Preliminary Assessment on the Interactions of *Wasmannia auropunctata* in Native Ant Communities (Hymenoptera: Formicidae) of a Mosaic Gallery Forest/Savannah in Lope National Park, Gabon

by

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ABSTRACT

This study was carried out in a savannah/forest mosaic at the Lopé National Park, in Gabon. Ninety-six pitfall traps were used, 39 in gallery forest and 57 in savannah. The foragers of eighteen morph species were collected in both habitats: 16 in gallery forest and 15 in savannah. *Wasmannia auropunctata* is the most frequent in the gallery forest, recorded in 90% of the samples, against 55% in savannah. On the other hand, *Pheidole megacephala* was found in 80% of the samples, *Camponotus negus* in 75% and *Polyrhachis latispina* in 60%, all of them more frequent in savannah than in gallery forest. Generally speaking, the other species were found in both habitats, except *Camponotus sericeus* which forages only in the savannah. Interactions in the savannah are much more complex than in the gallery forest.

Key words: Gabon, Lopé National Park, forest-savannah mosaic, community, *Wasmannia auropunctata*.

INTRODUCTION

Ants constitute an especially diverse and ecologically important group whose social behavior and ecological dominance have been the subjects of intensive biological studies (Hölldobler & Wilson 1990; Passera & Aron

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2006). They include around 11,000 described species, but more or less the same number of species remain to be discovered, principally in the tropics (Hölldobler & Wilson 1994; antbase.org, consulted on 12.02.2007). Ants have been considered as an ecological group of special interest given their properties as indicators of biodiversity (Roth *et al*. 1994), disturbance (Burbidge *et al.* 1992; Brown 1989; Delabie *et al.* 2006) and rehabilitation or successional stages in ecosystems (Majer 1983, 1985, 1992; Cabrera & Jaffe 1993; Roth *et al.* 1994).

Gallery forests grow along the banks of rivers where they lodge a range of animal species which live close to the water. This kind of forest exists in large forest formations, but they naturally expand in the savannah biome following the rivers. During the long dry periods that touched Africa, those gallery forests regularly played an important role allowing many animal and plant species to survive outside large forest refuges (White & Abernethy 1996).

In Gabon, 310 ant species in 56 genera were recorded from Monts Doudou, which has the highest species richness of ants yet recorded in Africa (Fisher 2004). Lévieux (1983) affirmed that there are around 120 underground and soil dwelling species in Ivory Coast savannas while only about 30 in forest grounds. The ant fauna of these areas, particularly their community structure, has been poorly studied (Lévieux 1983). Several types of forest savannah mosaic coexist in Lopé National Park, one of the thirteen parks created recently in Gabon, where entomological studies were seldom carried out until now. This situation is astonishing, since Gabon is one country of the Congo Basin that has the best potential for conservation of African animal and vegetal diversity (Walker 2006), while its biodiversity remains almost unknown in the country.

Biological invasions in this region have also gone largely unexamined, one of the most relevant is that of the Neotropical ant *Wasmannia auropunctata*. This species, which is both an opportunistic and efficient competitor, is able to displace the local myrmecofauna (e.g., Ulloa-Chacón & Cherix 1990). High populations of *W. auropunctata* have been related to marked reductions of other ant species, and also impacts on reptiles and mammals, especially in regions where it has been introduced, such as the Galapagos islands, New Caledonia, Vanuatu and Gabon (Clark *et al.* 1982; Wetterer *et al.* 1999; Lebreton *et al.* 2003), and also in agricultural lands in its native range, such

as cocoa farms in Brazil (Delabie 1988, Majer *et al.* 1994). The first record of *W. auropunctata* infestation in Africa is dated 1913, in the Gabonese capital of Libreville (Santschi 1914). Furthermore, several undocumented sources (Mikissa, pers. obs.) suggest a secondary voluntary introduction in cocoa farms in Gabon around 1920 to protect cacao culture against its insect pests. In Cameroon, Bruneau de Miré (1969) reported *W. auropunctata*'s occurrence near Kribi (02°50'N, 09°50'E). In this area, *W. auropunctata* was used as a biological control agent for some insect pests, such as cocoa capsids (Hemiptera; Miridae).

In Gabon, with no native competitors, *W. auropunctata* spread progressively throughout the country, threatening the animal biodiversity. *Wasmannia auropunctata* usually forms aggregations of nests on leaves of the exceptionally thick understory vegetation. It becomes difficult to walk through some zones of heavy infestation, such as Airport forest at Lopé, without having a physical contact with *W. auropunctata* and, consequently, suffering numerous painful stings (Walsh *et al.* 2004). The occurrence of *W. auropunctata* at Lopé was first recorded in 1982, in the garage area of a logging camp recently abandoned, which later became the first gorilla study area of the Station d'Etudes des Gorilles et Chimpanzés (SEGC). Villagers confirm that *W. auropunctata* was absent locally until logging roads were drawn during the 1970s (Walsh *et al.* 2004).

Here, we focused on the spread of *W. auropunctata* in the Gabonese savannah biome, aiming to understand its interactions with the ant communities in the gallery forest / savannah mosaics.

METHODS

Study area

The study was conducted in July 2006 at the Lopé National Park, Gabon (0°10'S to 0°16'S 11°33'E to 11°39'E). This park covers 5,000 km² and is characterized by an equatorial climate (Af- according Köppen's classification) due to its proximity to the Chaillu Massif Chain. The average temperatures oscillate between 27°C and 31°C in April (the hotter month) and 20°C and 22°C in July (the colder month). The average precipitation is around 1500mm/year. The vegetation represents roughly 85% tropical forest and 15% savannah and forest/savannah mosaic (Tutin & Fernandez, Pers. Com. 2002).

The sites for the study of *W. auropunctata*' spread were forest galleries and savannas along the Lopé, Mingoumé and Offoué rivers (Fig. 1).

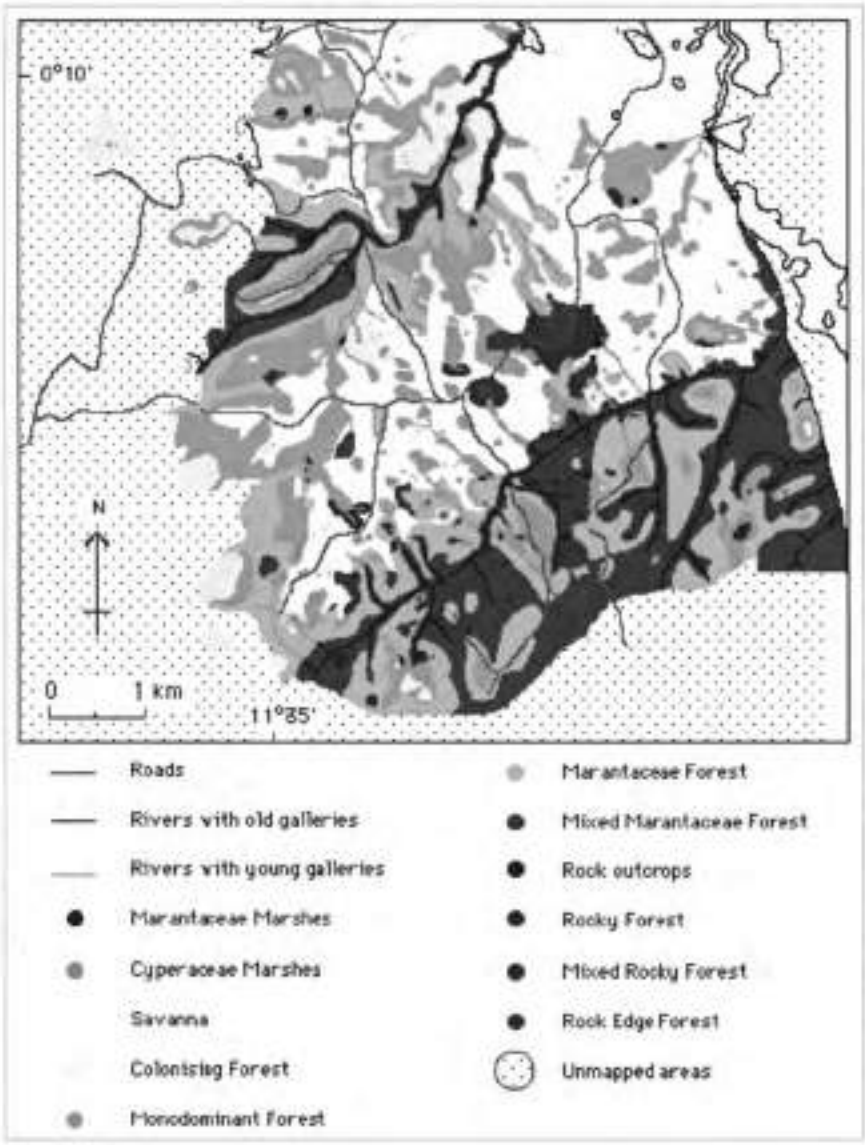

Fig.1. Mosaic Savannah/Forest in Lopé Park, Gabon.

Sampling of the ant community

Ants were sampled for each gallery forest savannah system in three different sites. Three linear transects, extending perpendicularly to the river from the river margins to 100m inside the savannah, were drawn in parallel in each gallery forest savannah. The pitfall traps consisted of plastic containers (25 mm internal diameter). They were half filled with a mixture of soapy water and rock salt (Bestelmeyer *et al.* 2000; Basset *et al.* 2004). During the experiment, 96 pitfall traps were placed along the transects at intervals of 10m between traps. Traps were left in the field for three days.

The ants were preserved in 90% alcohol for further mounting and identification at the laboratory. Vouchers are conserved in the collections of Ecole Nationale des Eaux et Forêts (ENEF) at Libreville, Gabon, and at the Mirmecology Laboratory (CPDC), CEPEC/CEPLAC, at Ilhéus, Bahia, Brazil.

Statistical analyses

The relative frequency of each ant species was calculated as a function of the number of traps where it was recorded in each area (savannah and gallery forest). For the data analysis we considered only the ants occurring in up to 5% of the traps, for a total of nine species. The positive or negative interactions between species (species foraging in the same areas) were tested by Chi^2 analysis with Yates' correction, which is an adaptation of the Room's model (1971) used to study associations between ants which form species mosaics in cocoa plantations in Papua New Guinea, Brazil and other countries (Room 1971; Majer *et al.* 1994).

The number of times where each species respectively showed significant ($p< 0.05$) positive or negative associations with another species was then totalled and the Index of Dominance (ID) (Majer *et al.* 1994) was calculated as follows:

Index of dominance (ID) = (N- P) / (N+ P)

where N is the number of negative associations and P is that of positive associations.

When ID< -0.8, the ant species is qualified as non dominant, whether ID is between -0.8 and +0.8, the ant species is said to be sub dominant and when ID> +0.8 the species is considered dominant.

RESULTS

Ant species richness in savannah and in gallery forest

A total of 18 ant species or morpho-species was recorded during the study, 16 from the gallery forest and 15 in savannah, belonging to nine genera (Table 1). The most represented subfamily was Formicinae (10 species), followed by Myrmicinae (7 species) and Ponerinae (1 species).

Distribution of *Wasmannia auropunctata* and other ants

Fig. 2 shows the relative frequency of the ants which numerously dominate the gallery forest or the savannah. *Wasmannia auropunctata* is present in up to 90% of the pitfall traps in the gallery forest while in the savannah it is present in only 55%. In contrast, *Pheidole megacephala* and *Camponotus negus* are more frequent in the savannah than in the gallery forest: 80% and 75% in savannah, respectively, and 20% and 22% in gallery forest, while *Camponotus sericeus* occurs only in the savannah.

Table 1. Ant species recorded through pitfall trapping at Lopé National Park, Gabon, July 2006.

Species	gallery forest	savannah
Formicinae		
Camponotus brutus	+	-
Camponotus sp. cf. acvapimensis	+	+
Camponotus sp. gp. maculatus	+	+
Camponotus (Myrmosericus) sp.	+	-
Camponotus negus	+	+
Camponotus sericeus	-	+
Camponotus chapini	-	+
Paratrechina longicornis	+	+
Polyrhachis latispina	+	+
Polyrhachis nigritana	+	+
Ponerinae		
Odontomachus troglodytes	+	+
Myrmicinae		
Wasmannia auropunctata (Roger) 1863	+	+
Pheidole megacephala	+	+
Pheidole sp.1	+	+
Cataulacus guinensis	+	-
Monomorium sp.1	+	+
Crematogaster cuvierae	+	+
Crematogaster sp.1	+	+

Table 2. Status and Index of dominance of some ants in Lopé gallery forest and savannah areas, Gabon, July 2006.

Species	Savannah		Gallery forest	
	Index of dominance	Status	Index of dominance	Status
Wasmannia auropunctata	0.51	Sub-dominant	0.77	Sub-dominant
Odontomachus troglodytes			-0.14	Sub-dominant
Camponotus sp. cf. *acvapimensis*	0.13	Sub-dominant	-0.18	Sub-dominant
Pheidole megacephala			-0.25	Sub-dominant
Polyrhachis latispina			-0.27	Sub-dominant
Paratrechina longicornis	0.71	Sub-dominant		
Camponotus sericeus	0.28	Sub-dominant		
Camponotus sp. gp. maculatus	0.05	Sub-dominant		
Camponotus negus	-0.21	Sub-dominant	-0.33	Sub-dominant

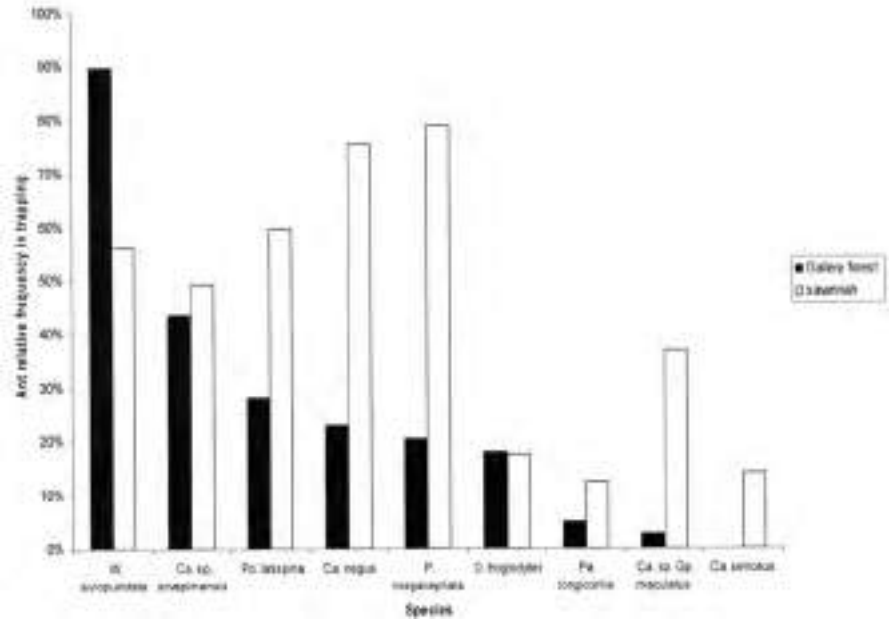

Fig.2. Relative frequency of ants in Lopé National Park savannah and gallery forest, July 2006, pitfall trapping.

Interspecific interactions

Table 2 exhibits the status of the species in each area as well as their index of dominance (ID). In both areas, all species obtained a sub-dominant score: none of the studied ants appear to be exclusive to any one territory..

Fig. 3 shows positive and negative significant interactions ($p < 0.05$) between the referred ants. More interspecific competition events occurred in

the savannah than in the gallery forest. In the savannah we noted four pairs of species with positive interactions (*W. auropunctata*/ *Camponotus* sp. cf. *acvapimensis*, *Camponotus* sp. gp. *maculatus*/ *C. sericeus, C.* sp. cf. *acvapimensis*/ *C. negus* and *C. negus*/ *C.* sp. gp. *maculatus*), against three in gallery forest (*W. auropunctata*/ *O. troglodytes*, *Polyrhachis latispina*/ *C.* sp. cf. *acvapimensis* and *Po. latispina*/ *C. negus*.)

The other observed interactions are negative, meaning that two given species are found together less frequently than would be expected by random sampling. *W. auropunctata* interacts negatively in the savannah with *C. sericeus* ($Chi^2 = 5.85$, $p < 0.0157$), *Paratrechina longicornis* ($Chi^2 = 3.90$, $p < 0.0482$) and *C.* sp. gp. *maculatus* ($Chi^2 = 16.27$, $p < 0.001$). Furthermore,

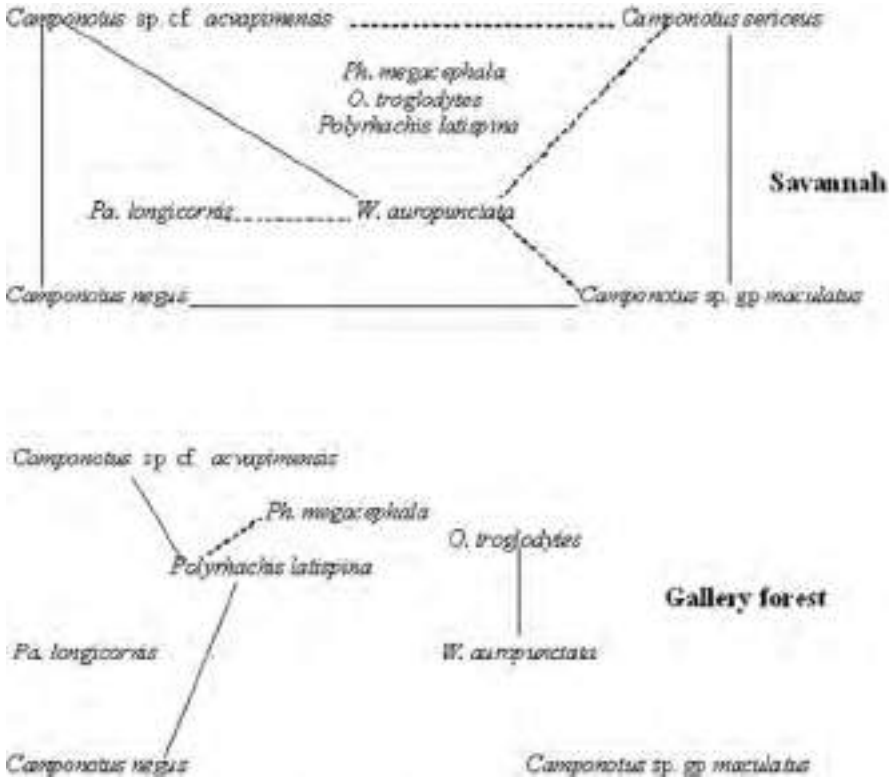

Fig.3. Representations of positive (solid lines) and negative (broken lines) interactions between ants at Lopé National Park, in savannah and gallery forest, following Room's model (1971).

C. sp. cf. *acvapimensis* shows a negative interaction with *C. sericeus* (Chi^2 = 6.02, p<0.0141).

In the gallery forest, only a single significant negative interaction (Chi^2= 3.91, p< 0.0480) exists, between *Ph. megacephala* and *Po. latispina*. The other species found have no significant interactions between them or with others (*Pa. longicornis* and *C.* sp. gp. *maculatus*) that show interactions with other ants on the savannah.

DISCUSSION

Distribution and specific richness

As we found the savannah to be richer in species than the gallery forest, our result corroborates Kolo's (2006) results for the Ivory Coast, but contrasts with Lévieux (1983) due obviously to our different methods of trapping. The ants *C.* sp. cf. *acvapimensis, C.* sp. gp. *maculatus, Ph. megacephala* and *O. troglodytes* have their nests between 0 and 50cm in the savannah grounds as Lévieux (1983) observed, while *C. sericeus* is tree-dwelling ant typical of savannah (Delage, 1971). The exotic little fire ant *W. auropunctata* is found in savannah at 60 m from the river margins, a little longer than the observation of Walker (2006) who found *W. auropunctata* at 20-30 m. In savannahs, *W. auropunctata* was found under stones, in rolled dead leaves, corroborating that this ant is a true generalist in the choice of its nest sites (Ulloa-Chacón and Cherix 1990; Young 1986; Blüthgen *et al.* 2000).

Wasmannia auropunctata's interactions with other ants

Our results made evident that interspecific competition is stronger in savannah than in gallery forest. In fact, it appears that a competition occurs for foraging areas between *W. auropunctata* and *C. sericeus*, since both of them dwell on the savannah trees and forage on the ground. Furthermore, both ants forage in the soil in search of honeydew produced by mealybugs living on roots. In particular, *W. auropunctata* utilizes Homoptera honeydew as up to 60% of its food source (Clark *et al.* 1982; Mikissa pers. obs.). Finally, *W. auropunctata* interacts negatively with *P. longicornis*, as shown by the traditional use of the latter by local human populations aiming at controlling *W. auropunctata* expansion. This form of control is highly successful according to the villagers. In a Neotropical rainforest within the natural range of *W.*

auropunctata, Tennant (1994) found that several other ants, particularly of the genus *Pheidole*, compete successfully with *W. auropunctata* and can keep its population density naturally low (Le Breton *et al.* 2003). Despite negative interactions, *W. auropunctata* coexists with several native ant species, overlapping ant species with similar dietary requirements and foraging behaviors (Le Breton *et al.* 2003).

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LITERATURE CITED

Basset, Y., J. F. Mavoungou, J. B. Mikissa, O. Missa, S. E. Miller, R. L. Kitching & A. Alonso 2004. Discriminatory power of different arthropod data sets for the biological monitoring of anthropogenic disturbance in tropical forests. Biodiversity and Conservation 13: 709-732.

Bestelmyer, B., D. Agosti, L. Alonso, R. Brandao, W. Brown, J. H. C. Delabie & R. Silvestre 2000. Field techniques for the study of ground-dwelling ants. *In*: Agosti, D., J. D. Majer, L.E. Alonso & T. Schultz (eds.), Ants: Standard methods for measuring and monitoring biodiversity. Smithsonian Institution Press, Washington 122-154 pp.

Blüthgen, N., M. Verhaagh, W. Goitia & N. Blüthgen 2000. Ant nests in tank bromeliads- an example of non-specific interaction. Insectes Soc. 47: 313-6.

Brown, K. Jr. 1989. The Conservation of Neotropical environments. Insects as indicators, *In:* Collins, N. M. & J. A. Thomas (eds.), The conservation of insects and their habitats. Fifteenth symposium of Royal entomological Society of London. Academic Hartcourt Brace Jovanovich Pubs, London pp. 354-404.

Bruneau De Miré, P. 1969. Une fourmi utilisée au Cameroun dans la lutte contre les mirides du cacaoyer : Wasmannia auropunctata Roger. Café Cacao Thé 13 : 209-212.

Burbidge, A. H., K. Leicester, S. McDavitt & J.D. Majer 1992. Ants as indicators of disturbance at Yanchep National Park, Western Australia. J. R. Soc. W. A. 75: 89-95.

Cabrera, M. & K. Jaffé 1993. Hormigas como bioindicadoras de la velocidad de recuperacíon de ecosistemas. *In:* Sociedad Venezolana de Entomología (eds.), Resumenes V Congresso Latinoamericano y XIII Congresso Venezolano de Entomología, Parlamar, Venezuela pp. 204.

Clark, D. B., C. Guayasamín, O. Pazmiño, C. Donoso & Y. Páez de Villacís 1982. The tramp ant *Wasmannia auropunctata:* autecology and effects on ant diversity and distribution on Santa Cruz Island, Galapagos. Biotropica 14:196-207.

Delabie, J. H. C. 1988. Ocorrência de *Wasmannia auropunctata* (Roger, 1863) (Hymenoptera, Formicidae, Myrmicinae) em cacauais na Bahia, Brasil. Rev. Theobroma 18: 29-37.

Delabie, J. H. C., V. R. L. M. Paim, I. C. Nascimento, S. Campiolo & C. S. F. Mariano 2006. As formigas como indicadores biológicos do impacto humano em manguezais da costa sudeste da Bahia. Neotropical Entomology 35 (5): 602-615.

Delage-Darchen, B. 1971. Contribution à l'étude écologique d'une savane de Côte-d'Ivoire (Lamto). Les fourmis des strates herbacées et arborées. Biologia Gabonica 7:461-496.

Fisher, B. L. 2004. Monts Doudou, Gabon : A floral and faunal inventory with reference to elevational variatio., California Academy of Sciences, San Francisco, California, pp. 295.

Hölldobler, B. & E. O. Wilson 1990. The Ants. Harvard University Press, Cambridge, Mass. 732 pp.

Hölldobler, B. & E. O. Wilson 1994. Journey to the Ants: A story of Scientific Exploration. The Belknap Press of Harvard University Press. 247 pp.

Kolo, Y. 2006. Dynamique spatiale et diversité des fourmis de la litière et du sol dans une mosaïque forêt-savane en Côte-d'Ivoire. Phd. thesis, Université Paris IV Pierre et Marie Curie. Pp. 150.

Le Breton, J., J. Chazeau & H. Jourdan 2003. Immediate impacts of invasion by *Wasmannia auropunctata* (Hymenoptera: Formicidae) on native litter ant fauna in a New Caledonian rainforest. Austral Ecology 28:204-209.

Lévieux, J. 1977. La nutrition des fourmis tropicales: V.- Eléments de synthèse. les modes d'exploitation de la biocœnose. Insectes Sociaux 3 : 235-260.

Lévieux, J. 1983. Le rôle des fourmis du sol dans les réseaux trophique d'une savane humide et d'une forêt hygrophile de Côte d'Ivoire. Bulletin de la Société de Zoologie de France 108: 35-36.

Majer, J. D. 1983. Ants: bio-indicators of mine-site rehabilitation, land use and land conservation. Environ. Management 7 (4): 375-383.

Majer, J. D. 1985. Recolonisation by ants of rehabilitated mineral sand mines on North Stradbroke Island, Queensland, with particular reference to seed removal. Austr. J. Ecol. 10 : 31-48.

Majer, J. D. 1992. Ant recolonization of rehabilitated bauxite mines of Pocos de Caldas. Brazil. J. Trop. Ecol. 8: 97-108.

Majer, J. D., J. H. C. Delabie & M. R. B. Smith 1994. Arboreal community patterns in Brazilian cocoa farms. Biotropica 26 (1): 73-83.

Passera, L. & S. Aron 2006. Les fourmis, comportment, organisation sociale et évolution. Ottowa: Presses Scientifiques du CNRC, 480pp.

Roth, D. S., I. Perfecto & B. Rathcke 1994. The effets of management systems on ground foraging ant diversity in Costa Rica. Ecol. Appl. 4 (3): 423-436.

Room, P. M. 1971. The relative distribution of ants species in Ghana's cocoa farms. Journal of Animal Ecology 40: 735-751.

Santschi, F. 1914. Formicides de l'Afrique occidentale et australe du voyage de M. le Professeur F. Silvestri. Bollettino del Laboratorio di Zoologia Generale e Agraria (Portici, Italia) 8:309-385.

Tennant, L. E. 1994. The Ecology of *Wasmannia auropunctata* in primary tropical rainforest in Costa Rica and Panama. *In*: Williams, D. F. ed., Exotic ants: Biology, impact, and control of introduced species. Westview Press, Boulder, CO. 80-90 pp.

Ulloa-Chacón, P. & D. Cherix 1990. Perspectives on control of the fire ant (*Wasmannia auropunctata)* on the Galapagos Islands, *In:* D. F. Williams (ed.), Exotic Ants: Biology, impact, and control of introduced species. Westview Press, Boulder, CO. pp. 63-72. .

Walker, K. L. 2006. Impact of the little fire ant, *Wasmannia auropunctata*, on native forest ants in Gabon. Biotropica 38 (5): 666-673.

Walsh, D. P., P. Henschel, A. Kate, C. E. G. Tutin, P. Telfer & A. L. Sally 2004. Logging speeds little red fire ant invasion of Africa. Biotropica 36 (4): 637-641.

Wetterer, J. K., P. D. Walsh & L. J. T. White 1999. *Wasmannia auropunctata* (Roger) (Hymenoptera: Formicidae), a destructive tramp-ant, in wildlife refuges of Gabon.. Afr. Entomol. 7: 292-295.

White, L. J. T., K. Abernethy 1996. Guide de la végétation de la Réserve de la Lopé. Multipress-Gabon. 229pp.

Young, A. M. 1986. Notes on the distribution and abundance of ground and arboreal-nesting ants (Hymenoptera : Formicidae) in some Costa Rican cacao habitats. Proc. Entomol. Soc. Wash. 88 : 550-71.