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A Large-scale Trial to Evaluate the Efficacy of a 1% Pour-on Formulation of Cyfluthrin (Cylence, Bayer) in Controlling Bovine Trypanosomosis in Eastern Zambia

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ABSTRACT

A trial to evaluate the efficacy of a 1% cyfluthrin pour-on formulation (Cylence, Bayer) in reducing the incidence of bovine trypanosomosis was conducted in an area of ca. 2000 km^2 of the Eastern Province of Zambia. The trial area was cultivated and carried a cattle population of approximately 11 animals/km^2. Cattle were the main host of tsetse. Following the free of charge treatment of the adult cattle at intervals of 7 weeks and at a dosage of 15 ml/100 kg body weight, there was an increase in the average packed cell volume in the herd although the decline in the incidence of trypanosomal infections was more prolonged. The monthly incidence of trypanosomal infections started to decline substantially 8 months after the treatments were initiated. No trypanosomal infections were detected from 10 months after the start of the trial.

Keywords: cattle, control, cyfluthrin, incidence, packed cell volume, pour-on, trypanosomosis, tsetse

Abbreviations: a.i., active ingredient; PCV, packed cell volume

INTRODUCTION

The attractiveness of their hosts was exploited as a control method for tsetse by researchers as early as the 1940s (Vanderplank, 1947; Whiteside, 1949; Burnett, 1954). Despite initial successes, this promising tsetse control method was abandoned because of the low persistence of the insecticides used at that time. It took almost 40 years before the method was taken up again. This was a result of the discovery of the persistent and less toxic synthetic pyrethroids. The first controlled study on the persistence of the toxic effect on tsetse of deltamethrin sprayed on cattle was conducted in Zimbabwe (Thomson, 1987). The results of the trials indicated a high mortality in

Glossina pallidipes and *Glossina morsitans morsitans* within the first two weeks of insecticidal treatment, followed by a long-lasting knock-down effect.

Despite the successful application of this method in other parts of Africa (e.g. Bauer *et al.*, 1992, 1995; Fox *et al.*, 1993; Leak *et al.*, 1995), it has not been used on a large-scale in southern Africa. This was mainly because of the earlier goal of eradicating tsetse from extensive areas, including those where cattle were absent (Lovemore, 1999). However, the current unfavourable economic environment has prompted a shift in emphasis from large-scale tsetse eradication to small-scale, sustainable, trypanosomosis control. As a consequence, control focuses on areas where bovine trypanosomosis is a constraint to development and where disease management practices can be improved (Doran and Van den Bossche, 2000). In such areas, insecticidal treatment of cattle may be an appropriate control control method.

A trial was conducted in a cultivated savannah area of eastern Zambia to evaluate the efficacy of using cattle treated with insecticide to control tsetse under conditions prevailing in southern Africa.

MATERIALS AND METHODS

Trial area

The trial was carried out in a rectangular area ca. 80 km long and 25 km wide (ca. 2000 km^2) situated at 30°44′–31°08′E and at 14°07′–14°42′ S, in the Petauke and Nyimba Districts of the Eastern Province of Zambia (Figure 1). The area was highly cultivated and carried a cattle population (Angoni breed) of approximately 11 animals/km^2 (Doran, 1998). The cattle were owned by about 32% of the households, with an average herd size per owner of 7.2 ± 0.6 animals (Doran, 2000).

The natural vegetation within the trial area can be classified in two main types, i.e. miombo and munga woodland. However, because of the mixed sedentary farming system and the demographic pressure on land for agriculture, ca. 60% of the area has been cleared of its natural vegetation. The annual climatic cycle comprises three seasons: the warm rainy season (from early November to late April), the cold dry season (from early May to late August) and the hot dry season (from early September to late October). *G. m. morsitans* was the only tsetse species and was present at relatively low density (Van den Bossche, 2001). It took ca. 75% of its blood meals from cattle (Van den Bossche and Staak, 1997). Tsetse-transmitted bovine trypanosomosis was endemic, with a monthly average incidence of 9.7%, and the index of abundance of tsetse explained 72% of the variance in this incidence (Van den Bossche, 2001). Trypanosomosis (mainly caused by *Trypanosoma congolense*) was controlled using trypanocidal drugs (Van den Bossche *et al.*, 2000). Trypanocidal drug resistance was not considered to be a problem. The trial area was subject to re-invasion by tsetse from all sides, except from the east, where re-invasion was prevented by odour-baited, insecticide-treated targets.

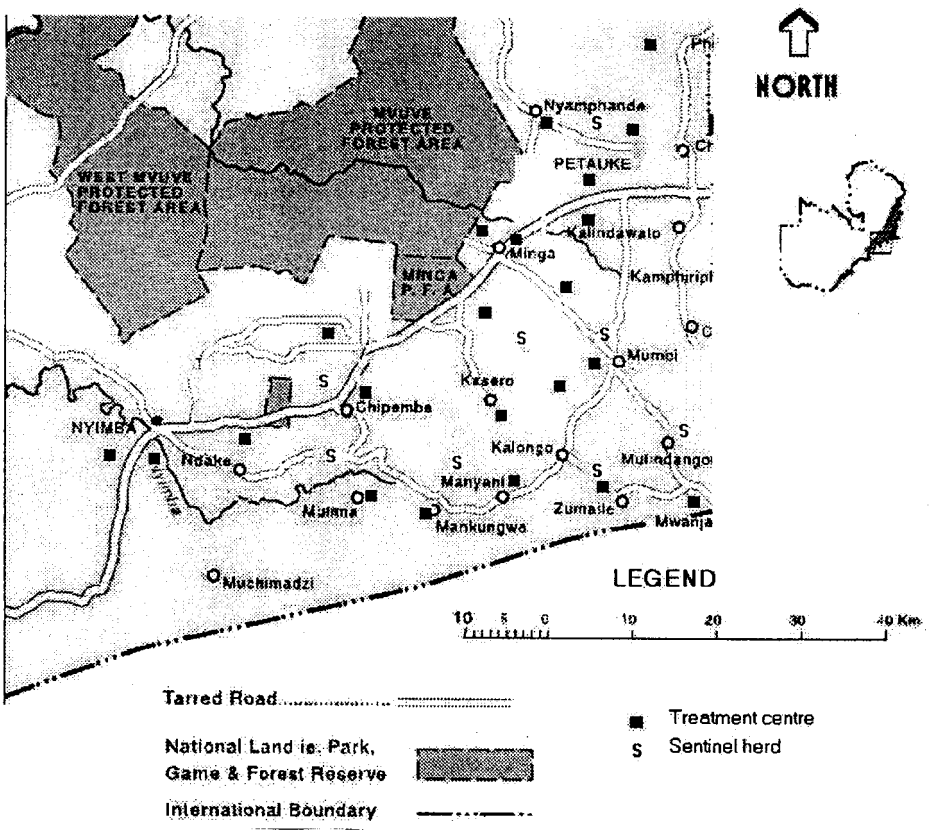

Figure 1. Map of the trial area, indicating the location of the treatment centres and sentinel herds

Insecticidal treatment

Between November 1998 and December 1999, a pour-on formulation containing 1% cyfluthrin (Cylence, Bayer, Leverkusen, Germany) was applied in a single line along the spine of adult animals, from shoulder to tail base, at a dose of 15 ml/100 kg body weight (0.15 g of a.i. per 100 kg), using an automatic pour-on applicator. The treatments were repeated at approximately 7-week intervals and the pour-on was applied free of charge. To facilitate the insecticidal treatment of all adult cattle in the trial area, 22 treatment centres were established (Figure 1). Records were kept of the number of animals treated at each centre during each treatment. The total number of animals treated was expressed as a proportion of the total number of animals in the trial area. Throughout the trial period, an average of 61.6% of the total cattle

population was treated with cyfluthrin during each treatment. However, the proportion of the cattle population that received treatment differed substantially between treatments (Figure 2). This figure was, on average, 53.7%±9.2% during most of the rainy season but reached a maximum average of 88.3%±10.2% between the end of the rainy season and the cold dry season. During the hot dry season, the average proportion of animals treated was again low (33.6%±1.1%).

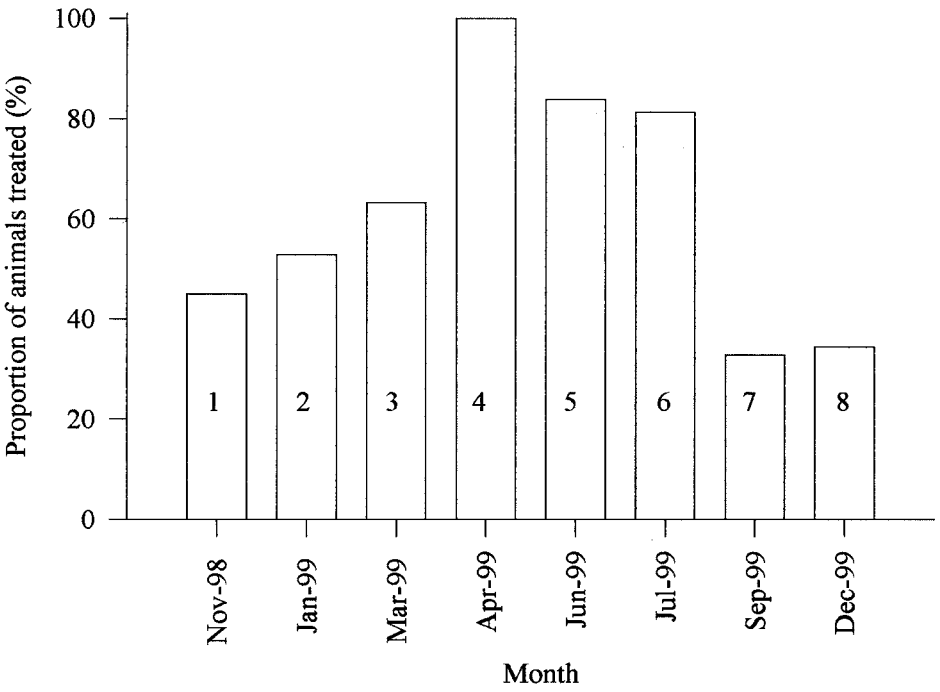

Figure 2. Proportion of the total cattle population treated with cyfluthrin pour-on during consecutive treatments

Trypanosomosis monitoring

Because of the low density of tsetse in the trial area and the anticipated difficulty in detecting *G. m. morsitans* populations at an even lower density once control measures had been implemented, the effect of the application of the pour-on on the density of the tsetse population was monitored indirectly by determing the incidence of trypanosomosis in eight sentinel herds located throughout the trial area (Figure 1). Each sentinel herd consisted of 20 eartagged adult Angoni cattle, kept under traditional village management. The herds were established in June 1997, 16 months before insecticide application started. Since a suitable control area was not available, the monthly

incidences of trypanosomal infections in the sentinel herds between July 1997 and October 1998 were used as the control. Although field trials have shown that cyfluthrin treatment has no effect on alighting responses and does not inhibit feeding or disease transmission (Vale *et al*., 1999), the sentinel cattle were not treated with the cyfluthrin pour-on. At the start of the trial, all the sentinel animals received an intramuscular treatment with diminazene aceturate (Berenil, Hoechst, Frankfurt am Main, Germany) at a dose of 7 mg/kg body weight. Each month, blood collected from each sentinel animal was examined using parasitological diagnostic methods and the incidence of trypanosomal infections was determined (Paris *et al*., 1982). Blood was collected from an ear vein into heparinized microhaematocrit centrifuge capillary tubes and onto glass slides, as thick and thin blood smears. The capillary tubes were sealed with 'Cristaseal' (Hawksley, Lancing, UK) and immediately centrifuged in a microhaematocrit centrifuge for 5 min at 7500*g*. After centrifugation, the PCV was determined. The buffy coat and the uppermost layer of red blood cells of each specimen were then extruded onto a microscope slide and examined under a phase-contrast microscope with a $\times 40$ objective lens for the presence of motile trypanosomes, Giemsa-stained thick and thin blood smears were examined under $\times 100$ oil immersion objective lens for the presence of trypanosomes.

Animals that were infected with trypanosomes received a curative treatment of diminazene aceturate, at a dose of 7 mg/kg body weight for *T. brucei* or 3.5 mg/kg body weight for *T. congolense* or *T. vivax*, by intramuscular injection. Animals given diminazene aceturate were considered to be protected during the subsequent two weeks, and were therefore excluded from the next calculation of the incidence of trypanosomosis.

Trypanocidal drug use

To evaluate the cattle owners' perceptions of the effect of the pour-on on the animals' condition, records on the sales of diminazene aceturate were obtained from the Veterinary Offices of the Districts. Diminazene aceturate sales between January and June 1999 were compared with the sales during the same period in 1998.

RESULTS

Incidence of bovine trypanosomosis

Between November 1998 and December 1999, the monthly average incidence of trypanosomosis was negatively correlated with the time elapsed since the start of the cyfluthrin applications ($r = -0.81$, $p < 0.05$). A period of slow decline in incidence (November 1998 – June 1999) was followed by a dramatic fall to 0.8% in August 1999 (Figure 3). From September 1999 onwards, no trypanosomal infections were detected in the sentinel cattle. Most of the trypanosomal infections (90.9%) were due to *T. congolense*. *Trypanosoma vivax* accounted for the remainder.

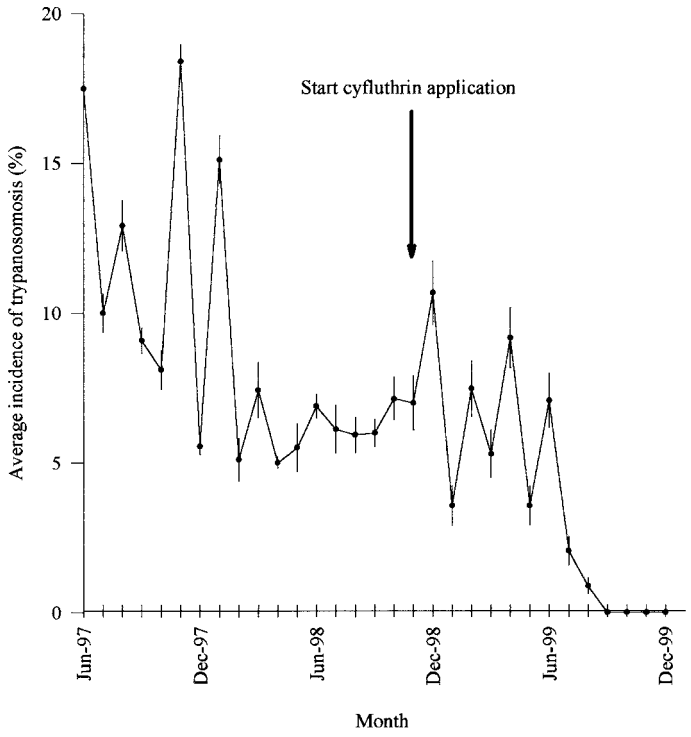

Figure 3. Monthly average incidence of trypanosomal infections ($\pm$SD) in sentinel cattle before and after the application of the cyfluthrin pour-on

Trypanocidal drug use

Despite the absence of a significant effect of the pour-on treatments on the incidence of trypanosomosis during the first seven months of the trial, sales of trypanocidal drugs decreased substantially during the same period. Between January and June 1999, a total of 3738 doses of diminazene aceturate was sold in the trial area compared to 13 134 doses during the same period in the preceding year.

Packed cell volume

The application of the pour-on resulted in an increase in the monthly average PCV of the sentinel cattle (Figure 4). During the period January to December 1998, the monthly average PCV in the sentinel cattle (28.5%$\pm$0.2%) was significantly lower (*t*-test, $p < 0.001$) than during the same period in 1999 (30.6%$\pm$0.5%) when the pour-on was being applied.

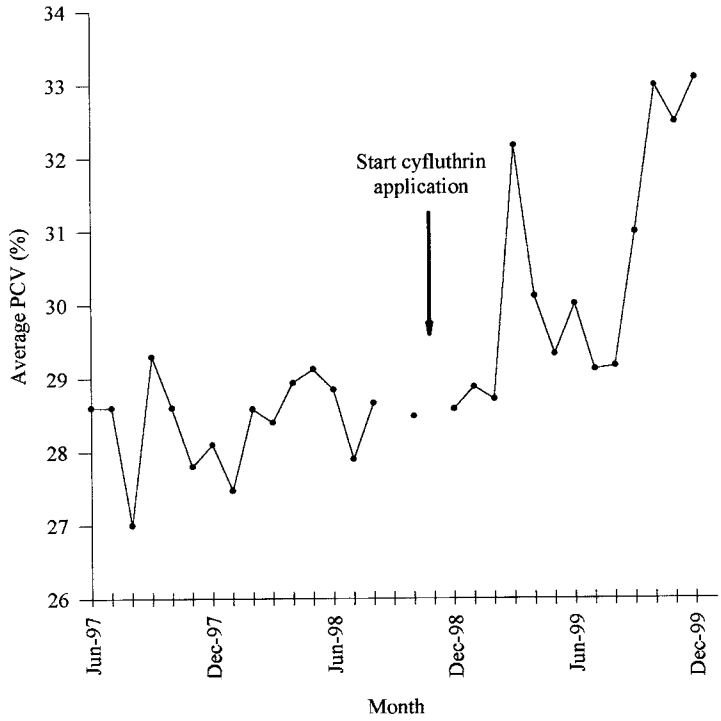

Figure 4. Monthly average PCV of sentinel cattle before and after the application of the cyfluthrin pour-on

DISCUSSION

Several studies have shown that regular treatment of cattle with pyrethroid insecticides, such as deltamethrin, flumethrin or cypermethrin, can significantly reduce the incidence of bovine trypanosomosis (e.g. Chizyuka and Luguru, 1986; Bauer *et al.*, 1992; Leak *et al.*, 1995). Results from this trial showed that a 1% pour-on formulation of cyfluthrin applied at 15 ml/100 kg body weight at 7-week intervals also resulted in a significant reduction in the incidence of trypanosomal infections in cattle compared with the pre-treatment incidence. Since the trial area was an extension of an existing control operation and all the remaining cultivated areas were included in the trial, it was impossible to establish a sentinel herd in an adjacent comparable area where tsetse and cattle were present. Therefore, the monthly average incidence of trypanosomosis in cattle recorded during the months preceding the trial was used as the control. In such an experimental set-up, it may be difficult to distinguish the real effect of the cyfluthrin treatments on the incidence of trypanosomosis or the herd average PCV from the effect of other factors, such as climate. However, long-term studies on the incidence of bovine trypanosomosis in the trial area have shown that, in the absence of control

measures, the incidence of bovine trypanosomosis is highest at the end of the dry/beginning of the rainy season (Van den Bossche, 2001). Hence, the observed decline in incidence is most likely to have been due to a decline in the density of tsetse after the application of the pour-on. The increase in the average PCV of the herd is also best explained by a decline in the incidence of trypanosomosis. Although the herd average PCV increased after the treatment started, consistently high average PCVs were only observed after the incidence of trypanosomosis was reduced to zero.

A spectacular effect on the monthly incidence was only observed 8 months after the application of the insecticide commenced. Several possibilities can explain this delay. First, the average proportion of animals treated between November 1998 and March 1999 (53.6%), was substantially lower than the coverage between April and July 1999 (88.3%). Second, insecticide being washed off during heavy rain showers or rubbed off when walking through tall grass and the effective unavailability of the insecticide on animals covered in mud may have reduced the effect of the insecticidal treatments on tsetse during the rainy season. Finally, the length of the persistence of cyfluthrin is inversely related to the average maximum temperature (Vale *et al.*, 1999). The average maximum temperature in the trial area varies between $33.1 \pm 5.9^{\circ}$C during the hot and wet season (November to April) and $26.1 \pm 1.0^{\circ}$C during the cold and dry season (May to August) (Van den Bossche, 2000). At this difference in mean maximum temperature, the persistence of cyfluthrin may be as much as 4 weeks shorter during the hot wet season compared to the cold dry season (Vale *et al.*, 1999).

Notwithstanding the fact that the trial area was subject to invasion by tsetse from three sides, no trypanosomal infections were detected in sentinel cattle herded close to the invasion front from September 1999 onwards. This finding accords with the prediction of a model described by Vale and colleagues (1999). Given the high proportion of feeds taken by tsetse from cattle throughout the year, the frequent application of insecticide and the relatively low density of tsetse in the trial area, the width of the zone near the invasion front where cattle are exposed to tsetse challenge is probably only 1–2 km (Vale *et al.*, 1999). On the assumption that tsetse have been eradicated from the remainder of the trial area, a barrier of treated cattle ca. 5 km wide would suffice to prevent tsetse reinvasion into the cleared area.

Despite the absence of an immediate effect on the incidence of trypanosomal infections, the cyfluthrin applications seem to have resulted in an immediate improvement in the condition of the sentinel cattle in the trial area. This is reflected in the increase in the monthly average PCV of the cyfluthrin-treated herd, which commenced soon after the treatments started. Such an increase in the herd average PCV, in the absence of an effect on the incidence of trypanosomal infections, has been observed by others and attributed to the effect of the pyrethroid insecticidal applications on the abundance of other vectors, such as ticks and biting flies (Bauer *et al.*, 1992, 1999; Baylis and Stevenson, 1998). The improvement in herd health was confirmed indirectly by the apparent substantial reduction in the sales of diminazene aceturate after the trial was initiated. Trypanocidal drugs are readily available in the trial area. The cattle owners have adopted a curative treatment strategy and apply most diminazene aceturate to animals that are clinically ill, usually without a confirmed diagnosis (Van den Bossche *et al.*, 2000). Hence, an improvement in the condition of the animals

would logically have resulted in a reduction in trypanocidal drug use, even in the absence of a spectacular effect on the incidence of trypanosomosis.

Although the trial was aimed only at evaluating the effectiveness of a pour-on formulation of cyfluthrin in controlling bovine trypanosomosis in a savannah area of southern Africa, some conclusions can be drawn on the appropriateness of this control method in the mixed sedentary farming system of the region. The efficacy of insecticide-treated cattle in controlling trypanosomosis hinges on the importance of cattle in the diet of the tsetse, the proportion of the total cattle population treated at regular intervals, and the invasion pressure from tsetse. The importance of cattle in the diet of the tsetse varies spatially but is usually high in areas where people and cattle have encroached into a tsetse-infested game area and where, because of cultivation, the density of large game animals has subsequently declined (Van den Bossche, 2001). The cattle owners' willingness and ability to pay for the insecticidal treatments will determine the proportion of cattle treated. In the trial area, trypanosomosis-related mortality was being avoided by treating each productive animal approximately once a year with diminazene aceturate. At this treatment rate, calving rates remain suppressed by trypanosomosis (Doran, 2000). Hence, the expected additional benefit accruing from the insecticidal treatments would be an increase in the calving rate from an average of 44% to 60% (Doran, 2000). The annual cost of obtaining this beneficial effect would be substantially higher than the cost of the current use of trypanocidal drugs. For the cattle owners living in the central part of the trial area, however, the need for insecticidal treatments would only be temporary. Cattle owners living on the fringe of the trial area, on the other hand, would have to continue applying insecticide to prevent re-invasion of tsetse from the surrounding tsetse-infested area and also to use trypanocides to treat infected animals or prevent infection. Even if the community covered the costs of these treatments at the fringes, the strategy for controlling trypanosomosis described above could only be sustained if an appropriate institutional framework provided assistance with the planning for and implementation of the insecticidal treatment. Such a framework would still need to be developed. However, the relative costs of using alternative procedures, such as the use of odour-baited targets as barriers against re-invasion (Hargrove, 1993), with the possible involvement of the private sector in their maintenance, merits consideration.

ACKNOWLEDGEMENTS

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Essai à grande échelle pour évaluer l'efficacité d'une formulation versable de cyfluthrine dosée à 1% (Cylence, Bayer) dans le contrôle de la trypanosomose bovine en Zambie de l'Est

Résumé – On a entrepris un essai pour évaluer l'efficacité d'une formulation de cyfluthrine versable dosée à 1% (Cylence, Bayer) dans la diminution de l'incidence de la trypanosomose bovine dans une zone d'environ 2000 km^2 de la province de la Zambie de l'Est. La zone sur laquelle a porté l'étude était cultivée et avait une population bovine d'approximativement 11 animaux/km^2. Le bétail était l'hôte principal des mouches tsé-tsé. Suite au traitement gratuit du bétail adulte à des intervalles de 7 semaines et à une posologie de 15 ml/100 kg de poids corporel, on a pu constater une augmentation de l'hématocrite moyen dans le troupeau, bien que la diminution de l'incidence des infections trypanosomales se soit étalée sur plus de temps. L'incidence mensuelle des infections trypanosomales a commencé à diminuer considérablement 8 mois après l'institution des traitements. Aucune infection trypanosomale n'a été détectée 10 mois après le démarrage de l'essai.

Experimento a gran escala para evaluar la eficacia de una formulación al 1% de cifluthrin pour-on (Cylence®, Bayer) en el control de la tripanosomiasis bovina al este de Zambia.

Resumen – Se llevó a cabo un experimento para evaluar la eficacia de una formulación al 1% de cifluthrin *pour-on* (Cylence®, Bayer) en la reducción de la incidencia de la tripanosomiasis bovina, en un área de unos 2000 km^2 al este de Zambia. El área experimental fue cultivada y poblada con unas 11 cabezas/km^2 de ganado vacuno. El ganado vacuno era el principal huésped de la mosca tse-tsé. Después del tratamiento gratuito del ganado adulto a intervalos de 7 semanas y a una dosis de 15 ml/100 kg de peso vivo, se observó un incremento del valor hematocrito en el rebaño, aunque la disminución en incidencia de infestaciones por tripanosoma fue posterior. La incidencia mensual de las infestaciones por tripanosoma empezó a disminuir sustancialmente 8 meses después del inicio de los tratamientos. No se detectaron infestaciones por tripanosoma a partir de los 10 meses tras el inicio del experimento.