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Management of Termite Pests in Three Public Services of Korhogo (North of Côte d'Ivoire)

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Authors' contributions

This study was carried out in collaboration among all authors. Author TC designed the study, wrote the protocol, performed the statistical analysis, managed data storage and wrote the first draft of the manuscript. Author DD co-designed the study, managed the data processing, supervised the study, managed the literature searches and reviewed drafts. Authors AAMA and KPK co-designed the study, cosupervised the study and read manuscripts. All authors read and approved the final manuscript.

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ABSTRACT

Termites are becoming economic pests because of their appetite for wood and wood products in human dwellings and building materials. The objective of this study is to assess the impact of these insects on the activities of public services in the city of Korhogo, located in the north of Côte d'Ivoire. Termite attacks was investigated in 3 public services of the city. A survey was conducted to identify the control methods used against these pests. The results showed that termite pests represent a real problem. A total of 7 species of termites responsible for attacks were collected. These species belong to the wood-feeders, fungus-growers and grass-feeders group. The fungus-growers are the most involved in the observed attacks. *Pseudacanthotermes militaris*, which was involved in 54% of the attacks, was the most dangerous species. Termite attacks and damages were observed on doors, wooden shelves, ceilings, birth and marriage records. Surveys reveal that

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only chemical control is used in these services to control termites. A total of four pesticides were used to control termites in the three services visited. These were Cypercal 50 EC, K-Othrine® SC25, Actellic® 50 EC and Furadan 3G. Unfortunately, these products appear to be ineffective in some services. It is therefore important to take more effective and environmentally friendly measures to limit the impact of these insects on the activities of the public administrations of the town of Korhogo.

Keywords: Termites; public services; attacks; pesticides; Korhogo.

1. INTRODUCTION

Termites are one of the major biotic components of tropical ecosystems, where they, along with earthworms and ants, are true ecosystem engineers [1-4]. They have long been presented as the guarantor of monitoring natural and transformed ecosystems because of their hypersensitivity to environmental change [5, 6] and can be used as biological indicators to estimate the state of ecosystem degradation. However, despite their ecological role, termites are also a scourge for crops and dwellings [7]. To date, about 10% of the 3106 termite species described have been reported as pests [8]. Damage can be caused to crops, buildings, pastures and forests, and even to non-cellulosic materials such as electrical cables [9]. For dwellings in particular, the activity of these insects can affect the quality of use of buildings but also cause major disorders [10]. In the most extreme cases they can lead to the collapse of structures. Several control measures are used in some European countries. France, for example, has taken legislative measures to limit the proliferation of termites in buildings, but in Côte d'Ivoire this is not yet the case [11]. Work on termites in urban environments is rare in Africa and particularly in Côte d'Ivoire. The study by [12] had shown that termites were a problem for the furniture and gardens of the university in the town of Korhogo in the north of the country. However, the town has many public services threatened by termites. The aim of this work is to assess the impact of termites on the activities of other important public services in Korhogo's city in order to draw the attention of the public to the importance of taking the issue of urban termite pests very seriously.

2. METHODOLOGY

2.1 Study Area

The studies were conducted in the dry season from March to April 2020, in the town of Korhogo (9°34' N - 5°37' W). The city was divided into different districts (Fig. 1). The climate is tropical Sudanese dry with two contrasting seasons: the rainy season runs from mid-April to October and the dry season from November to mid-April. The average annual rainfall varies between 1000 and 1600 mm. Rainfall is the predominant climatic factor. The average hygrometry is 65-70%. The average annual temperature varies between 24°C and 36°C. The soils are generally low in humus and of average fertility.

Three public services in the city of Korhogo were selected for this study (Fig. 1).

- ✓ The Korhogo Regional Hospital (CHR) is located in the Téguéré district. This hospital houses several buildings with wooden furniture, doors, windows and ceiling.
- ✓ The Town Hall of Korhogo is a site of several buildings located in the Administrative district. The town hall is the place where marriages are celebrated and births are declared. It therefore houses an archive room where birth registers, marriage registers and other administrative documents are kept.
- ✓ The sub-prefecture of Korhogo: This is a site of several buildings also located in the town centre. It is a birth registration centre for the villages of the sub-prefecture. It also houses an archive room where birth registers and other important administrative documents are kept.

2.2 Termite Sampling and Evaluation of Termite Attacks

Termites were sampled in each of the 3 services. The work consisted of inspecting the various buildings on the study sites and detecting the presence of termite attacks. The structure was said to be attacked when it carries galleries or veneers with or without termites [13]. And it was said to be damaged when it presents degradations linked to termite attacks making it unfit for the natural use for which it was intended. A total of 25 structures were observed in the three services: 13 at the CHR, 12 at the town hall

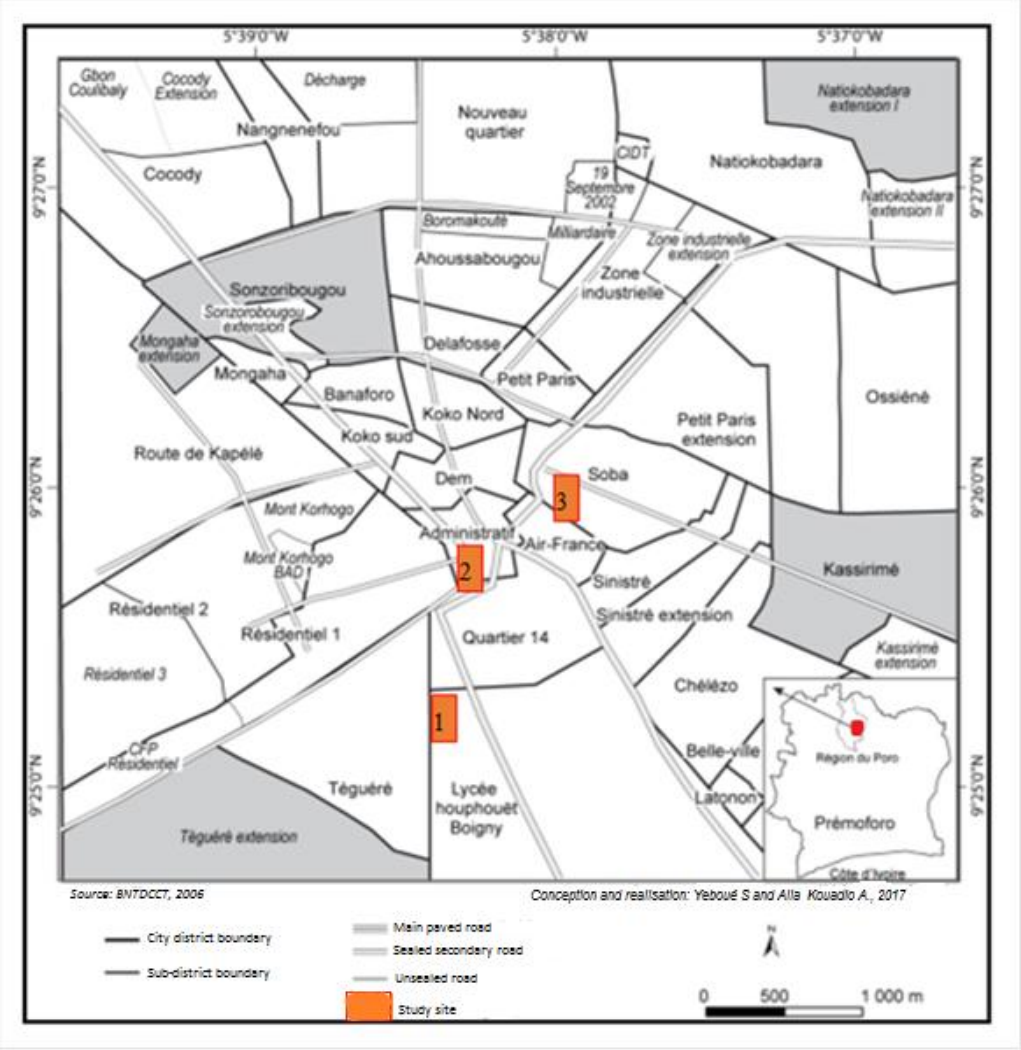

Fig. 1. Location of study sites in the city of Korhogo

1. *The Korhogo Regional Hospital (CHR)*
2. *The Town Hall*
3. *The sub-prefecture*

and 10 at the sub-prefecture. The damage observed was photographed, and the termites responsible for the damage were then sampled in pill boxes containing 70° alcohol.

2.3 Inventory of Control Methods

Another stage of this study was to carry out a survey to make an inventory of identify the control methods used against these pests in these different sites. The control methods and products used against termites were surveyed among the managers of each department. These control methods were classified and the active ingredient of each product was noted.

2.4 Identification of Termites

The collected termites were observed and identified down to the species level in the laboratory under a binocular magnifying glass, using the identification keys of [14-20]. After the identification, each species was placed into one of the feeding groups (i.e., fungus-growers, soil-feeders, wood-feeders, and grass-feeders) defined according to termite diet, mandible morphology, and gut content in the worker caste. All fungus-growers consume grass, dung, wood, and litter via an exo-symbiosis with the fungus *Termitomyces* for the decomposition of plant matter. The soil-feeders feed on soil organic

matter and occasionally on very decayed wood. Most wood-feeders consume dead wood, but some species feed on living plants. The grass-feeders are exclusive consumers of grassy plant materials.

2.5 Data Analysis

The inventory data were analysed by determining the following ecological. Simpson's index served to measure the diversity of the termite assemblage. This index and its evenness were computed by using the PAST software [21]. The frequency of species involved in the attacks was also calculated according to the following formula:

$$F = Ni * 100 / Nt$$

F= frequency of the species
Ni= Number of times the species has been observed
Nt= Total number of samples

3. RESULTS

3.1 Inventory of the Species of Termites Responsible for the Attack

A total of 7 species of termites were recorded in the 3 services (Table 1). These species are divided into 3 subfamilies and 5 genera belonging to the termitidae family alone. The Macrotermitinae subfamily was the most diverse with 5 species. The sub-prefecture, with 4 species in total, register the largest number of species, while the CHR and town hall each recorded 3 species.

The calculated diversity indices differed from one site to another. The sub-prefecture and the town hall recorded the highest Simpson's indexes with 0.75 and 0.53 respectively. The CHR recorded a low Simpson index of 0.48. The evenness index remained in the same direction as the Simpson Index.

3.2 Relative Abundance of Feeding Groups

A total of 25 samples were collected. The collected species belonged to 3 trophic groups: fungus-growers, grass-feeders and wood-feeders. Fungus-growers were represented by 5 species while wood-feeders and grass-feeders were represented by one species each. Fungus-growers were present in 23 samples and were the most abundant group (Fig. 2).

3.3 Structures Attacked by Termites in Services

Termite attacks were observed in the buildings and archive rooms of all three services.

At the **town hall**, termite attacks were visible in the archive office where birth and death registers, marriage certificates and several important documents are stored (Fig. 3). All these paper documents were consumed by the termites, with a strong presence of earth veneers.

At the **CHR**, termite attacks were observed to the door structures, wooden windows, the wall, and the electrical installations.

At the **sub-prefecture**, doors and electrical installations were the elements attacked by termite pests.

3.4 Frequency of Termite Species Involved in the Attacks

At the Korhogo **town hall**, three genders were responsible for the attacks. These were *Macroterms bellicosus, Pseudacanthotermes militaris* and *Trinervitermes geminatus*. Among these species, *P. militaris* was the most observed species in terms of visible attacks to the documents and boxes stored in the archive office. This species recorded a frequency of 62% in this service. *M. bellicosus* and *T. geminatus* recorded respectively 25% and 13% presence in the observed attacks (Fig. 4).

At the Korhogo **CHR** the attacks observed was caused by 3 species of termites. The most aggressive was always *P. militaris* with 67% of the attacks observed in this service (Fig. 4). *Ancistrotermes cavithorax* and *Ancistrotermes crucifer* recorded respectively 25% and 8% frequency of occurrence in the attacks observed in this site.

At the **sub-prefecture**, 4 species of termite pests involved in the attacks were recorded. These are: *A. cavithorax, A. crucifer*, *Macrotermes subhyalinus* and *Amitermes evuncifer*. Each of these species has a 25% frequency of occurrence of all attacks (Fig. 4).

Table 1. Distribution of termite species and diversity indices per study site

Familly	Sub- famillies	Genera	FG	Town Hall	CHR	Sub-prefecture
Termitindae	Macrotermitinae	*Macrotermes bellicosus.*	f	*		
		Macrotermes subhyalinus				*
		Ancistrotermes cavithorax	f		*	*
		Ancistrotermes crucifer	f		*	*
		Pseudacanthotermes militaris	f	*	*	
	Termitinae	*Amitermes evuncifer*	w			*
	Nasutitermitinae	*Trinervitermes geminatus*	g	*		
Diversity indices		**Simpson**		0.53	0.48	0.75
		Evenness		0.82	0.76	0.98

***FG**= Feeding groups; f: fungus-growers; g: grass-feeders; w: wood-feeders*

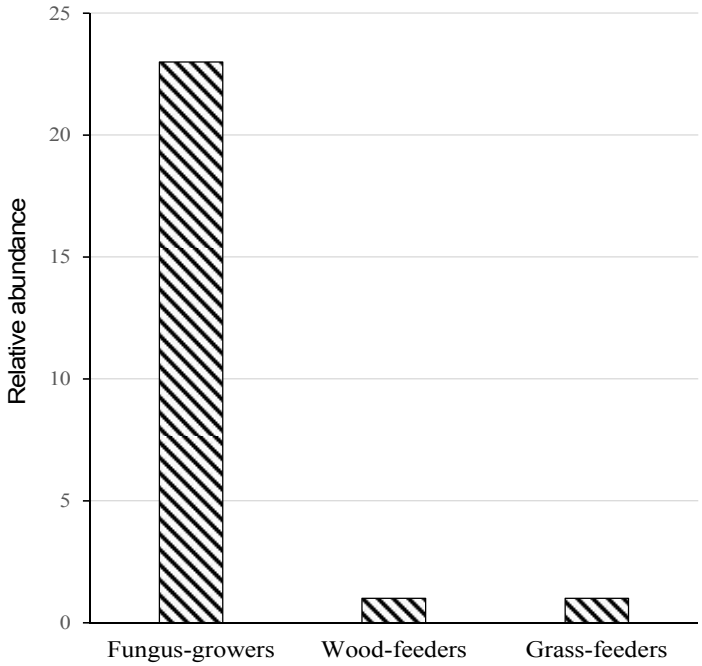

Fig. 2. Relative abundance of feeding groups

Of the three study sites, *P. militaris*, which was involved in 54% of the attacks, was the most aggressive species. It was followed by *A. cavithorax* with a frequency of 17% (Fig. 4).

3.5 Inventory of Control Methods used against Termites

In all 3 services, only the chemical method is used to control termites. The survey reveals that a total of 5 products are used in these services (Fig. 3): Cypercal 50 EC, K-Othrine® SC25, Actellic® 50 EC and Furadan 3G. The first 4 products mentioned are used in liquid form while Furadan 3G is used in granular form. The active ingredients of each of these products are known (Table 2).

CHR uses Cypercal 50 EC and K-Othrin® SC25 alternately. Cypercal 50 EC is a product that acts by contact, while K-Othrin® SC25 acts by contact and ingestion. Both products are mixed with water and sprayed on termite infested areas.

At the sub-prefecture, those responsi ble for this structure use ACTELLIC 50 EC. It is an organophosphorus insecticide, polyvalent, containing 500g/l of pirimiphos-methyl. With low toxicity, it destroys all insect pests, and has a contact and vapour action. ACTELLIC 50 EC's broad spectrum of ACTELLIC 50 EC effectively controls a variety of flying and crawling insects.

Fig. 3. Termite damage at investigation sites

A: Town hall archive room, B, C: Registers and other documents attacked by termites; D: Termite attacks on electrical equipment; E: Termite attacks on doors, F: Termite attacks on ceilings.

Only furadan is used for the Korhogo town hall. FURADAN is an insecticide containing 3% carbosulfan, an active ingredient of the carbamate family. Because of its toxicity, carbosulfan has been banned in the European Union since 2008.

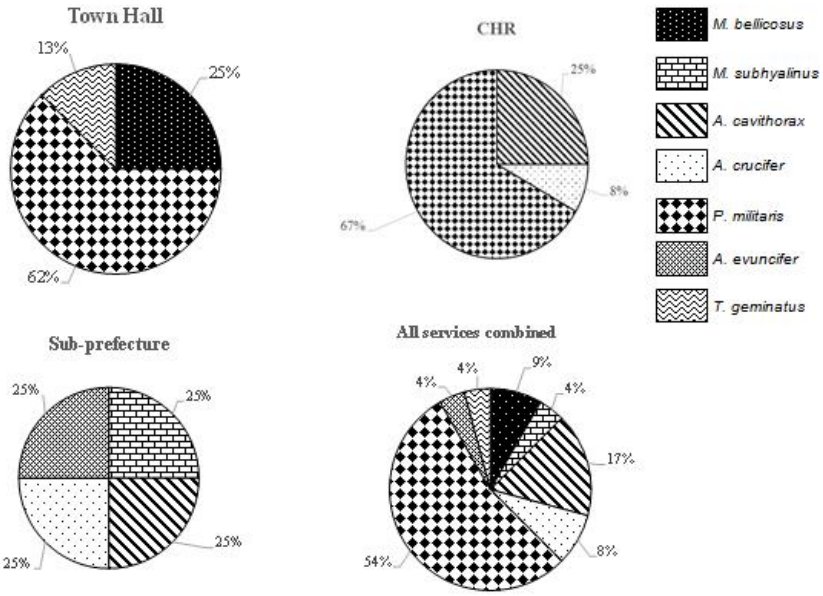

Fig. 4. Frequency of termite species involved in the attacks

Fig. 5. Photo of the different products used against termites

Table 2. Pesticides used against termites in different services

Sites	Name	Familly	Active ingredients	Form	Mode of action
CHR	Cypercal 50 EC	Pyrethroid	Cyperméthrine 50g /L	Liquid	By contact
	K-Othrine® SC25	Pyrethroid	Deltaméthrine 25 g/l	Liquid	By contact and by ingestion
Sous - Préfecture	Actellic® 50 EC	Organophosphorus	Méthyl-pirimiphos 500 g/l	Liquid	By contact, ingestion and fumigant action.
Mairie	FURADAN 3G	Carbamates	3% of carbofuran	Granules	By contact and systemic action

4. DISCUSSION

A total of 7 species of termites were collected in the three public services of the city of Korhogo. Of these species, *Pseudacanthotermes militaris* was the most dangerous for the infrastructure in these study services. These species were responsible for a lot of attacks and damage to furniture, ceilings, doors, but especially to archived marriage, birth and death registers of the population. These registers and archived documents are of vital importance to the people of the commune. The destruction of these documents leads to many inconveniences, sometimes irreversible. In Côte d'Ivoire, the issue of termites in urban areas was

reported in Korhogo [12]. These authors showed that termites are a real problem for the infrastructure of the university in the city of Korhogo. Deon and Fouquet [22] have also shown that in the TOM (Territoires d'Outre-Mer), termites are one of the main causes of degradation in constructions and buildings, after natural disasters, as they often cause very significant damage.

The termites sampled in this study are mostly subterranean termites that have access to furniture through the basement of houses. Through the galleries, the termites penetrate the basement, pass through the electrical installations to access the furniture. The easy access of termites to the interior of buildings is said to be due to the fact that no provision was made to combat these insects when the buildings were constructed. However, since the 1990s, the extent of termite damage in urban areas has led some developed countries, such as France, to take measures to curb the impact of these insects on buildings. The law n°99-471, voted on 8 June 1999 in France, defines the modalities for the implementation of a control policy in which all the actors are involved, namely the State, local authorities, professionals as well as building owners [23]. But in Côte d'Ivoire, no law has been passed to prevent termite-related problems in urban areas.

The results of the survey showed that in the sites visited only the chemical method is used to deal with termite pests. A total of four chemicals are used to control termites in the three departments visited. These are Cypercal 50 EC, K-Othrin® SC25, Actellic® 50 EC and Furadan 3G. These 4 chemicals are not specific to termites and were not all approved by the Ivory Coast government. Indeed, since 2006, the carbosulfan-based pesticide Furadan has been banned by the Comité Sahélien des Pesticides (CSP) [24,25]. Studies have shown that Carbosulfan is a WHO Class II (moderately hazardous) pesticide [26, 27] and that it is a cholinesterase inhibitor [28]. Its use could lead to serious health problems. The products used are not always effective in curbing termite damage.

5. CONCLUSION

The results have shown that termite pests represent a real danger. The attacks and damage caused by these insects could have enormous repair costs. In total, 7 species of termites responsible for attacks were collected. Fungus-growers group was the most involved in the attacks observed. *Pseudacanthotermes militaris*, involved in 54% of the attacks, was the most dangerous species. Termite damage has been observed on doors, wooden shelves, ceilings, birth and marriage registers. Surveys reveal that only chemical control was used in these departments to fight termites. The pesticides used were Cypercal 50 EC, K-Othrine® SC25, Actellic® 50 EC and Furadan 3G. Unfortunately, the products used appear to be ineffective to the town hall and the sub-prefecture. In view of the extent and costs of repairs related to termites, it would be necessary to continue studies in order to propose effective and environmentally friendly methods of control for better control of these pests.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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