Assessment of the Efficiency of Insecticide Paint and Impregnated Nets on Tsetse Populations: Preliminary Study in Forest Relics of Abidjan, Côte d'Ivoire

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Abstract

Glossina palpalis palpalis is the main vector of human and animal trypanosomiasis in Côte d'Ivoire. This species, being the only tsetse species in the city of Abidjan, is hosted by the National park of Banco located in the middle of Abidjan, the zoological park and in a relic forest within the University of Nangui-Abrogoua, both in Abidjan. A programme for the elimination of these suburban tsetse populations has been initiated, in the context of which various tsetse control tools have been evaluated. In the zoological park, insecticidal paint (Inesfly®) was applied around the animal cages, and then supplemented with insecticide-impregnated netting around the larger animal cages. Tsetse population densities were monitored with Vavoua-style traps both inside the zoological park and in the site of University Nangui Abrogoua used as control site. Tsetse densities in the traps fell by over 90% following application of the insecticidal paint, and declined to zero after adding the insecticide impregnated nets in both study sites. The study confirms the close contact between tsetse populations from the zoological park and the University Nangui Abrogoua area, and shows that the sequential use of insecticide paint and impregnated nets can be effective for tsetse control.

Introduction

Thirty-one species and subspecies of *Glossina* (Diptera: Glossinidae), commonly known as tsetse flies, are listed in sub-Saharan Africa in an area of about 10 million m2 between the 15º N and 29º S (Ford & Katondo, 1973). Nine species and subspecies are found in Côte d'Ivoire (Brunhes *et al.*, 1998), including *Glossina palpalis palpalis*, which is the main vector of human african trypanosomiasis (HAT) in the forest areas (Gouteux *et al.*, 1983). *G. p. palpalis* is also present in urban and peri-urban ecotopes (Courtin *et al.*, 2005), and it has been reported in the relics forests surrounding of the French military camp (43rd BIMA) in Abidjan (Keck *et al.*, 2009; Kaba, 2006), of the Zoological park of Abidjan, and of the campus of Nangui Abrogoua University (formerly University of Abobo-Adjamé) (Allou *et al.*, 2009). It is in this context that the Leverhulme Trust Tsetse Research Network has initiated a testing programme of fight against tsetse flies in order to eliminate them with a set of technics. Although these forest relics in Abidjan are geographically independent to each other, there is no significant genetic isolation between their tsetse populations (Kaba *et al.*, 2012), suggesting that successful control of

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these flies would require simultaneous or sequential interventions over the whole sub-urban area. The impact of insecticidal paint and insecticide-impregnated netting deployed within the Zoological Park, with the use of Vavoua traps to monitor tsetse density is reported. The site of the University Nangui Abrogoua served as a control site.

Materials and methods

Study area

The Zoological park and the campus of the Nangui-Abrogoua University are located in Abidjan in the south of Côte d'Ivoire. The Zoological park covers approximately 20 ha and composed of partially degraded equatorial forest. Only 4 ha are used for cages and enclosures for a variety of vertebrates, including chimpanzee and other monkeys, buffalo, antelope, hyena, lion, and various snakes, lizards, and turtles; that together offer a ready availability of bloodmeals for tsetse flies (Allou *et al.*, 2009).

Close to the Zoological park is the campus of the Nangui-Abrogoua University (UNA) (formerly called University of Abobo-Adjamé), which is the second largest university in Abidjan. It covers an area of 130 ha, with 5 ha representing the relic forests. The relic forests in these two study areas are at various stages of degradation, separated from each other – and from the nearby Banco forest reserve – by roads and heavily urbanized areas (Fig. 1). Like the rest of southern Côte d'Ivoire, study areas are characterized by two rainy seasons (a minor

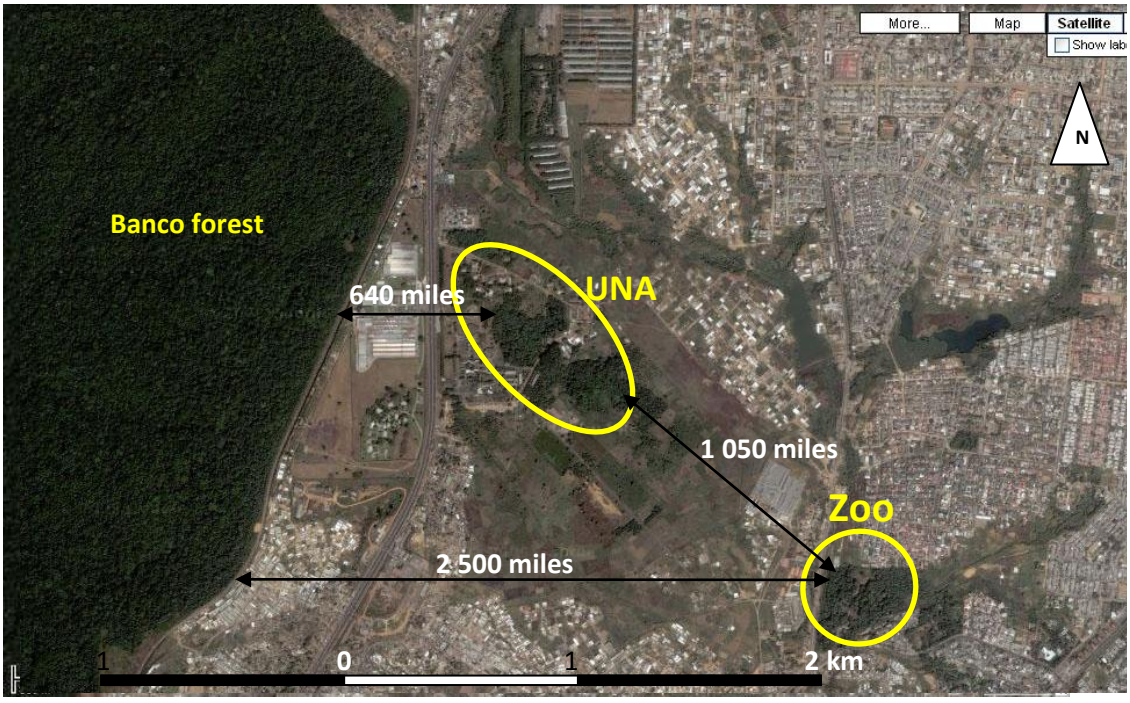

Fig. 1. Study area: ZOO: Zoological park; UNA: University of Nangui-Abrogoua

one from September to October, a major one from April to July), and two dry seasons (a minor one from July to August, a major one from November to March). The temperature ranges between 25 °C and 33 °C, with an annual rainfall of about 1500 mm.

Tsetse control tools

The insecticidal paint is a slow-release formulation provided by Inesba, known as Inesfly 5AIGR NG. It is a white vinyl paint of aqueous base, with active ingredients contained in CaCO3 + resin microcapsules. In the formulation tested during the trial, the active ingredients were 0.7% alpha-cypermethrin, 1.0% d-allethrin, and 0.063% pyriproxyfen. Prior to use, the paint was diluted with an equal volume of water, and applied using a manual backpack compression sprayer. The insecticide-impregnated netting provided by Vestergaard-Frandsen SA, is a black polyvinyl netting factory impregnated with deltamethrin.

Tsetse control trial

To monitor tsetse densities before and during the trial, a total of 12 monitoring traps of the Vavoua type (Laveissière & Grébaut, 1990) were placed in the two study areas subdivided as follows: six traps in the Zoological Park and six traps in the UNA campus. These traps were set-up for the first time in August 2008 for 4 consecutive days. Trapping sites were then georeferenced so that the traps could be placed in the same sites on successive sampling occasions at approximately monthly intervals throughout the trial period.

The insecticidal paint was applied to the outer walls and grills of the five largest animals (chimpanzee, buffalo, antelope, hyena and lion) enclosures during August 2009. The walls were first manually cleaned with a wet brush for removing all marks of dust and others impurities (moisture, etc.), allowed to dry, and then manually sprayed with the diluted inesfly formulation until a visually continuous covering was achieved (Fig. 2).

The second phase of the trial involved adding impregnated netting around the same animal enclosures previously painted (Fig. 3). About 1,500 m length of insecticide-impregnated nets (1 m height) was, thus, deployed in February 2011 during the dry season to reduce possible leaching of the insecticide by rainwater. Before their deployment and 1 year after deployment of the netting, samples of the net fabric were analysed at the Central Laboratory of Ecotoxicology and Agrochemicals, in order to evaluate the residual concentrations of insecticide in the nets.

Tsetse density monitoring

The density of tsetse flies was monthly monitored during 4 consecutive days using Vavoua-style traps placed at georeferenced positions both in the zoological park and the UNA campus. The 12 traps were firstly used for the monitoring. In order to confirm the decline of the tsetse densities observed after three monitoring sessions, trapping was improved by adding more four traps in each study sites. Thus, the total number of traps used moved from 12 to 20 (10 traps in the zoolological park and 10 traps in the UNA) by the end of the trial. No tsetse monitoring was carried out during the period that followed the implementing of nets (from February to August 2011) because of the civil war.

Fig. 2. Insecticide paint applied to the wall in the cage of lions

Fig. 3. Insecticide impregnated nets set-up around the cage of lions

From the trap collections, apparent density of tsetse flies per trap *(ADT)* and per day was calculated so that the apparent reduction in tsetse density after application of the control tools was compared as follows:

$$\text{Reduction rate} = \frac{ADT_0 - ADT_n}{ADT_0} \times 100 \text{ with } ADT_0$$

the apparent tsetse density before deployment of control tools and ADT_n the apparent density in months after treatment.

Mann – Whitney test was used to test the effect of the paint insecticide on Zoological site. This analysis was performed with Statistica software 6.0 with α at 5%. Thus, any value of $P < 0.05$ was considered significant.

Results

Evaluation of efficiency of the insecticidal paint

Prior to application in July 2009, the tsetse density was relatively high: *ADT* = 13.4 tsetse fly/trap/day, reflecting a considerable nuisance to zoo workers and animals. However, 3 months after application of the paint, the *ADT* dropped to 3.6 tsetse fly/trap/day; which means a reduction rate of more than 70%. In November 2010, *ADT* was 1.5 tsetse fly/trap/day– a significant decrease of 89% (Fig. 4); (Mann-Whitney: $F = 10.82$; $P = 0.01$); and zoo workers commented that not only did the zoo animals appear calmer, but also themselves were much less bothered by biting flies.

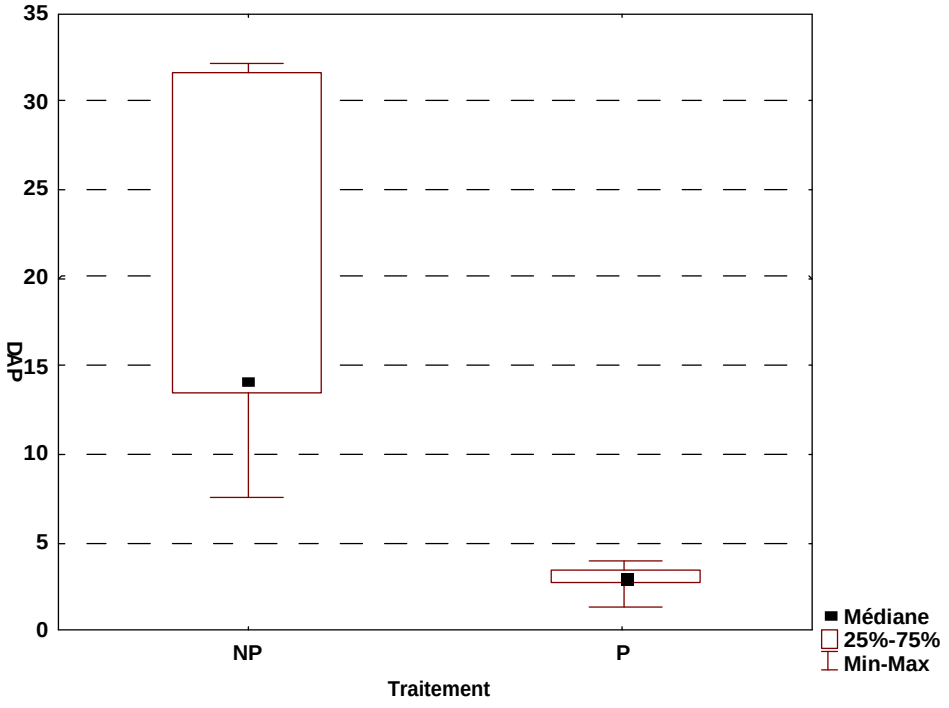

Fig. 4. Effect of insecticide paint in the zoological park; ADT: Apparent density of tsetse flies per trap and per day; NP: Before the implementation of the paint; P: After the implementation of the paint

In the UNA campus, before insecticide paint application in the zoo, *ADT* was 11.1 tsetse fly/trap/day. It fell to 1.8 tsetse fly/trap/day three months later (reduction rate of more than 80%) then to 0.7 tsetse fly/trap/day in November 2010 for a reduction rate of 93.69%.

Evaluation of the insecticide-treated nets

Prior to their deployment in January 2011, the tsetse density at the zoological park was relatively low (1.83 tsetse fly/trap/day). This density dropped to zero for all subsequent evaluations from September 2011 to November 2012. At the UNA campus, the tsetse density was 0.38 tsetse fly/trap/day prior to the deployment of impregnated netting at the zoo in January 2011. Subsequent evaluations showed the following results:

September 2011: 2 flies caught; *ADT* = 0.08 tsetse fly/trap/day; October 2011: 11 flies caught; *ADT* = 0.46 tsetse fly/trap/day, and November 2011: 5 flies caught; *ADT* = 0.21 tsetse fly/trap/day. From that month, no tsetse was caught in the UNA (*ADT*= 0) during the subsequent evaluations up to November 2012 (Fig. 5).

HPLC analysis of insecticide concentrations on the netting showed that at the time of their first deployment in January 2011, the average deltamethrin level was 0.621 mg per g of netting. One year after their deployment, the deltamethrin levels had declined to an average of 0.384 mg per g of netting (Fig. 6).

Discussion

The Inesfly insecticidal paint has shown its effectiveness against mosquito populations (Mosqueira *et al.*, 2010ab) and also against domestic and peridomestic Triatominae (Amelotti *et al.*, 2009; Dias & Jemmio, 2008), but this is the first time that tool is tested under field conditions against tsetse flies. As a spray formulation, application of the paint proved to be straightforward, and gave a visually satisfactory result. The paint effectively transforms the animal cages to a form of baited trap for the tsetse (and other biting and nuisance flies) in the sense that the flies remain attracted to the zoo animals, but can pick up a lethal dose of insecticide when landing on the treated surfaces with the insecticidal paint, resulting in a reduction of the apparent density of tsetse by around 90% within a little more than 6 months. Other studies would be required to determine the relative effects of the different active ingredients in this formulation, which includes two different pyrethroids and an insect growth regulator (pyriproxifen), and to determine the most cost-effective application rates.

Meanwhile, the product as supplied resulted in improvement to the appearance of the treated cages and a dramatic reduction in the apparent density of tsetse (and of other biting and nuisance flies). A reduction in tsetse density was also seen for the nearby UNA campus, even though no control interventions were applied there (other than the Vavoua traps used to monitor tsetse density). This endorses results of genetic analysis of these tsetse populations, which indicated that tsetse flies from these two areas are not isolated (Kaba *et al.*, 2012), suggesting that tsetse from the UNA campus would also be visiting the zoo for blood feeding upon caged animals.

Having shown that the insecticidal paint was effective in reducing the tsetse populations, the impact of insecticide-

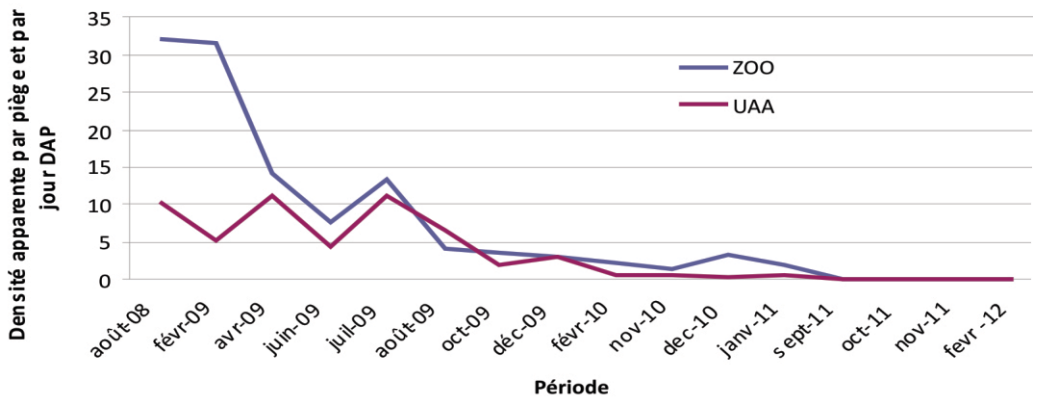

Fig. 5. Evolution of the ADT in the zoological park and University of Nangui Abrogoua during the period of trial, Zoo: zoological park of Abidjan; UNA: University of Nangui Abrogoua

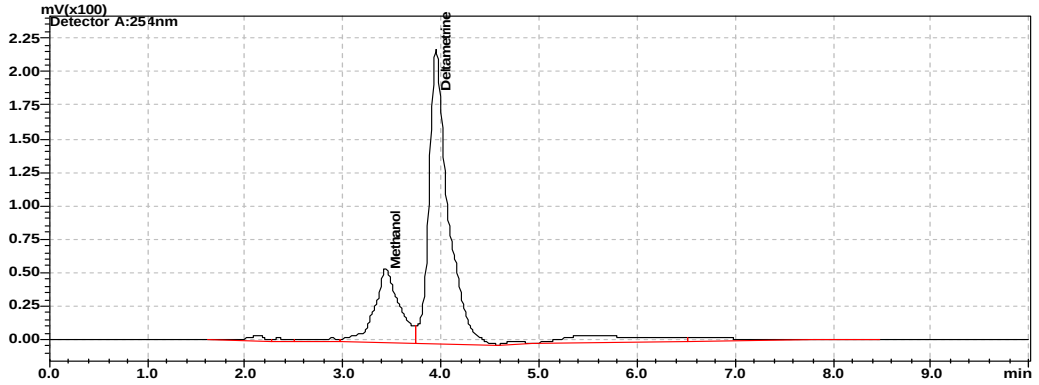

Fig. 6a. Initial chromatogramme of insecticide impregnated nets (before their implementation around cages)

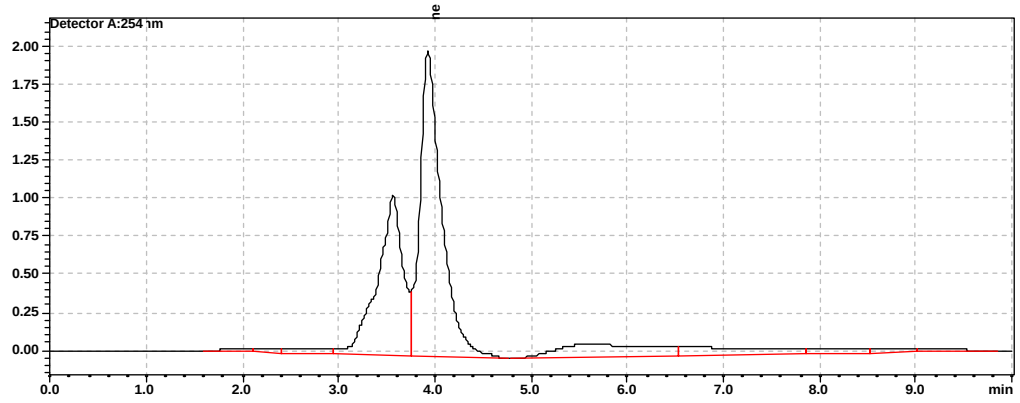

Fig. 6b. Final chromatogramme of insecticide impregnated nets (after their implementation around cages

impregnated netting, which was deployed in January 2011 was also evaluated. The post-election civil unrest in Côte d'Ivoire during 2011 made it impossible to continue tsetse monitoring until September of that year, but subsequent results indicate that the combination of insecticidal paint and insecticide-impregnated was sufficient to dramatically reduce the tsetse populations in the zoo and also in the UNA campus. The insecticidal paint was easy to apply and gave a satisfactory visual appearance to the treated walls that was appreciated by visitors and zoo workers. The insecticide treated netting was also easy to set-up by a team of five persons; although 12 h on 2 days were needed to set-up the net around all cages and the visual effect was less pleasing.

The efficiency of these nets had already been demonstrated by work against *G. p. gambiensis* on the Loos Islands in Guinea (Kagbadouno *et al.*, 2011), and is believed to be enhanced by the black colour of the thread that gives the impression to the fly to be in a shady resting site required before or after a blood meal (Bauer *et al.*, 2005). Maintaining *ADT* to zero after the nets can also be explained by the long persistence of these impregnated nets for one year after exposure to the site of the zoo (0.621 mg / g prior to 0384 mg/g after). The residual concentration of deltamethrin in these nets has controlled tsetse flies. The work carried out in Laboratory by Laurence (2002) showed that a dose of 45mg/m² can kill between 30s and 48 h *Glossina palpalis gambiensis.*

The civil unrest of 2011 in Côte d'Ivoire, mainly in Abidjan, led to substantial changes in and around the Zoo and UNA campus, including the death of some of the larger animals in the Zoo, which could have probably contributed to reduce the density of tsetse flies. Nevertheless, a zero apparent density of tsetse flies since September 2011 in the Zoo was obtained and a similar result was also obtained in UNA since December 2011. For that reason, it can be argued that the combination of insecticidal paint and insecticide-impregnated netting could be a useful approach for tsetse control in some areas particularly in farms and or pasturages, where large animals like cattle can effectively serve to attract tsetse flies.

Acknowledgement

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