emery (Hymenoptera: Formicidae) in the Ethiopian zoogeographical region. Bulletin of the British Museum (Natural History), Entomology **42**: 43-81.

Bolton B, 1982. Afrotropical species of the Myrmicine ant genera *Cardiocondyla*, *Lepthothorax*, *Melissotarsus*, *Messor* and *Cataulacus* (Formicidae). Bulletin of the British Museum (Natural History), Entomology 45: 307-370.

Bolton B, 1983. The Afrotropical dacetine ants (Formicidae). Bulletin of the British Museum (Natural History), Entomology **46**: 267-415.

Bolton B, 1986. A taxonomic and biological review of the tetramoriine ant genus *Rhoptromyrmex* (Hymenoptera: Formicidae). Systematic Entomology **11**: 1-17.

Bolton B, 1987. A revision of the Solenopsis genus-group and revision of Afrotropical *Monomorium* Mayr (Hymenoptera). Bulletin of the British Museum (Natural History), Entomology **54**: 263-452.

Bolton B, 1994. *Identification guide to ant genera of the world.* Harvard University press, Cambridge Massachusetts, 222 p.

Bolton B, 1995. A New General Catalogue of the Ants of the world. Harward University Press, Cambridge, Massachusetts 504 p.

Bolton B, 1996. A preliminary analysis of the ants (Formicidae) of Pasoh forest reserve. **In** Lee S L, Dan YM, Gauld ID, Bishop J B (eds) Conservation Management and Development of Forest. Proceedings of the Malaysia-United Kingdom Programme workshop. Frim, Kuala, Lumpur pp 84-95

Bolton B, 2000. The ant tribe Dacetini. . Memoirs of the American Entomological Institute. **65**: 1-1028.

Bolton B, and Brown W Jr, 2002. *Loboponera* gen. n. and a review of the Afrotropical Plectroctena genus group (Hymenoptera: Formicidae). Bulletin of the British Museum (Natural History), Entomology **71**: 1-18.

Bolton B, 2003. Synopsis and Classification of Formicidae. Memoirs of the American Entomological Institute **71**: 1-370.

Buckley RC, 1982. Ant-plant interactions: a world review. In: Buckley RC (ed.), Ant-Plant Interactions in Australia. W.Junk Publishers, The Hague, The Netherlands, pp.111-141.

Chao A, 1987. Estimating the population size for capture-recapture data with unequal catchability.- Biometrics 43: 783-791.

Colwell R K, 2005. Statistical estimate of Species Richness and Shared Species from Samples. Version 7.5. Website ‹purl.oclc.org./estimates›

Darkoh MBK, 2003. Regional perspectives on agriculture and biodiversity in the drylands of Africa. Journal of Arid Environments 54, 2 : 261-279.

Diomande T 1981. Etude du peuplement en fourmis terricoles des forêts ombrophiles climaciques et des zones antropisées de la Côte d'Ivoire méridionale. Thèse de Doctorat d'Etat, Université d'Abidjan, Côte d'Ivoire, 245p.

Fisher B L 1998. Ant diversity patterns along an elevational gradient in the Réserve Spéciale d'Anjanaharibe-Sud and on the Western Masoala Peninsula, Madagascar. – Fieldiana: Zoology 90: 39-67.

Fisher B L and Robertson H G, 2002. Comparison and origin of forest and grassland ant assemblages in the high plateau of Madagascar (Hymenoptera: Formicidae). Biotropica 34: 155-167.

Fittkau EJ and Klinge H, 1973. On biomass and trophic structure of the Central Amazonian rainforest ecosystem. - Biotropica 5: 2-14.

Floren A, Freking A, Biehl M and Linsenmair KE 2001. Anthropogenic disturbance changes the structure of arboreal tropical ant communities. – Ecography 24: 547-554.

Floren A and Linsenmair KE, 1997. Diversity and recolonisation dynamics of selected arthropod groups on different tree species in lowland rain forest in Sabah, Malaysia. Canopy Arthropods (eds Stork NE, Adis J and Didham RK), pp 344-381. Chapman & Hall, London, UK.

Hölldobler B and Wilson EO, 1990. *The ants*. Harvard University Press. Cambridge, Massachusetts. 732 p.

Jepsen JU, Topping CJ, Podderskaer PN, Andersen, 2005. Evaluating consequences of land use strategies on wildlife populations using multiple-species predictive scenarios. Agriculture, Ecosystems and Environment 105: 581-594

Kenne M, Corbara B et Dejean A, 1999. Impact des fourmis sur les plantes cultivées en milieu tropical. L'Année Biologique 38 :195-212.

Kouassi P, 1999. Structure et dynamique des groupes trophique de la macrofaune du sol d'écosystèmes naturels et transformés de Côte d'Ivoire. Thèse de Doctorat d'Etat, UFR Biosciences, Université de Cocody, Abidjan, 201p.

Koulibaly A, 2008. Characteristics of vegetation and regeneration dynamics under land use pressure in the forest-savanna mosaics of Lamto Reserve and Comoé National park regions, in Côte d'Ivoire.- PhD thesis, laboratory of Botany, University of Cocody, Abidjan, 150p.

Krebs CJ, 2002. Programs for Ecological Methodology. 2nd ed. Website: http://www. Zoology.ubc.ca/Krebs Pub Benjamin/Cinning (ISBN)

Lavelle P, 1987. Biological processes and productivity of soils in the humid tropics. In: Lavelle P, Dangerfield M, Fragoso C, Eschenbrenner V, Lopez-Hernandez D, Pashanasi B and Brussaard L. The relationship between soil macrofauna and tropical soil fertility. p137-169.

Lévêque C, 1994. Environnement et diversité du vivant. Collection Explora, pp127

Lévêque C and Mounolou J C, 2001. Biodiversité : Dynamique biologique et conservation. Edition Dunod, Paris 248 pp

Lévieux J, 1973. Étude du peuplement en fourmis terricoles d'une savane préforestière de Côte d'Ivoire. Revue d'Ecologie et de la Biologie du Sol **10 :** 379-428.

Lobry de Bruyn LA and Conacher AJ, 1994. The bioturbation activity of ants in agricultural and naturally vegetated habitats in semi-arid environments. Australia Journal of Soil Research 32: 555-570.

Lobry de Bruyn LA, 1999. Ants as bioindicators of soil function in rural environments. Agriculture, Ecosystems and Environment 74: 425-441.

Longino J T, Coddington J and Colwell R K, 2002.The ant fauna of a tropical rainforest: estimating species richness three different ways. - Ecology 83: 689-702.

Majer JD, 1976.The influence of ants and ant manipulation on cocoa farm fauna. Journal of Applied Ecology, 13: 157-175.

Majer JD and Nichols OG, 1998. Long-term recolonization patterns of ants in Western Australian rehabilitated bauxite mines with reference to their use as indicators of restoration success. Journal of Applied Ecology 35: 161–182

Martin JEH, 1983. Les insectes et les arachnides du Canada, Partie 1/ Récoltes, Préparation et conservation des insectes, des acariens et des araignées. Publication 1643 de la Direction Générale de la Recherche. Agriculture du Canada.

Mitchell CE, Turner MG, Pearson, SM, 2002. Effects of historical land use and forest patch size on myrmecochores and ant communities. Ecological Application 12: 1364-1377.

New TR, 2000. How useful is ant assemblages for monitoring habitat disturbance on grasslands in south eastern Australia? Journal of Insect conservation 4:153-159.

Peck SL, Mcquaid B and Campbell CL, 1998. Using ant species (Hymenoptera: Formicidae) as biological indicator of agro ecosystem condition. - Environment Entomology 27: 1102-1110.

Perfecto I and Snelling R, 1995. Biodiversity and the transformation of a tropical agro ecosystem-ant in coffee plantations. Ecological Applications 5: 1084-1097.

Philpott SM, Foster PF, 2005. Nest-site limitation in coffee Agroecosystems: artificial nests maintain diversity of arboreal ants. Ecological Applications 15: 1478- 1485.

Philpott SM, Armbrecht I, 2006. Biodiversity in tropical agroforests and the ecological role of ants and ant diversity in predatory function. Ecological Entomology 31: 369- 377.

Roth DS, Perfecto I and Rathcke B, 1994.The effects of management-systems on ground foraging ant diversity in Costa Rica. Ecological Applications 4: 423-436.

Schonberg LA, Longino JT, Nadkarni NM, Yanoviak SP and Gering JC, 2004. Arboreal ant species richness in primary forest, secondary forest and pasture habitats of a tropical montane landscape. Biotropica 36: 402-409.

Vasconcelos HL, 1999. Effects of forest disturbance on the structure of groung-foraging ant communities in Central Amazonia. Biodiversity and Conservation 8: 409-420.

Van Mele P, 2008. A historical review of research on the weaver ant Oecophylla in biologicalcontrol. Agric. For Entomol.10:13-22.

Vasconcelos HL, Vilhena JMS and Caliri GJA, 2000.Responses of ants to selective logging of a central Amazonian forest. Journal of Applied Ecology 37: 508-514

Wilson EO, 1987.The arboreal ant fauna of Peruvian Amazon forests: a first assessment. Biotropica 19: 245-251.

Wright SJ, 2005. Tropical forests in a changing environment trends in Ecology and Evolution 20: 553- 560

Yéo K, 2006. Dynamique spatiale et diversité des fourmis de la litière et du sol dans une mosaïque forêt-savane en Côte d'Ivoire. Thèse unique de Doctorat des universités Pierre et Marie Curie Paris VI et Abobo-Adjamé, 212p

Yéo K, Konaté S, Tiho S and Camara SK (in press). Impacts of Land use systems on ant communities in a tropical forest margin (Oumé – Côte d'Ivoire).

Table 2: Ant species recorded during the surveys and their relative abundance in land use types. (Common species are in bold; specie whose abundance varied significantly between land use types (using one-way Anova, P < 0.05) are denoted with the symbol (*).Land use type abbreviations: LF: Lamto forest; RF: Rural forest; FC: Food crop plantations; CP: Cocoa plantations; PP: Pineapple plantations).

	Land use types				
	LF	RF	FC	CP	PP
Ponerinae					
Anochetus africanus Mayr, 1865	0	0	1	0	0
Anochetus katonae* Forel, 1907	19	0	0	0	0
Anochetus sp.2	2	1	0	0	0
Asphinctopone sp.1	3	1	0	0	0
Centromyrmex sellaris Mayr, 1896	0	5	0	0	0
Hypoponera sp.1	0	1	0	1	0

Hypoponera inaudax Santschi, 1919	18	23	6	5	0
***Hypoponera* sp.5**	2	13	1	3	0
Hypoponera* sp.6	2	17	6	2	0
Leptogenys ferrarii Forel, 1913	1	0	0	0	0
Leptogenys sp.1	1	7	0	0	0
Leptogenys conradti Forel, 1913	1	0	0	0	0
Loboponera basalis Bolton & Brown, 2002	1	3	0	0	0
Odontomachus troglodytes Santschi, 1914	3	0	3	9	1
Pachycondyla tarsata Fabricius, 1798*	20	28	27	33	3
Pachycondyla soror Emery, 1899	15	5	0	1	0
Pachycondyla ambigua Weber, 1942	0	3	2	1	0
Pachycondyla brunoi Forel, 1913	10	12	7	3	0
Pachycondyla caffraria Smith, 1858*	10	40	19	4	1
Pachycondyla analis Latreille, 1802	0	0	3	1	0
Phrynoponera gabonensis Andre,1892	0	2	0	0	0
Plectroctena lygaria Bolton, Gotwald & Leroux, 1979	1	0	0	2	0
Psalidomyrmex foveolatus Andre, 1890	2	5	0	0	0
Platythyrea conradti Emery, 1899	1	1	0	0	0

Table 2 Continued.

	LF	RF	FC	CP	PP
Myrmicinae					
Pyramica minkara Bolton, 1983	1	2	0	0	0
Pyramica maynei Forel, 1916	2	2	2	2	0
Pyramica tigrilla Brown, 1973	3	0	0	0	0
***Pyramica* sp.1**	2	20	2	6	0
Pyramica marginata Santschi, 1914*	2	14	3	1	0
pyramica hensekta Bolton, 1983	1	0	0	0	0
Pyramica sistrura Bolton, 1983	0	1	0	0	0
Pyramica laticeps Brown, 1962	1	1	0	0	0
Pyramica concolor Santschi, 1914	0	1	0	0	0
Strumigenys petiolata Bernard, 1953	3	2	0	0	0
Strumigenys rufobrunea Santschi, 1914*	13	30	30	30	0
Strumigenys nimbrata Bolton, 1983	4	2	3	4	0
Cataulacus guineensis Smith, 1853	2	2	0	0	0
Calyptomyrmex kaurus Bolton, 1981	27	7	8	15	0
Monomorium invidium Bolton, 1987	8	3	1	7	0
Monomorium bicolor Emery, 1877	0	1	5	0	0

Monomorium pharaonis Linnaeus, 1758	8	5	5	2	5
Monomorium egens Forel, 1910	2	0	1	0	0
Monomorium* sp.1	22	34	9	38	0
Monomorium sp.2	0	0	0	0	1
Oligomyrmex (Crateropsis) elementeitae Patrizi, 1948	0	2	2	2	0
Oligomyrmex perpusillus Emery, 1895	0	0	1	0	0
Oligomyrmex thoracicus Weber, 1950*	34	40	26	52	2
Oligomyrmex silvestrii Santschi, 1914	14	11	2	6	0
Paedalgus saritus Bolton & Belshaw, 1993	7	16	4	2	0
Decamorium decem Forel, 1913	0	8	1	2	0
Tetramorium intonsum Bolton, 1980*	3	15	10	1	1
Tetramorium brevispinosum Stitz, 1910	0	0	1	0	0
Tetramorium sp.1	5	0	0	0	0
Tetramorium zambezium Santschi, 1939*	29	12	30	10	1
Tetramorium minimum Bolton, 1976	11	8	3	1	1
Tetramorium sericeiventre Emery, 1877*	0	0	15	0	0

Table 2 continued

	LF	RF	FC	CP	PP
Tetramorium amentete Bolton, 1980	7	0	0	0	0
Tetramorium distinctum Bolton, 1976	20	2	0	0	0
Tetramorium calinum Bolton, 1980	0	0	1	0	0
Tetramorium sp.3	1	0	0	0	0
Tetramorium flavithorax Santschi, 1914	10	8	0	5	0
Pheidole sp.1	1	0	0	0	0
***Pheidole* sp. 2**	5	13	21	33	13
Pheidole buchholzi Mayr, 1910*	26	37	10	0	5
Pheidole* sp.3 (temitophila group)	3	9	3	17	18
Pheidole* sp.4 (temitophila group)	31	6	10	0	15
Pheidole excellens Mayr, 1862	0	1	25	0	3
Pheidole sp.5	1	3	0	0	0
Pheidole sp.6	0	2	0	0	0
Crematogaster striatula Emery,1892	7	4	2	0	0
Crematogaster sp.1	0	1	2	0	0
Crematogaster sp.2	1	0	0	0	0
Crematogaster africana Mayr, 1895*	25	8	1	0	0
Crematogaster sp.3	0	0	0	1	0
Crematogaster sp.4	0	0	1	0	0
Crematogaster rugosa Andre, 1895	1	0	0	0	0

Cardiocondyla shucardi forel, 1891	0	0	6	1	0
Cardiocondyla neferka Bolton, 1982	0	1	2	7	0
Cardiocondyla emeryi Forel, 1881	2	2	24	6	0
Pristomyrmex orbiceps Santschi, 1914	1	9	0	0	0
Formicinae					
Lepisiota cacozela Stitz, 1916?	4	8	11	14	0
Lepisiota sp.1	0	0	2	0	0
Lepisiota sp.2	0	0	0	3	0
Lepisiota sp.3	0	1	0	0	0
***Paratrechina weissi* Santschi, 1911**	3	8	23	14	3
Plagiolepis mediorufa Forel, 1916	1	1	0	1	0
Oecophylla longinoda LATREILLE, 1802	5	3	0	2	0

Table 2 continued

	LF	RF	FC	CP	PP
Camponotus maculatus Fabricius, 1782*	6	13	2	1	0
Camponotus flavomarginatus Mayr,1862	0	0	0	0	1
Camponotus acvapimensis Mayr, 1862*	0	2	15	0	16
Camponotus sp.1	0	0	2	0	0
Camponotus sp.2	0	0	0	0	5
Polyrhachis Phidias Forel, 1910	1	0	0	0	0
Polyrhachis viscosa Smith, 1858	0	1	0	0	0
Polyrhachis schistacea Gerstacker, 1859	0	4	0	0	0
Aenictinae					
Aenictus decolor Mayr, 1819	1	0	0	0	0
Aenictus sp.1	0	0	1	0	0
Dorylinae					
Dorylus (Anomma) nigricans s/sp terrificus Santschi, 1923	1	0	6	0	5
Dorylus (Thyphlopone) fulvus s/sp dentifrons Wasmann, 1904	1	0	3	0	0
Dorylus (Rhogmus) fuscipennis var. lugubris Santschi, 1919	0	2	0	1	0
Dorylus (Dorylus) bequaerti Forel, 1913	1	0	6	1	0
Dorylus sp.1	0	1	0	0	0
Dorylus (Rhogmus) sp.2	0	2	8	0	0
Dolichoderinae					

Tapinoma lugubre Santschi, 1917	4	10	13	13	0
Tapinoma luteum Mayr, 1907	0	2	1	0	0
Technomyrmex andrei Emery, 1899	8	7	0	0	0
Cerapachyinae					
Cerapachys foreli Santschi, 1914	1	0	0	0	0
Cerapachys nitidulus Brown, 1975	4	3	0	0	0
Cerapachys lamborni Crawlay, 1923	3	3	0	0	0
Cerapachys sp.1	2	0	1	0	0
Cerapachys sp.2	0	1	0	0	0
Sphinctomyrmex sp.1	0	0	2	0	0

Table 2 continued

	LF	RF	FC	CP	PP
Amblyoponinae					
Amblyopone santschii Menozzi, 1922	0	2	0	0	0
Amblyopone pluto Gotwald & Levieux, 1972	0	1	0	0	0
Apomyrma stygia Brown,Gotwald & Levieux, 1971	0	0	1	0	0
Proceratinae					
Discothyrea mixta Brown, 1958	1	0	0	0	0
Probolomyrmex guineensis Taylor, 1965	1	0	0	0	0
Pseudomyrmecinae					
Tetraponera mocquerysi André, 1890	0	1	0	0	0
Total	506	588	444	366	100