Experimental Study on the Efficacy and Persistence of Deltamethrin 1\%, Pour-on (Smash) for the Control of Tsetse Flies in the Southern Rift Valley of Ethiopia

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**ABSTRACT**

Different technologies have been introduced and applied practically in the field for many years for the control of tsetse flies. The present study was conducted to test the efficacy and persistence of deltamethrin 1\% pour-on against tsetse flies on six experimental animals. Among these animals three were poured-on with the insecticide and the rest three kept without insecticide. Deltamethrin 1\% pour-on was applied on experimental animals on the middle backline from shoulder to the base of tail using T-bar applicator, according to the manufacturers' recommended dose. The knockdown effects of the insecticide were observed at 5', 10' and 15' for seven consecutive weeks. Experimental sites (middle back, belly, leg and neck) of both experimental and control groups were identified and marked with ink. The knockdown effects of the insecticide were checked weekly for seven consecutive weeks. A total of 1,800 test insects were used for the bioassay excluding weak flies. The average knockdown effect of the insecticide at 5', 10' and 15' were 41\%, 39\% and 21\% respectively in the week one and 33\%, 36\% and 31\% at 5', 10' and 15' respectively in week two. The highest knockdown effect was recorded at 5' of exposure (46\%) in week three, followed by 31\% at 15' and 23\% at 10' of exposure. The proportion of knock down of the flies in week 4 was 18\%, 36\% and 46\%. In week five, 20\%, 52\% and 28\% of flies have been knocked down at 5', 10' and 15' of exposure. The proportion of knock down of flies in week 6, were 18\%, 42\% and 39\% at 5', 10' and 15' of exposure respectively. With regard to week seven, almost no flies of the experimental group have been knocked down except one on the neck at 15' of exposure. It was observed that deltamethrin 1\% pour-on uniformly spread and covered the entire body of the animal within few hours of application and no adverse effect was detected over the period of the experiment. The present study demonstrated that deltamethrin 1\% Sc, pour-on is very effective at the dose rate and time interval recommended by manufacturers' in knocking down of tsetse flies attempting to feed blood meal from animals treated with the insecticide.

**Key words:** Deltamethrin, Efficacy, Persistence, Pour-on, Tsetse.

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**INTRODUCTION**

Trypanosomiasis continues to remain a major constraint to livestock and agricultural production and consequently human health. The impact of animal trypanosomosis is mainly attributed to morbidity and mortality of livestock, treatment as well as control costs, and denied access to land resources and more importantly draught power to cultivate land for food crops. In addition, pregnant cows abort, oxen could not plough, equines could not be used for transportation, milking cows reduce milk production, and the death of animals that are not properly treated [1].

Tsetse transmitted trypanosomiasis poses a serious threat to the lives and livelihood of entire communities affecting about 300 million people in the 37 countries of sub Saharan Africa, with 55 million of them at the risk of catching the diseases. WHO has reported an estimated number of 500,000 people already infected with sleeping sickness and about 50,000 died every year. The situation is deteriorating as increasingly new cases are being registered every year. FAO has estimated that every year Africa loses over 5 million cattle and other livestock in deaths caused by trypanosomiasis and uses over 35 million doses of trypanocidal drugs in the futile effort to maintain livestock free of the diseases [2].

The potential area of tsetse infestation has been variously estimated at 66,000km\(^2\) based on 1,6000meter above sea level breeding limit [3] 97,855km\(^2\) based on a 1,600 meter above sea level breeding limit [4] and between 135000-220,000 km\(^2\) based on the maximum dispersal up to 11,700-200,000 meter above
sea level [5]. In Ethiopia, tsetse flies infest an area of approximately 240,000 km² (about 21% of its territory). About 50,000 km² of this area is located in the southern rift valley of Ethiopia. About 10-14 million heads of cattle in Ethiopia, 4-6 million heads of cattle in southern region and 2-3 million of cattle in the southern rift valley are in the risk [6]. Evidence from Ethiopia suggests that a team ox in the tsetse infested area is only capable of cultivating 60 percent of the land as against 100% that can be cultivated in a tsetse free area [1]. Thus, the potential benefit of tsetse and trypanosomiasis control appear to be highest in areas where there is good potential for integrating livestock in to profitable and sustainable livestock farming systems [7].

In the past, campaigns against tsetse flies to control trypanosomiasis both in animals and humans depended mainly on large scale killing of the game animals that act as reservoirs trypanosome infection and as a source of blood for the flies. It also common to clear large areas of the bush in order to destroy the habitats of the adult flies; these methods were fairly successful, but are now largely unacceptable on ecological and economic grounds. Currently, most anti tsetse measures rely on the use of insecticides applied from the ground or by air craft. The population of tsetse flies have been also reduced or eradicated in localized areas by the use of traps. These have the advantages of being cheap, can be used easily by local labor and are harmless to the environment [8]. Application of insecticide (deltamethrin 1% pour-on) is recently developed technology and can be regarded as modification of the target method whereby instead of fixed target stationary traps targets insecticide treated domestic animals, primarily cattle can be used as attractive pour on applications which has led to a very high degree of vector suppression and trypanosomiasis control for it has a good chance of success it is considered necessary that domestic livestock must be presented for treatment on a regular basis and cattle must represent the over helming proportion of the host complex of the tsetse in the area [1].

Deltamethrin is broad spectrum insecticide which is effective against tsetse flies via direct contact. Deltamethrin is in the chemical class of pyrethroids (deltamethrin ,alphacy pamethrin,cyfluthrin and flumethrin) but unlike other pyrethroids, deltamethrin consists of one pure compound. Pyrethroids ingeneral, interfere with normal production of nerve signals in the nervous system. Pyrethroids act on nerve membranes by delaying the closing of activation gate for the sodium ion channel. Researchers distinguish between two classes of pyrethroids based on electrophysiological studies with nerves and symptoms of toxicity. This results in prolonged permeability of the nervous system to sodium ion and produces a serious of repetitive nerve signals in sensory organs, sensory nerves and muscles [9].

The insecticide pyrethroid (deltamethrin 1%) applied on the middle back of the animals (cattle) in the experimental sites (belly, leg, middle back line and neck which are marked and insecticide applied at the dose of 1 ml per 10kg body weight by using T-bar applicator as recommended by manufacturers [7]. When compared to other control methods, treating animal is cheaper than constructing and deploying and insecticide treated target and traps. There are several problems associated with using targets, such as the loss of targets due to general wear and tear and theft. Damages less with insecticide treated cattle [7]. Various companies manufacture deltamethrin 1% in different forms and Deltamethrin 1% SC, pour-on (Smash) manufactured by Tagros chemicals of India Ltd, which is currently used by STEP for tsetse control has been used for the experiment [1]. Therefore, the objectives of the study were:
1. To examine the efficacy and persistence of deltamethrin 1% pour-on on the animal body in dry (hot) season for the control of tsetse flies in the southern rift valley of Ethiopia.
2. To understand the speed of distribution of deltamethrin pour-on on the animal body and check for any adverse effect.

MATERIALS AND METHODS

Study Area
This experiment was conducted in Arbaminch Nech Sar Park, Gamo Gofa Zone, which is located 501 km south of Addis Ababa in the Southern Nations, Nationalities and Peoples Region. The total area of Arbaminch zuria is 1,638.3 square kilometre with mean annual temperature of 15.1-25°C and mean annual rainfall of 801-1600 in millimetre. The elevation of an area ranged from 1001-2500 metres above the sea level and found on latitude of 5.704177-6.181852° and 37.3140-37.8137° longitude. The number of livestock in Arbaminch town (6,440 cattle, 2,775 goats, 726 sheep and 4,500 poultry) and the human population of the district is estimated to 172,162 and cattle populated estimated to 88,691 out of which 13158 are ploughing oxen. The Nech Sar Park has “Kolla” agro climatic condition which is suitable for tsetse flies population. The temperature of Arbaminch Nech sar national park represents the temperature of most tsetse infested areas and suitable for fly collection and considered as ideal place for carrying out
the experiment. The species of tsetse flies found in the National park is *G. pallidipes* which is also used for the present study.

**Study Animals**

The animals used for the study were local Zebu breeds of cattle purchased from chano local cattle market. The history of the animals was taken to know the origin of the animals. This was done to avoid animals that have originated from tsetse control areas. Animals originated from tsetse control areas might have treated with the insecticide any time during the year and may affect result of the experiment. Six animals (cattle) were used for the experiment. Three of them were used as experimental group and three as control group. All animals in both groups were identified by their colour and given different names. Four similar sites were selected on the body (middle of the back, belly, leg and neck) of each animal of both groups and marked with ink to easily recognize and consistently use the sites for the fly feeding (picture-1).

![Picture 1: experimental sites marked](image)

**Study Design**

The study was designed to determine the efficacy and persistence of Deltamethrin 1% for the control of tsetse flies in the study area. It was experimental (cross sectional study) where the insecticide was applied on the backline of both experimental (insecticide treated) and control (non-treated) animals and the efficacy and persistence of the insecticide monitored once a week for 7 weeks by allowing the wild tsetse flies collected from Nech Sar National Park to feed on animals of both groups. The study was designed to meet the overall objectives of the experiment.

**Methodology**

*Application of deltamethrin 1%, pour-on*

Deltamethrin 1% SC, pour on (Smash) was obtained from the Southern Tsetse Eradication Project (STEP). The insecticide was applied at the dose rate of 1ml/10kgbw (according to the manufacturer’s recommendation) along the backline of the animal from shoulder to the base of the tail using T-bar applicator. It is important that the correct dosage be applied to the animal to ensure control of the target pest and to avoid poisoning to the animal. All animals were kept on indoor feeding. The experimental and control groups were kept in separate places under the same management condition.

Pour on application requires less chemical and considered less wasteful than dips or whole body aprons, and dosage is more precise than whole body spray, power application are increasingly popular [1].

*Monitoring the efficacy and persistence of the insecticide*

Wild tsetse flies (*Glossina pallidipes*) were collected from Nech Sar National Park using NGU traps. The traps made of blue and black cloth with white mesh on the top were used for the fly collection. They were deployed at about 200-250 metre apart from each other by fixing on the standing poles. They were deployed 50 metre away from access road to minimize visibility to people and avoid lose or disturbance. The traps were deployed in a bush land and wooded grass land vegetation, which is preferred by *G. pallidipes*. The area of about 2-3 meter radius width of the trap sites were cleared-off vegetation for increased visibility. The traps were placed 30 centimetre high from the ground with the cage securely fixed and grease applied to all supporting poles to control ants from climbing the poles and eating the flies caught in the top cage. The traps were deployed under the shade but in a clear area to avoid direct exposure of the flies to sun and keep them active. A bottle containing about 100 millilitre of cow urine was kept near the trap to attract flies.
was placed under each trap as attractant and the mesh of the cage checked for holes to avoid lose of flies [10].

Picture 2: Trap deployment for fly collection.

Traps were deployed and fly collection conducted within three hours of deployment to avoid excessive exposure to the sun [1]. Fly collection was conducted by removing the top cages containing the flies. The flies were transferred to PVC cages using aspirator and immediately fed on the animals. Ten tsetse flies were placed in each cage and the cages held on the feeding sites identified on the animal body. A minimum of 5 and maximum of 10 flies can be used for the experiment based on the density of the flies [7].

240 *G. pallidipes* flies were collected each week for seven weeks (240x7=1680) and fed on six animals (3 experimental and 3 control) at 5, 10 and 15 minutes. The feeding was conducted after one week of insecticide application on the backline of the animals. The PVC cages containing 10 flies were held on each identified and marked sites on the body of the animals and knock down effect recorded at 5, 10 and 15 minutes per week for 7 weeks. The cages remained on the body of the animal until 15 minutes and removed, since almost all flies were expected to be knocked down at this time [11,1]. The flies were closely observed and the knockdown recorded.

Picture 3: Recording of knockdown time of fly
Data Analysis
The data was stored in the micro-soft excel spread sheets and analyzed. The tested hypothesis was seasonal (dry) period efficacy and persistence of deltamethrin 1% pour-on application [12].

RESULTS
The present study was conducted to determine the knockdown effect and persistence of deltamethrin 1% pour-on. The knockdown effect of the insecticide was observed at 5, 10 and 15 minutes for 7 consecutive weeks. The results of each site were compared to each other for the efficacy of the drug. Similarly the result of each week was compared for the persistence of the drug. Both experimental and control animals were monitored and the results compared.

With regard to week 1, the average knockdown effect of the insecticide at 5, 10 and 15 minutes is 41%, 39% and 21%, respectively. The number of flies knocked down at 5 minutes of exposure is higher at this time on the belly, followed by Back, neck and legs in a declining order. The number of flies knocked down at 10 and 15 minutes are higher at this time on the neck and legs as compared to the back and belly. On the other hand, no flies have been knocked down at 5 and 10 minutes of exposure but on average 1 and 2 on the back and belly have been recorded respectively, at 15 minutes of exposure for the control group. The average knockdown of the four feeding sites at 5, 10 and 15 minutes are shown in figure 1.

![Figure 1: Average knockdown at 5, 10 and 15 minutes of exposure on week 1](image)

The knockdown effect of the insecticide on week 2 was 33 %, 36% and 31% at 5, 10 and 15 minutes respectively. The highest average knockdown was observed on the belly followed by back, neck and legs at 5 minutes of exposure. The highest average knockdown at 10 minutes of exposure was observed on the leg followed by neck, belly and back in a declining order. At 15 minutes of exposure, the highest average knockdown was observed on the neck followed by back, leg and belly in a declining order, With regard to the control group, 1 fly on average have been knocked down at 5 and 15 minutes on the belly and neck each while no knockdown was recorded at 10 minutes of exposure. The average knockdown at 15 minutes exposure was on average 1 and 2 flies on the leg and belly, and back respectively (Figure 2).

![Figure 2: Average knockdown at 5, 10 and 15 minutes of exposure on week 2](image)
Considering week 3, the highest knockdown was recorded at 5 minutes of exposure (46%) followed by 15 minutes (31%) and 10 minutes (23%) respectively. The highest average knockdown at 5 minutes exposure was recorded on the back followed by belly, neck and leg in the declining order. At 10 minutes exposure, the highest average knockdown was observed on the belly, neck, back and leg in declining order, the highest average knockdown was observed on the leg neck, back and belly at 15 minutes exposure respectively. With regard to the control group no fly knockdown was observed at 5 minutes exposure and only 1 on the average have been recorded on the back at 10 minutes of exposure. Similarly 1 fly on the average have been knocked down on the back and belly each, while others recorded zero. The result is presented by figure 3.

![Figure 3: Average knockdown at 5, 10 and 15 minutes of exposure on week 3.](image)

The present study also showed that the proportion of knocked down flies on week 4 was 18%, 36% and 46% at 5, 10 and 15 minutes of exposure respectively. The highest average knockdown at 5 minutes of exposure was on the belly followed by back and neck, and leg in a declining order. The average number of flies knocked down on the neck was higher followed by back and belly, and leg in a declining order. Most of the flies knocked down have been observed at 15 minutes of exposure, the highest being recorded on the leg followed by back, belly and neck in a declining order. Regarding the control group, one fly on the average has been recorded on the back, belly and neck at 5 minutes exposure, 2 flies on the back at 10 minutes exposure, and 1 fly on the back, neck and leg at 15 minutes exposure. This is shown in figure 4.

![Figure 4: Average knockdown at 5, 10 and 15 minutes of exposure on week 4](image)

Regarding week 5, 20%, 52% and 28% of the flies have been knocked down at 5, 10 and 15 minutes exposure. The highest average knockdown at 5 minutes of exposure was recorded on the back and belly followed by neck and leg in the declining order. It was also observed that the highest average knockdown...
at 10 minutes of exposed have been recorded on the neck followed by back, belly and leg in declining order. On the other hand, no flies have been knocked down on almost all animals in the control group except 1 on the neck at 5 minutes exposure and 1 on the back at 10 minutes exposure. This is illustrated by figure 5.

**Figure 5**: Average knockdown at 5, 10 and 15 minutes of exposure on week 5

On week 6, the proportion of knocked down flies were 18%, 42% and 39% at 5, 10 and 15 minutes of exposure respectively. When the result of each feeding time is separately considered, the highest average number of flies knocked down at 5 minutes of exposure was higher on the back followed by belly and neck, and leg in a declining order. The knocked down flies at 10 minutes exposure was higher on the neck followed by belly, back and leg at a declining order. When considering the flies knocked down at 15 minutes of exposure, the average number of flies on the leg is higher followed by neck, belly and back in declining a order. Regarding the control group, no flies have been knocked down at 5 minutes of exposure, 1 on the back and leg at 10 minutes of exposure and 1 on the neck at 15 minutes of exposure. The result is illustrated on Figure 6.

**Figure 6**: Average knockdown at 5, 10 and 15 minutes of exposure on week 6

With regard to week 7, almost no flies of the experimental group have been knocked down except 1 on the average on the neck and leg at 15 minutes of exposure. Similarly, no flies have been knocked down from the control group except 1 fly on the average on the back at 10 minutes of exposure. This is shown on Figure 7.
The present study showed that the total average number of flies knocked down on week 1 and 2 were lower as compared to weeks 3-5. The fly knock down has steadily declined at week 6 and very few flies have been knocked down on week 7. This is shown in Figure 8.

**Figure 8:** The total average number of weekly fly knockdown for experimental animals.

**DISCUSSION**

Different technologies have been introduced and applied in the field for many years for the control of tsetse flies. These have provided a suitable solution to the problems of animal trpanosomiosis [13]. However, it is debatable and in recent years the control technologies, which are environmentally safe and economically feasible have been developed.

The use of insecticide treated cattle (application of deltamethrin 1% pour-on formulation to cattle) has adequately reduced tsetse fly population and trypanosomosis incidence in cattle. In addition, the case of developing resistance to sustained use of insecticides was major concern worldwide. However, no resistance of tsetse to synthetic pyrethroids has yet been reported [11].

The present study showed that deltamethrin 1% pour-on, uniformly spread and covered the entire body of the animal within few hours of application. No adverse effect has been observed throughout the study period. It was observed that the insecticide effectively knocks down the tsetse flies attempting to feed blood from animals treated with the insecticide. It revealed that the insecticide effectively works through week 5 but start declining at week 6 and totally fails on week 7. It was recognized that the knockdown effect of the insecticide varies on different parts of the animal at different times of exposure.

The flies have been uniformly knocked down on different feeding sites of the animal body on week 1 as explained by Taylor and Francis [8]. Most of the flies exposed to the insecticide have been knocked down at 5 minutes of exposure as compared to 10 and 15 minutes of exposure. However, there is no big difference between 5 and 10 minutes of exposure. On the other hand there is a big difference between 10 and 15 minutes of exposure as well as 10 and 15 minutes of exposure. This shows that the flies required...
less time of exposure to pick enough dose of the insecticide to be knocked down [14]. It was also observed that an extended time of exposure is required on the neck and legs to knockdown the flies as finding of Taylor and Francis [8]. Few flies have been knocked down from the control group due to manipulation to transfer the flies to the PVC cages. No big difference in the fly knockdown has been observed between the times of exposure on week 2. The flies exposed to the back and belly required less time to be knocked down [15], while those exposed to neck and legs required longer time to pick the insecticide to be knocked down. On week 3, the highest proportion of the flies has been knocked down at 5 minutes followed by 15 minutes and 10 minutes of exposure. This shows that the insecticide is effective in this week but the variation in the knockdown effect may be attributed to the time individual flies came in contact with the insecticide in attempting to feed blood meal. Most of the flies have been knocked down within a short time of exposure and only some required longer time of exposure. In week 4, only few flies have been knocked down in 5 minutes of exposure and most of the flies have been knocked down in 10 and 15 minutes of exposure. The number of flies knocked down on different parts of the body at 5 minutes of exposure is also fewer as compared to 10 and 15 minutes of exposure. This illustrates that the insecticide needs longer time of exposure to knock down the flies. On the other hand there are some flies knocked down from the control group which could be attributed to the effect of manipulation while transferring the flies to the PVC cage. Similar results have been observed in week 5 where only few flies have been knocked down in 5 minutes of exposure and most of the flies at 10 minutes of exposure. This indicates that the insecticide needs longer time of exposure to knock down the flies.

Only few flies have been knocked down at 5 minutes of exposure in week 6 and the majorities have been recorded at 10 and 15 minutes of exposure. This shows that the flies need longer time in week 6 to be knocked down. Only few flies have been knocked down from the control group. On the other hand, very few flies have been knocked down in week 7 only at 15 minutes of exposure and almost similar results have been observed in the control group. This shows that the effect of the insecticide was totally failed at this week. Following the previously published work in Burkinafaso and Zimbabwe [16]; it has commonly been accepted that pour on persist for 100 days, but compared with this work it emphasizes that the persistence can much often be less in accord with the findings of Thomson et al [1991] which showed that pour-on persisted for only about 40 days at Rekomitjie, this trial was also somewhat consistent with the Thomson findings, that is, persistence of deltamethrin can be prolonged up to 42 to 45 days according to manufacturers’ recommended persistence interval, but as the study area is very hot, the persistence may affected by maximum temperature, because, temperature offers a means of reconciling different indications for the persistence, also the persistence period of deltamethrin can be affected by the season of year as illustration of Torr et al [17] and the formulation used.

Generally, when the entire efficacy and persistence of the insecticide is considered, the insecticide is very effective from weeks 1-5, as illustrated in fig 9. Week 0 is also considered effective since it is the time when the insecticide was just applied on the animal body. Therefore, it was revealed that the insecticide is effective for 7 weeks starting from the week of application (week 0) and continue through week 5 of monitoring. This shows that the insecticide should be re-applied at week 6 as findings of Vale et al [18] to maintain the efficacy of the insecticide.

When compared with other control methods, treating animal is cheaper, but it requires cooperation of society greatly (better community participation) bring about successful results as idea of Chadenga [19]. More restricted application (belly, legs, middle back line and neck) of insecticide was effective [17]. It was believed that these strategies will reduce the requirement for insecticide costs by 95% and mitigate the impact on non target species including ticks and also it reduces the cost burden to farmers [20]. Moreover, practical lessons were showed that use of pour on to cattle was found easy to apply, require less labour and highly appreciated if sufficient number of cattle were allowed within the environment to be cleared of tsetse; so that the result of this experiment indicated that deltamethrin is effective against tsetse flies and persistent on animal body up to between 5 and 50 days at the manufacturers’ recommended dose. The current experiment (trial) was conducted to demonstrate and confirm of hypothesis recommended by manufacturers’ in the efficacy and persistence of deltamethrin at the given time interval (45 days).In this trial, it was demonstrated that deltamethrin is effective at the dose and time interval recommended by the manufacturer.

CONCLUSION AND RECOMMENDATIONS
In conclusion, the present study has clearly indicated that Deltamethrin1 %; pour-on (smash) is effective for 6 weeks and should be repeated at a 6 weeks interval for effective tsetse control. No adverse effect has been observed throughout the study period. It was noted that the knockdown effect of the insecticide was good on all parts of the body, although different proportions have been recorded on different feeding sites identified for the experiment. It was also observed that some flies exposed to non treated (control)
animals have been knocked down which might be due to the effect of manipulation. The same was expected to occur with experimental animals. Finally the application of deltamethrin 1% pour on formulation to cattle has adequately decreased tsetse fly population. Based on the above conclusion the following recommendations were made in relation to the use of the insecticide.

- Further study should be conducted during the wet season to know the entire picture of the efficacy and persistence of the insecticide in both seasons.
- The use of deltamethrin 1% should be properly scheduled according to the findings of this study.
- The insecticide (deltamethrin) should be compared with the same products of other companies to see the difference and similarities.
- Great care is should be required while transferring the flies to PVC cages to avoid the damage.

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REFERENCES

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