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Evaluation of Deltamethrin applications in the control of tsetse and trypanosomosis in the southern rift valley areas of Ethiopia

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ABSTRACT

A study aimed at evaluating the efficacy of Deltamethrin (0.4% impregnated targets and 1% pour-on formulation) in controlling tsetse and trypanosomosis was carried out in two selected 10 km × 10 km Universal Transverse Mercator Grids of the Southern Tsetse Eradication Project (STEP) area in the southern rift valley of Ethiopia. The Grids selected were H3 (site I) and G5 (site II) in two districts of the Wolaita Zone. The trial was underway from September 2003 to April 2004. The strategy followed to accomplish the trial was a pre-intervention phase (entomology and parasitology) and an intervention phase with insecticide (Deltamethrin 0.4%)-impregnated odour-baited targets in site I and Deltamethrin 1% 'pour-on' application to cattle in site II. The intervention phase was monitored on a monthly basis. Following the deployment of 460 targets at a density of 4 targets per km² in trial site I, the relative abundance of tsetse fly (*Glossina pallidipes*) declined from a pre-intervention mean catch of 1.35 flies per trap per day to 0.05 flies per trap per day at final monitoring. These resulted in an 88.9% overall reduction. Similarly, an 83.25% reduction was recorded in the incidence of trypanosomosis in sentinel cattle as it dropped from 10.75% (first monitoring) to 1.8% (last monitoring). The corresponding measures of packed cell volume (PCV) have shown a significant improvement from a mean of 21.8% (95% confidence interval (CI): 20.7–22.9) at first monitoring to 25.5% (95% CI: 24.3–26.7) of last monitoring ($P < 0.01$). In site II, the trial was started by spraying Deltamethrin 1% pour-on to 409 cattle at a rate of 1 ml/10 kg body weight. Pour-on treatment was repeated every month throughout the trial period. A sharp drop in the relative abundance of tsetse fly was revealed soon after. The catch was nil at fourth monitoring as it declined from 0.91 flies per trap per day of pre-intervention ($P < 0.01$). A 94.9% overall reduction was achieved. The incidence of trypanosomosis in sentinel cattle also declined from 10% (first monitoring) to 0.95% (last monitoring) with about 90.5% decline. An improvement in the overall mean PCV was seen as it rose from a mean of 24.1% (95% CI: 22.9–25.3) at first monitoring to 27.2% (95% CI: 26.2–28.1) at last monitoring which revealed a significant increase ($P < 0.01$) until the third monitoring and maintained a stable state thereafter. This work finally disclosed that a relatively better efficacy was attained by using Deltamethrin pour-on formulation than targets in controlling tsetse and trypanosomosis. However, this difference did not prove an apparent significance ($P > 0.05$). So it is recommended to continue the current tsetse suppression by using the integrated approach of both techniques under consideration.

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1. Introduction

Tsetse-transmitted trypanosomosis is the main constraint to livestock production in the continent of Africa, preventing full use of land to feed the rapidly increasing human population (Murray et al., 1991). It affects 37 sub-Saharan countries, extending over 10 million km² of land (Erkelens et al., 2000). In Ethiopia, the potential area of tsetse infestation has been estimated at 220,000 km² (MOA, 1995). These tsetse-infested and problem areas are confined to the west and south-western region of the country. Five species of tsetse namely *Glossina morsitans submorsitans*, *G. pallidipes*, *G. fuscipes fuscipes*, *G. tachinoides*, and *G. longipennis* are known to exist. These vectors cyclically transmit four species of trypanosomes (*Trypanosoma congolense*, *T. vivax*, *T. brucei brucei* of livestock and *T. rhodesiense* of human) (Langridge, 1976).

The disease is excluding the agriculturally suitable land in the infested part of the country and a total of 14.8 million heads of cattle, 6.12 million sheep and goats, and a considerable number of other domestic animals are at risk (MOA, 1995). Various efforts of control of the disease and losses thereof have been directed mainly at the parasite through trypanocidal drugs and the vector through odour-baited and insecticide-impregnated targets/traps and insecticide-treated cattle (Slingenbergh, 1992; Leak et al., 1996). Vector control operations have been implemented mainly through specifically designed joint projects that offered some promising local results (Lemecha et al., 2006). However, the vector control operation is limited in areas of approximately 14% of the total tsetse-infested area (MOA, 1995). Moreover, recent situations of tsetse fly advances to previously unoccupied sites and development of trypanocidal drug resistance are thought to hamper the envisaged results of these efforts.

The Rift valley is part of the country in the south-western region which is most severely affected. About 25,000 km² area that is an agriculturally potential land in the Rift valley is infested by tsetse flies. In this part of the country, almost all domestic animals in and adjacent areas of the valley are at risk of acquiring the disease at any time (Vreysen et al., 1999). The suppression of high fly population densities using conventional tsetse control techniques involve the use of insecticide-impregnated, odour-baited targets and insecticide-treated cattle (pour-on) techniques have been practiced in the tsetse-infested area.

Although the two techniques tend to show some degree of harmony, the different approaches of their practice and as a result the achievements obtained in tsetse suppression could reveal some disparity. Assessments regarding the length of time required for achieving a significant result, convenience of application, labour requirement and cost conditions were discussed in several reports. However, information about the comparative evaluation of the two techniques with determination of their efficacies is lacking. Such information could be helpful for better understanding and choosing the right technique for use in the suppression activity of the current project area. Therefore, the objective of this study is to compare the efficacy of Deltamethrin as

0.4% impregnated, odour-baited targets and 1% pour-on formulation applied to cattle.

2. Materials and methods

2.1. The study area

The Southern Tsetse Eradication Project (STEP) area has been divided into three operational blocks. The first block, an approximate area of 6000–7000 km² is situated in the southern rift valley and most of the area lies within the administrative boundary of the Southern Nation Nationalities and Peoples Region (SNNPR). The trials were carried out in an area of about 100-km² grids selected from two districts of the Wolaita Zone within STEP area. The peasant associations (PA's) namely: Tora-Sedebo and Adecha found close to Bilate River in Damot Woyde district were considered as site I. These PAs found in the specified Grid H3 are located at about 36 km eastward from Soddo town. The coordinates for 'Grid H3' are 6°47'50"N–6°52'30"N and 37°55'00"E–38°00'00"E. The second site was Abela-Mareka PA of Humbo district referred to as 'site II' 'Grid G5'. This PA is 40 km south of Wolaita Soddo town on the way to Arba Minch near to Lake Abaya. The coordinates for 'Grid G5' are 6°32'00"N–6°37'00"N and 37°49'44"E–37°55'00"E. The altitudes of both sites were in the range of 1300–1600 m above sea level. According to the information supplied by the respective district agricultural offices cattle population for sites I and II was estimated as 1754 and 1500, respectively. Cattle in these areas were indigenous East African Zebu type kept under traditional extensive system.

2.2. Study methodology

2.2.1. Study design

The strategy chosen for conducting the trial involves a pre-intervention phase (cross-sectional study) and intervention phase (longitudinal study). Pre-intervention phase comprises of baseline data collection to determine the existing situation just before the intervention. It was conducted in September 2003. Following this, an intervention phase kicked off by application of test insecticide (Deltamethrin) in the sites I and II. Monitoring of the intervention phase was in operation monthly from October 2003 to April 2004.

2.2.2. Sampling method

In site II owners were told to bring their animals to the sampling site for free pour-on treatment. Conversely, owners in site I were encouraged to co-operate in tsetse control and free drug treatment was promised to encourage them to bring their animals in accordance to the schedule of this work. Then systematic random sampling was carried out to examine animals for baseline parasitological survey. This time the animals were systematically selected by drawing numbers on the cards distributed to the owners. These cards bearing numbers were distributed to owners on arrival to the sampling site and each owner receives a card assigned for each animal brought. For entomology, abundance of tsetse flies,

frequency of trypanosomosis cases, altitude category, vegetation type, cattle grazing land and watering points were taken as criteria to determine the ideal habitat of tsetse flies for study site selection.

2.2.3. Pre-intervention phase (cross-sectional study)

2.2.3.1. Entomological data. Entomological data collection was carried out by deploying a total of 71 NG2G traps (35 in site I and 36 in site II). The NG2G traps (Brightwell et al., 1991) constructed from locally made blue and black cloth with white mesh on the top were baited with 3-week-old bovine urine and acetone in two different dispensing bottles. Traps were set at approximately 200–250 m apart. All trap positions were geo-referenced (using hand-held GPS, Garmin 48), and the altitude and vegetation type recorded. It was attempted to include different vegetation types such as bush land (BUL), wooded grassland (WGL), and cultivated land (CUL) for trapping. Collection of trapped flies took place 72 h after deployment.

2.2.3.2. Parasitological and haematological data. A total of 323 cattle aged above 1 year old were randomly selected and sampled. Blood samples were collected from marginal ear veins using micro-haematocrit capillary tube and sealed on one side with cristaseal (Hawksely Ltd.). The capillary tube was then transferred to a haematocrit centrifuge and spun for 5 min at 1200 revolutions per minute. The centrifuged capillary tube was measured for PCV values on the haematocrit reader. It was then cut 1 mm below the buffy coat and the contents of the tube expressed on to a slide, mixed and covered with a 22 mm × 22 mm cover slip. This slide was then examined under 40× objective using phase contrast (Murray et al., 1977) or dark field microscopy to examine for the presence/absence of motile trypanosomes. Animals detected positive for trypanosomes as well as showing the clinical signs were treated with curative dose of Berenil® (Diminazene aceturate) at a dose rate of 3.5 mg/kg body weight intramuscularly. Simultaneously, sentinel cattle comprising 95 and 75 in sites I and II, respectively, were selected and ear-tagged for monitoring during the intervention phase.

2.2.4. Intervention phase (longitudinal study)

2.2.4.1. Insecticide-impregnated odour-baited targets (site I). Tsetse suppression was carried out at site I by deploying a total of 460 impregnated targets. Targets were made of blue-black-blue cloth of 175 cm × 50 cm overall size. They were impregnated with Deltamethrin 20% (w/v) suspension concentrate (S.C.) diluted with water to a concentration of 0.4% spray liquid. Then the targets were immersed and kept for 20 min to allow sufficient absorption of insecticide liquid (an approximated 100-mg active ingredient). Therefore, 1 l of Deltamethrin 20% (w/v) suspension concentrate (S.C.) was used to impregnate 500 targets sufficient for first-round deployment and subsequent replacement. Community participation was initiated to undertake the task of target deployment assisted by technical staff. The targets were deployed at a density of

four targets per km² where they were positioned approximately 250 m apart. Acetone was used as the odour attractant in this case. Odour replenishment was made 3 months after the initial deployment.

2.2.4.2. Pour-on application (site II). In site II, insecticide-treated cattle were used as the strategy for tsetse suppression. Nearly one-third of the cattle in the area, including calves younger than 1 year, were selected and treated with pour-on insecticide. A total of 2200 treatments were carried out throughout the intervention period in site II with an average of 440 treatments monthly. This was done by spraying Deltamethrin 1% (w/v) pour-on ready-for-use formulation (Appropriate Applications Ltd., USA) at a dose rate of 10 ml per 100 kg body weight. Consequently, 44 l of Deltamethrin 1% pour-on ready-for-use formulation was used in due course of action. A special applicator (T-bar applicator) was used to apply the insecticide along the line starting from in front of the shoulder running back to behind the hip.

2.2.4.3. Intervention monitoring. The intervention phase was monitored to assess its impact on tsetse fly population, trypanosomosis incidence in sentinel cattle and degree of improvement in PCV of animals. It was conducted by collecting monthly entomological, parasitological and haematological data. Entomological monitoring was conducted by deploying NGU traps in the previous sites of catch using odour baits (acetone and bovine urine). Their collection was carried out as usual. Parasitological and haematological examinations were subsequently conducted on blood samples taken from established sentinel cattle. On average, a period of 1 week long was often spent in monitoring activity. Thus a total of five subsequent monitoring visits (M1, M2, M3, M4 and M5) took place to accomplish the envisaged trials.

2.3. Statistical analysis

Initially all sorts of data were stored in Microsoft Excel spreadsheet. It was edited and then transferred to the statistical software called Intercooled Stata version 7.0 for Windows 98/95/2000/NT (Stata Corporation, College Station, TX, USA) for different ways of analysis. Descriptive statistics, confidence intervals, Student's *t*-test, chi-square test, and analysis of variance (ANOVA) were applied in analysing disparity between variables. The pre-intervention entomological data (trap catches) were calculated as apparent density (relative abundance) and expressed as mean catch off tsetse flies per trap per day. These mean results of both sites were then compared by Student's *t*-test. Similarly, prevalence was determined for the pre-intervention parasitological data and compared by chi-square test. For the intervention results, entomological data were first converted in to $\ln(\text{catch} + 1)$ to determine 'de-transformed mean' (geometric mean) in each monitoring visit and compared by Student's *t*-test. Then percentage reduction was calculated to determine the efficacy of test insecticide according to the technique used. Calculating the incidence rates of each monitoring and the rate of reduction in the disease status by descriptive

Table 1
Summarized pre-intervention entomological result.

| Site | Number of traps | Tsetse species | Catch | | | |
|-------|-----------------|----------------------|-------|--------|-------|--------------------|
| | | | Male | Female | Total | RA (95% CI) |
| I | 35 | <i>G. pallidipes</i> | 62 | 80 | 142 | 1.35 (0.909–1.796) |
| II | 36 | <i>G. pallidipes</i> | 26 | 72 | 98 | 0.91 (0.712–1.103) |
| Total | | | 88 | 152 | 240 | 1.12 |

RA, relative abundance of tsetse fly per trap per day; CI, 95% confidence interval.

Table 2
Pre-intervention parasitological profile of cattle in trial sites.

| Site | Cattle | | | | | | Prevalence % (95% CI) |
|-------|----------|-----------|-----------|-----------|--------|-------|-----------------------|
| | Examined | Infected | | | | | |
| | | <i>Tc</i> | <i>Tv</i> | <i>Tb</i> | Mixed | Total | |
| I | 171 | 29 | 8 | 2 | – | 39 | 23 (0.17–0.29) |
| II | 152 | 20 | 6 | 4 | 2 | 32 | 21 (0.15–0.27) |
| Total | 323 | 49 (70%) | 14 (20%) | 6 (8%) | 2 (2%) | 71 | |

CI, confidence interval; *Tc*, *Trypanosoma congolense*; *Tv*, *T. vivax*, *Tb*, *T. brucei*.

statistics assessed the situation of the disease during intervention and then McNemar's test was used. Moreover, the mean PCV of sentinel cattle before and after intervention were evaluated using Student's *t*-test for related samples. Only new cases were considered when calculating the incidence rate. Further, the individual level PCV records for parasitaemic and non-parasitaemic cattle were tested by ANOVA. Finally, an attempt to estimate the corresponding prevalence to infections in sentinel cattle from the incidence records of the final monitoring was made. This was believed to assist in comparing current result with that of pre-intervention.

3. Results

3.1. Pre-intervention

3.1.1. Entomology

Glossina pallidipes was the only species of tsetse detected (Table 1). There was no statistically significant difference in mean catch of tsetse flies per trap per day between the sites ($P > 0.05$). However, the result indicated that there was significant predominance of female flies ($\chi^2 = 7.56$; $P < 0.01$).

3.1.2. Parasitology

No statistically significant difference was observed between the two sites in trypanosome infections detected at pre-intervention ($P > 0.05$) as shown in Table 2.

Table 3
Pre-intervention frequency distribution in PCV versus infection status.

| Number of cattle | PCV <25% | | PCV ≥25% | |
|------------------|-------------|-------------|-------------|-------------|
| | Site I | Site II | Site I | Site II |
| Infected | 37 | 26 | 2 | 6 |
| Non-infected | 61 | 38 | 71 | 82 |
| Total | 98 (57.31%) | 64 (42.11%) | 73 (42.69%) | 88 (57.89%) |

3.1.3. Haematology

In this study, a PCV measurement of 25% was considered as a threshold value. The overall PCV profile of examined cattle has shown that majority of parasitaemic cattle had a PCV lower than the threshold value set (Table 3).

The individual animal-level PCV values recorded were also treated by using one-way ANOVA and thus non-parasitaemic cattle had significantly higher mean PCV (25.65% (95% CI: 25.17–26.13); $P < 0.01$) than parasitaemic ones (18.8% (95% CI: 17.74–19.87)) (Fig. 1). Furthermore, the mean PCV of cattle at site I was 23.5% (95% CI: 22.78–24.24) and that of site II was 24.8% (95% CI: 24.05–25.65) without significant variation ($P > 0.05$) between the sites.

3.2. Intervention

3.2.1. Entomology

Tsetse fly catches of the subsequent intervention monitoring were converted into $\ln(\text{catch} + 1)$ to show the result obtained. The result revealed a significant decline ($P < 0.01$) in both sites when the last monitoring (M5) was compared to pre-intervention (Fig. 2). This was more substantiated by percentage efficacy determined as 88.9% and 94.9% for sites I and II, respectively. However,

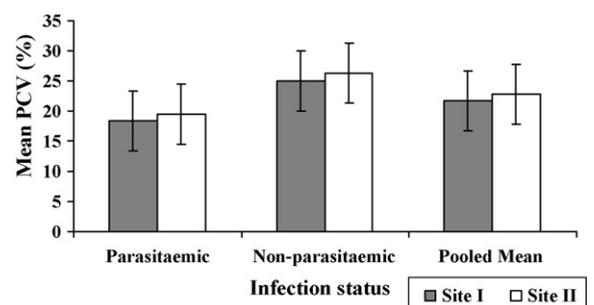


Fig. 1. Pre-intervention PCV profile in cattle according to infection status.

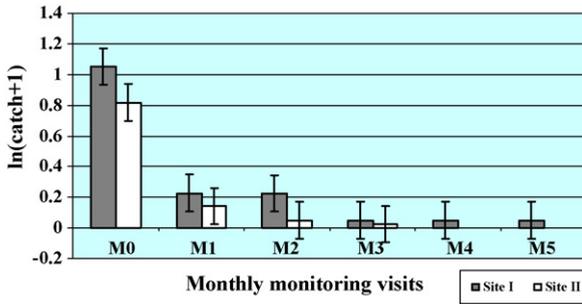


Fig. 2. Mean (geometric) tsetse fly catch at each monitoring of intervention phase. M0 = pre-intervention; M1, M2, M3, M4, M5 = 1st–5th monitoring.

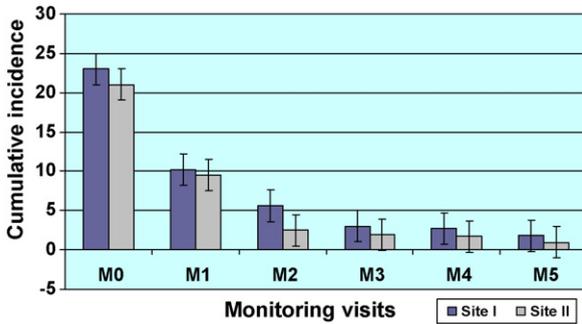


Fig. 3. Reducing incidences of trypanosomosis in sentinel cattle during intervention. M0 = pre-intervention; M1, M2, M3, M4, M5 = 1st–5th monitoring.

the difference between the two sites in this aspect was insignificant ($P > 0.05$) (Fig. 3).

3.2.2. Parasitology

The rates of infection detected during the intervention phase indicated that there was a tendency of continuous decline in the incidence of trypanosomosis in sentinel

Table 4
Incidences of trypanosomosis in sentinel cattle in site I.

| Monitoring visits | Number of animals | | | Incidence | |
|-------------------|-------------------|-----------------------|----------|-----------|------------|
| | Examined | Animal months at risk | Infected | Rate | Cumulative |
| 1 | 91 | 93 | 10 | 0.1075 | 0.1019 |
| 2 | 63 | 154 | 9 | 0.058 | 0.056 |
| 3 | 49 | 168 | 5 | 0.03 | 0.03 |
| 4 | 45 | 188 | 5 | 0.027 | 0.027 |
| 5 | 44 | 220 | 4 | 0.018 | 0.018 |

Table 5
Incidence of trypanosomosis in sentinel cattle in site II.

| Monitoring visits | Number of animals | | | Incidence | |
|-------------------|-------------------|-----------------------|----------|-----------|------------|
| | Examined | Animal months at risk | Infected | Rate | Cumulative |
| 1 | 65 | 70 | 7 | 0.10 | 0.095 |
| 2 | 58 | 122 | 3 | 0.025 | 0.025 |
| 3 | 45 | 154 | 3 | 0.0195 | 0.019 |
| 4 | 42 | 174 | 3 | 0.017 | 0.017 |
| 5 | 42 | 210 | 2 | 0.0095 | 0.0095 |

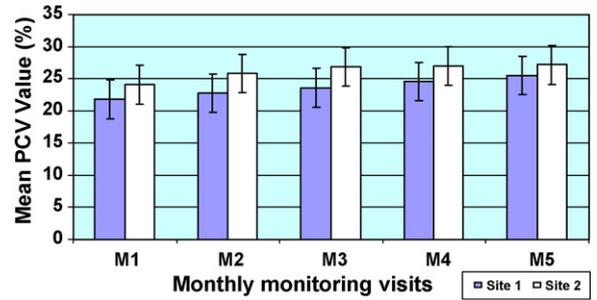


Fig. 4. PCV profile of sentinel cattle showing improvement at each monitoring (intervention).

cattle from both sites (Tables 4 and 5). The magnitude of this decline reveals a reduction of 83.25% in site I and 90.5% in site II. However, no significant variation was shown in trypanosome counts between the sites at last monitoring ($P > 0.05$).

According to prevalence estimation derived from final monitoring, a 9% prevalence of trypanosome infection was noted from site I where about 60% overall reduction was demonstrated as compared with pre-intervention (23%). Similarly, a pre-intervention prevalence (21%) of site II has dropped to 4.75% with a 77.4% reduction.

3.2.3. Haematology

In general, there was a general trend of gradual improvement in mean PCV of cattle monitored in sites I and II. There was a statistically significant ($P < 0.01$) rise in mean PCV in both sites throughout the intervention. The mean PCV of cattle in site I has followed a continuous improvement throughout the subsequent intervention monitoring. Similarly, the mean PCV in site II (Fig. 4) has shown a continuous increment only up to the third monitoring visit and maintained a slightly stable state thereafter. At last monitoring, the mean PCV of sentinel cattle in site II was 27.2% (95% CI: 26.2–28.1) without

significantly varying ($P > 0.05$) from that of site I with mean of 25.5% (95% CI: 24.3–26.7).

4. Discussion

The apparent densities of tsetse flies caught in pre-intervention phase were 1.35 flies per trap per day and 0.91 flies per trap/day in sites I and II, respectively. Muturi et al. (2000) reported a similar finding where they caught 1.4 flies per trap per day in the southern rift valley of Ethiopia. This report indicates that *G. pallidipes* was the principal vector caught in all low land areas under 1600 m above sea level. The pre-intervention findings of trypanosomosis prevalence were 23% and 21% in sites I and II, respectively. These results are closer to the previous (25.9%) reports by Muturi et al. (2000) in low altitude strata (<1600 m above sea level) of the project area. The detection of a high proportion of *T. congolense* (70%) in both sites of this study appears to be consistent with the previous reports of Abebe and Jobre (1996) in south-west Ethiopia. Moreover, Muturi et al. (2000) also reported about 66.86% *T. congolense* and 20.57% *T. vivax* infections in the project area. The current study did not report the finding of *T. vivax*, and this might be because of the different in vector control operations, drug intervention measures, sampling areas and season of study.

Marked difference was noticed in PCV according to the infection status of animals, where parasitaemic animals had generally lower mean PCV than non-parasitaemic ones. About 94.87% of the parasitaemic animals in site I and 81.25% in site II had PCV lower than the threshold value set (25%). According to Stephen (1986), anaemia is one of the most important indicators of trypanosomosis in cattle. The level of anaemia or the PCV usually gives a reliable indication of the disease status (Trail et al., 1991, 1993). The appearance of parasitologically negative animals with PCV values of less than the threshold value set (25%) may be due to the inadequacy of the detection method used (Murray et al., 1977) or delayed recovery of the anaemic situation after current treatment with trypanocidal drugs. Furthermore, the occurrence of positive animals with PCV of greater than 25% might be thought of recent infections of the animals. Therefore, trypanosome infection and mean PCV recorded in the current study were found to be highly related. Other factors are also anticipated to affect the PCV profile of animals. However, these factors are likely risks for both parasitaemic and non-parasitaemic animals (Van den Bossche and Rowlands, 2001).

During the intervention phase, the apparent density of tsetse flies caught decreased over the trial period. The mean of tsetse flies caught at the final monitoring in particular was lower than that at pre-intervention level. The overall reduction achieved in tsetse apparent density for site I was 88.9%. This could be attributable to the use of impregnated and baited targets with regular follow-up. Similarly, subsequent replacements of lost and damaged targets and replenishment of odours have contributed to sustain the effect of this technique. Leak et al. (1996) found out a decline of mean catch from 2.1 flies per trap per day of pre-control to 0.41 flies per trap per day in a period of 12 months after initiation of control using targets impreg-

nated with Deltamethrin 0.1% W/V. However, there is a relatively high rate of reduction in the current trial. This might be linked to the strength of concentration of Deltamethrin used to impregnate targets (0.4% W/V) in the current work leading to a better knockdown effect. Cherenet et al. (2006) also reported a lower incidence of trypanosome infection in tsetse-free zones than in tsetse-infested zones of the Amhara Region of northwest Ethiopia.

Similarly, the apparent density of tsetse flies caught every month from site II has dropped to nil at fourth monitoring of intervention, with overall reduction of 94.9% efficacy recorded. This is attributable to pour-on intervention. This demonstrates that Deltamethrin 1% pour-on has impacted on tsetse population by quick knockdown effect. This is consistent with Leak et al. (1995) where a trial carried out in Ethiopia with Cypermethrin-based pour-on (Ectopor, Ciba-Geigy Ltd, Switzerland) monthly application had resulted in a 98% decrease in apparent density of *G. pallidipes*. The efficacy of insecticide-treated cattle in controlling trypanosomosis hinge 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. Van den Bossche et al. (2004) have shown that the importance of cattle in the diet of tsetse varies spatially but is usually high in areas where people and cattle have encroached into a tsetse-infested game area. This was demonstrated in current study area.

Intervention and subsequent monitoring have shown that the incidence of trypanosomosis in site I declined from 10.75% at first monitoring to 1.8% at final monitoring. This finding confirms that there was a reduction of about 83.26% with a slow trend. Such slow rate of reduction could partly be due to the shorter time taken than the average required. Lumamba et al. (1997) and Chamsa and Mweempwa (1997) proved that using insecticide-impregnated odour-baited targets could spend not less than 9 months to attain a marked drop in disease incidence as well as achieve scanty fly catch. Gradual improvements were noticed monthly in mean PCV of sentinel cattle in site I. The mean PCV have followed a constant increment throughout the intervention time. The improvement shows a strongly positive correlation to intervention progress while negatively correlated to mean tsetse catch and monthly incidence of trypanosomosis.

In site II as well a subsequent decline of trypanosomosis incidence falling to 0.95% was observed at final monitoring. An overall reduction in the incidence was 90.5%. Together with this, a marked increase in mean PCV was observed. However, the increment became stable after third monitoring. Van den Bossche et al. (2004) reported monthly incidence of trypanosomosis being negatively correlated with the time elapsed since the start of Cyfluthrin applications in the control of *G. m. morsitans* in Zambia. Leak et al. (1995) also reported a rise in PCV of cattle from a mean of 23.8% at pre-control to 26.8% following tsetse control trial with Cypermethrin. Miruk et al. (2008) also reported a reduction of trypanosomes prevalence and PCV value in non-tsetse-controlled areas. According to this report, monthly mean PCV values were negatively correlated with trypanosome incidence. The significant increment noticed in mean PCV is an evidence of reduction

in incidence of trypanosomiasis as interventions progress and the consequent improvement in health status of sentinel cattle. Besides this, a relatively higher mean PCV recorded in site II at each intervention monitoring most likely shows that pour-on treatment has impact on ticks, biting flies and other blood-feeding ecto-parasites.

The overall reduction in prevalence was also estimated by computing from the incidence record as derived by Thrusfield (1995) and compared to pre-intervention. To this effect, a 77.4% overall prevalence reduction was reached in site II. This is in agreement to a 70% reduction in trypanosome prevalence in cattle reported by Leak et al. (1995). By contrast, only 60% reduction was achieved in site I.

Although the use of insecticide-treated cattle seems relatively suitable, the issues of cost, effect on non-target species (e.g. dung beetles) and related aspects (enzootic stability) need to be addressed. Most trials of this kind seem to be assisted by projects. As the insecticide formulations meant for this purpose might require foreign currency, it seems economically unaffordable to extrapolate the obtained results to the farmers' level. In this regard, Vale (2002) demonstrated that spraying preferred insecticides only on legs or belly (where tsetse flies rest most often) at predetermined intervals will virtually eliminate such risks while controlling tsetse so effectively. It was believed that this strategy will reduce the requirement for insecticide by 90%, thus reducing the cost burden to farmers. Similarly, Torr et al. (2002) documented that selective application of insecticides to adult cattle appears to be beneficial. This strategy proved that it may reduce insecticide costs by 95% and mitigate the impact on non-target species, including ticks. Furthermore, the practice of leaving young untreated in this case offers valuable opportunity to preserve enzootic stability for tick-borne diseases. In view of these matters, the current trial in site II was conducted with spraying a portion of the cattle population with young left untreated.

In addition, the case of developing resistance to sustained use of insecticides was a major concern worldwide. With regards to this phenomenon, no resistance of tsetse to synthetic pyrethroids has yet been reported, although there are now numerous reports of resistance developing in ticks and other insects to these insecticides (Leak, 1999). As the aim of the current tsetse suppression programme is to facilitate for eradication by releasing sterile males, the likelihood of the problems of this sort in tsetse seems much less. However, the case in ticks requires investigation. Moreover, the issue of sustaining the results achieved is the question raised most often. As tsetse flies are relatively mobile, there is a constant re-invasion pressure against areas from which tsetse fly has been controlled unless measures are taken up to natural boundaries or an effective barrier is maintained (Leak, 1999). Given that these measures are considered, tsetse could be controlled with consequent control of trypanosomiasis.

In conclusion, the application of both impregnated (0.4% Deltamethrin) targets and Deltamethrin 1% pour-on formulation to cattle have adequately reduced tsetse fly population and trypanosomiasis incidence in cattle with

resultant improvement in mean PCV. Moreover, practical lessons were learned that use of pour-on to cattle was found easy to apply, requires less labour and highly appreciated by user community. However, this advantage could be maintained if sufficient number of cattle were allowed within the environment to be cleared of tsetse. Otherwise, it appears too difficult to attain the envisaged results. Conversely, the use of impregnated targets is generally known to be labour-intensive, offers a slow reduction in trypanosomiasis incidence and coupled with accessibility risks (such as irregular topography and wild animals). Despite these, the technique is still considered as alternative for tsetse fly pocket areas where cattle do not normally access. Similarly, a substantial outcome could be achieved by applying targets if community participation is initiated in the control scheme with associated technical training. So, the current trial suggested that there was no marked difference recorded between the two strategies compared.

Therefore, the current 'Southern Tsetse Eradication Project (STEP)', is recommended to continue with the integrated use of both methods in the tsetse fly suppression activity. In addition, as the operations are carried out in blocks the risk of re-invasion of controlled sites in first block from uncontrolled adjacent blocks need to be addressed and the activity has to be continued until fly catches drop to undetectable level and the phase of sterile male fly release started.

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