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Evaluation of the efficacy of various concentration of deltamethrin impregnated targets on tsetse fly in and around Arba Minch, South Western 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 longevity of 20% deltamethrin impregnated targets in 0.2%, 0.4% and 0.8% concentrations checked against the tsetse fly at 5, 10 and 15 minutes of exposure. The selected concentrations of Deltamethrin 20% were applied to targets by dilating with respective dilutants. Then the targets were deployed in selected area for experiment. Flies were collected and brought to the site of the bioassay. The knockdown effect of the insecticide was observed at 5, 10 and 15minutes for every two weeks interval. A total of 900 tsetse flies were used for the bioassay excluding weak flies. The knockdown effect of the insecticides was equally effective in 0.2%, 0.4% and 0.8% concentration ($P>0.05$) in all the three exposure times. However, the number of knockdown flies significantly differ in between the three different exposure times ($P<0.05$).With regard to days of trial, as the number of days increases the number of knockdown flies decreased significantly. For instance, on day 85, at 5minutes, the number of knockdown flies significantly declined by half compared to day 1. The number of flies knockdown significantly differ as the exposure time and number of days increased since the concentration of deltamethrins declined through time. The present study demonstrated that deltamethrin impregnated targets at 0.2%, 0.4% and 0.8% concentrations were equally effective throughout the experimental period. Therefore, we recommend the use of 0.2% concentration to impregnate targets during fly control. However, this is a controlled experiment which has to be further validated in field condition using poor-on techniques on animals.

Keywords: Deltamethrin, efficacy, longevity, target, Tsetse fly

Introduction
Trypanosomosis is a debilitating and fatal disease of various domestic animals. It is the widespread disease complex caused by several species of blood and tissue dwelling protozoan parasite of genus *trypanosome*. It is affecting cattle and other wide range of hosts in sub-Saharan Africa. The impact of animal trypanosomosis is mainly attributed to morbidity and mortality of livestock, treatment costs, foreign exchange that have been generated from livestock and livestock productions, and denied access to land resources and more importantly draught power to cultivate land for food crops [1].

Trypanosomosis and its vectors are distributed over 10 million km^2 of potentially productive lands of Africa between latitudes 14^0N and 29^0s [2]. In Ethiopia tsetse have been invading potentially productive lands in the south, south west and western parts of the country. It is estimated that a total of 220, 000km^2 areas are currently believed to be infested by different species of *Glossina* and livestock dwelling below 2000 m.s.l are at high risk of infection by trypanosomes [3]. A total of 23.15 million livestock is at risk of contracting the disease [4].

In animals the disease is characterized by variable degrees of morbidity and mortality. The major clinical signs that manifested on cattle are anemia generalized enlargement of superficial lymph nodes lethargy and progressive loss of body condition, fever and loss of appetite occur intermittently during the parasitemic peaks, the latter becoming marked in the terminal stages of the disease [5].

There are five economical important animal trypanosome species in Ethiopia namely; *Trypanosoma vivax, T. congolese, T. brucei T. evansi* [6] *and T.equiperdum* [7]. Most tsetse transmission is cyclical and begins when the fly injects blood from trypanosome infected animal [1]. Transmission of trypanosome by insects may be affected by widely different means. Cyclical transmission, during which the trypanosome is actively multiply in vectors, occurs through the intermediary of Glossina or tsetse flies. This form of transmission occurs with trypanosome *Congolese, T.vivax, T. simiae, T.brucei.* Trypanosomosis is also mechanically transmitted by tsetse and other biting flies through the transfer of blood from one animal to another [6].

The most important mechanical vectors are the flies of genus tabanus, but haematopota, liperosia, stomoxys and chrysops flies have also been implicated. In Africa, both *T.vivax* and the *T.brucei* sub species such as *T. evansi* have spread beyond the tsetse fly belts and the transmission is principally by *Tabanid* and *hippoboscid* flies [8].

Several previous studies have revealed the presence of five species of Glossina in Ethiopia, namely; *Glossina pallidipes*and *G. morsitans submorsitans from morsitan group, G.fucipes fucipes* and *G. tachnodes* from *palpalis group* and *G.longipennes* from *fusca* group. All are reported to play role in the transmission of African animal trypanosomosis [6].

Different technologies have been introduced and applied in the field for many years for the control of tsetse flies. Bait technology, consisting of either insecticide-treated targets or traps baited with synthetic or semi-synthetic odours, or insecticide-treated cattle, has become the most common method of controlling tsetse (*Diptera: Glossinidae*) across Africa. These have provided a suitable solution to the problems of animal trpanosomiosis [8]. The increasing use of insecticide-treated targets throughout Africa is a result of the technique's efficacy, its relatively low cost, the amenability of the technique for use by communities and individuals and its unique ability to protect areas cleared of tsetse from reinvasion by tsetse in adjacent infested areas [9].

Trypanosomosis is mainly controlled using trypanocidal drugs, but the effective use of drugs is threatened by the development of wide spread resistance. In order to combat drug resistance control of vector is found important. Among the vector control methods insecticide impregnated target becomes primary interest of choice having different advantages like deployed by the community, placed in areas inaccessible by cattle.

Deltamethrin belongs to the chemical class of pyrethroids that are synthesized from chrysanthemum flowers. As a lipophillic compound, it is not soluble in water and therefore is highly stable in the physical environment. Unlike many pyrethroids, deltamethrin is also stable in air and sunlight: when exposed to either, it does not degrade, even after two years' time at 40 degrees Celsius. Deltamethrin is broad spectrum insecticide which is effective against tsetse flies control through direct contact. It interferes with normal production of nerve signals in the nervous system. Also it acts on nerve membranes by delaying the dosing of the activation gate for the sodium ion channel. The use of deltamethrin 20% impregnated target 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 [7].

So far much research was not done on efficacy of deltamethrin with different concentration impregnated on target. In view of that, the present study was made in the evaluation of deltamethrin with varying concentration. Hence the objectives of this paper were to select the correct concentration of deltamethrin to be applied on the target, to set the longevity of targets once deployed in the forest, and to determine the exposure time for fly knockdown with respect to the concentration of deltamethrin

2. Materials and Methods

2.1. Study Area

This experiment was conducted in Arba Minch, zuria district, Gamo Gofa Zone, which is located 505 km south of Addis Ababa and 273 km from Hawassa, regional city of South Nation Nationalities and people's regional state. This district is one of the fifteen districts and two city administration of the zone. The total area of Arba Minch zuria is 1,638.3 square kilometer with a mean annual temperature of 15.1-25 ^{0}C and mean annual rainfall of 801-1600 in millimeter. The elevation of an area ranged from 1001-2500 meters above the sea level and found at latitude of 5.9-6.4^0 and 37.310-37.36^0 longitude. The number of livestock in Arba Minch town 6,440 cattle, 2,775 goats, 726 sheep and 4,500 poultry and the human population of the district is estimated to 99,204 and cattle populated estimated to 135, 683 out of which 13158 are ploughing oxen [10]. The wild games of the district and Nech Sar national park includes lions, Zebra, Antelope, Warthog, Hippopotamus etc are considered as great role in providing blood for the tsetse flies and reservoir host for trypanosomasis [11]. The Nech Sar Park has "Kolla" agro climatic condition which is suitable for tsetse flies population. The temperature of Arba Minch 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.

The two most fish productive lakes are Abaya and Chamo found in the district. Some of the most important rivers like; kulfo, hare, sile, and Godoro are used to irrigate for banana, cotton, mango and crop productions. The crops produced this area are corn, teff, barley sorghum, beans and coffee [11].

2.2. Study population

The study was conducted on 900 randomly collected tsetse flies populations, collected from the Nech Sar national park where a lot of flies are suspected to be found.

2.3 Study design

The experimental study was designed to determine the efficacy of Deltamethrin 20% with various concentrations for the control of tsetse flies in the study area. In this experiment targets were impregnated in the selected concentration of deltamethrin i.e. 0.2%, 0.4%, and 0.8% and the efficacy was monitored once every two weeks for 10 weeks by allowing the wild tsetse flies collected from the Nech Sar National Park to contact with a piece of target in the cage.

2.4 Sampling method

About 900 numbers of flies were collected for the study from Nech Sar National Park and brought to Arba Minch, in sectary field station where the targets were deployed.

2.5. Study method

2.5.1 Materials

The study was conducted by using targets, traps,

Deltamethrin20%, feeding cage, Aspirator, acetone, phenol, cow urine, grease, mesh and pin.

2.5.2 Methodology

A concentration for target to be impregnated was calculated according to the dilution formula $C_1V_1 = C_2V_2$ and prepare deltamethrin 20% to 0.2%, 0.4% and 0.8% and calculating the respective dilutants in litter where; C_1= 20% deltamethrin V_1= 250ml, C_2= selected concentration of deltamethrin 20%, i.e. 0.8%, 0.4% and 0.2% then, solve for V_2 and got 6.25, 12.5 and 25 liters of dilutants respectively. After that, three buckets were taken and add calculated dilutants then mix with deltamethrin 20% with respective concentration. Finally, the target was impregnated in each bucket within the solution and deployed in selected site in the field.

Monitoring the efficacy of deltamethrin 20% and longevity of targets: Tsetse flies (*Glossina pallidipes*) were collected from the Nechi 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. The traps were deployed in a bush land and wooded grass land vegetation, which is preferred by *G. pallidipes*. The area of about 2-3m radius width of the trap sites were cleared- off vegetation for increased visibility. The traps were placed 30 cm 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 the sun and keep them active (figure 1). A bottle containing about 100ml of acetone, cow urine and/or phenol was placed under each trap as attractant and the mesh of the cage checked for holes to avoid loss of flies

Fig 1: Trap deployment for fly collection.

Traps were deployed (figure 2) and fly collection conducted within three hours of deployment to avoid excessive exposure to the sun [12]. Fly collection was conducted by removing the top mesh containing the flies. The flies were transferred to cages using aspirator which contain equally cut target pieces. The cages containing 30 flies were allowed in each case and knock down effect recorded at 5, 10 and 15 minutes per every two weeks for 10 weeks. The cages were kept until 15 minutes, since almost all flies were expected to be knocked down at this time [7, 12]. The flies were closely observed and the knockdown recorded.

Fig 2: Cutting the target at equal size with the cage

3. Data Analysis

The data collected was entered into Microsoft excel, and analyzed using SPSS version 20. Then, split-plot ANOVA or mixed model with repeated measures was used, with significance levels (P=0.05).

4. Results

The result of mean fly knockdown effect and longevity of targets impregnated in the deltamethrin 20% with varying concentration was monitored using mean and standard deviation of knockdown flies (table 1)

Table 1: The mean number and standard deviation of knockdown flies with respect to increased concentration and contact time.

Concentration		Time	
	5 minutes	10 minutes	15 minutes
0.2%	15.4 ± 6.7^{aB}	24.5 ± 4.7^{aB}	30 ± 0.0^{aB}
0.4%	16.8 ± 6.4^{aB}	26.5 ± 3.5^{bB}	30 ± 0.0^{aB}
0.8%	19.2 ± 6.1^{aB}	28.4 ± 3.2^{bA}	30 ± 0.0^{aB}

Superscript small letter “a” indicates the presence of significance difference between rows. Small letter “b” indicates the absence of significance difference between rows. Capital letter “A” indicates the presence of significant difference between columns. Capital letter “B” indicates the absence of significance difference between the columns.

The fly knockdown effect and longevity of targets impregnated with the selected concentration of deltamethrin 20% were monitored throughout the experimental period by using the mean and standard deviation keeping the time as constant (Table 2).

Table 2: The mean number and standard deviation of knockdown flies with respect to increased number of days and contact time.

Number of experiment	Time		
	5 minute	10 minute	15 minute
Day 1	30.0 ± 0.0^{acet}	30.0 ± 0.0^{acet}	30.0 ± 0.0^{at}
Day 15	22.0 ± 2.6^{bdcer}	30.0 ± 0.0^{acet}	30.0 ± 0.0^{ar}
Day 29	20.0 ± 2.5^{bdcer}	30.0 ± 0.0^{acet}	30.0 ± 0.0^{ar}
Day 43	19.7 ± 2.1^{bdcer}	29.3 ± 1.2^{aceft}	30.0 ± 0.0^{ar}
Day 57	18.0 ± 2.0^{bdcer}	27.0 ± 3.0^{aceft}	30.0 ± 0.0^{ar}
Day 71	16.0 ± 2.0^{bcdcr}	26.3 ± 3.5^{acefr}	30.0 ± 0.0^{ar}
Day 85	14.0 ± 2.0^{bdcr}	25.3 ± 3.5^{bacefr}	30.0 ± 0.0^{ar}
Day 99	12.7 ± 3.1^{bdcer}	24.8 ± 4.0^{badcfr}	30.0 ± 0.0^{ar}
Day 113	10.3 ± 1.5^{bcer}	22.3 ± 3.5^{bdcefr}	30.0 ± 0.0^{ar}
Day 127	8.3 ± 1.5^{bcer}	19.7 ± 1.5^{bdcefr}	30.0 ± 0.0^{ar}

Superscripts “abcdef”; showed level of significance across columns and whereas “rt” showed across rows

The mean fly knockdown effect and longevity of targets impregnated with the deltamethrin20%in 0.2%, 0.4% and 0.8% concentrations were monitored throughout the experimental period by using estimated marginal means (figure 3).

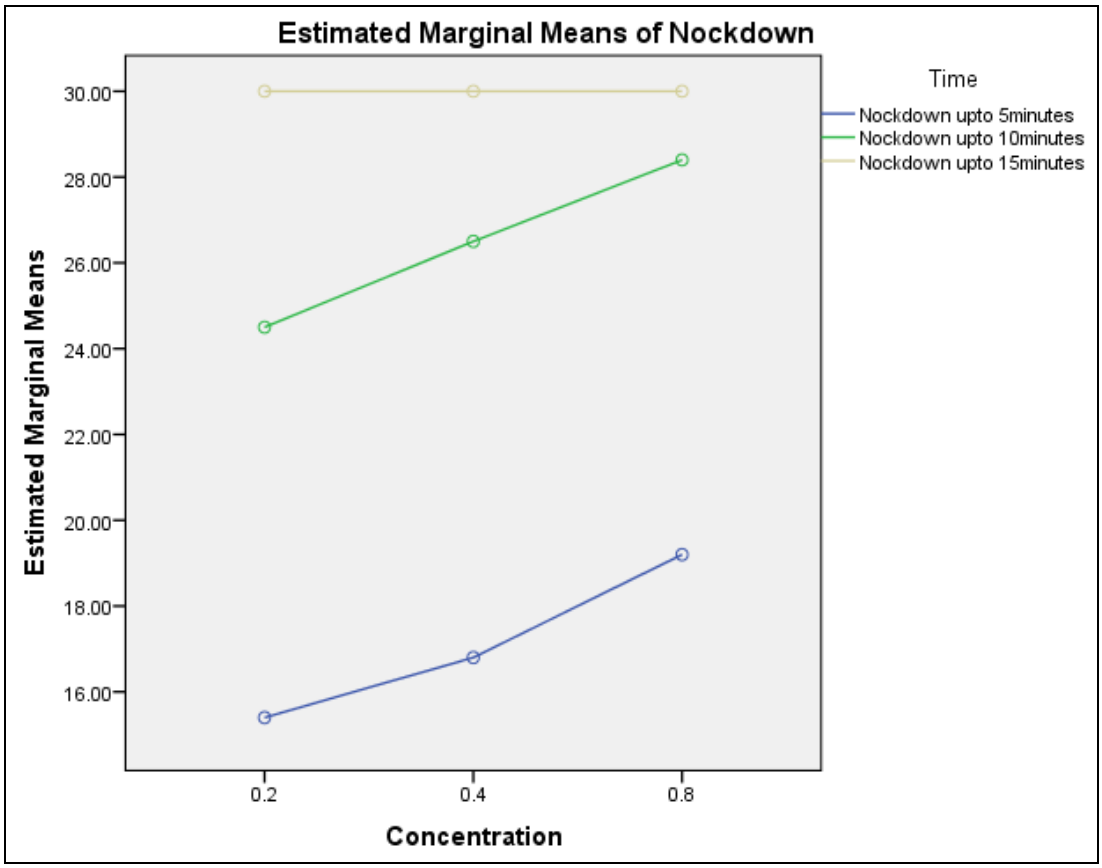

Fig 3: The mean flies' knockdown in selected concentration at 5, 10 and 15 minutes exposures.

The mean flies knockdown effect and longevity of targets impregnated with 0.2%, 0.4% and 0.8% concentrations at 5, 10 and 15 minutes exposure were indicated in figure 4.

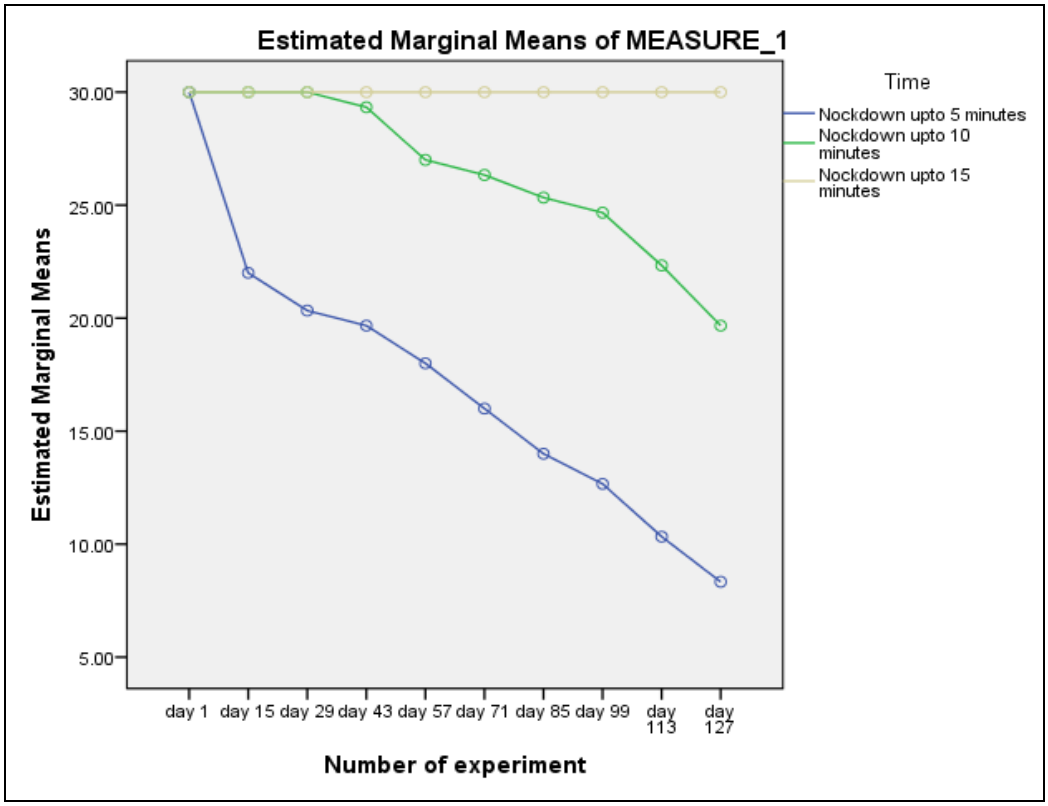

Fig 4: the estimated marginal means of flies' knockdown with respect to experimental period at 5, 10 and 15 minutes exposures.

In consecutive experiments the survivals of the flies increase with the increase in the day of experiments (figure 5).

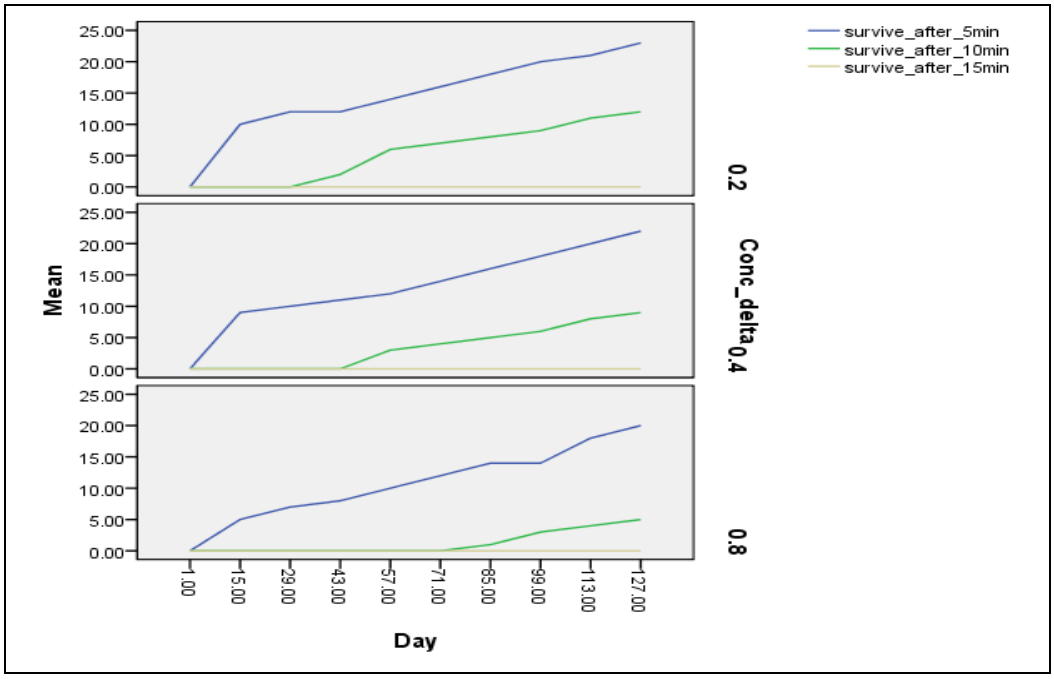

Fig 5: survival of flies throughout the experiments in all concentration after 5, 10 and 15 minute's exposure.

5. Discussions

The present study showed that the insecticide effectively knocks down the tsetse flies throughout the experimental periods although slight declining has been seen starting from the second experiment in all selected concentrations. The results also suggest that the knockdown effect of the insecticide significantly (P<0.05) varies at different times of exposure (table 1), [9]. In the present study there was no significant difference between the knockdown effect of targets impregnated with 0.8% deltamethrin and 0.2% deltamethrin, indicating that the 0.2% deltamethrin concentration was as effective as the 0.8% deltamethrin (table 1).

The present study revealed that the flies' knockdown effect of each selected concentration at different times of exposure significantly differs (P<0.05) across the rows of (table 1), this showed more exposure time expose the flies to pick enough dose of the insecticide to be knocked down. However, there was no significant difference (P>0.05) across columns between the different concentrations of deltamethrin (table 1). This indicates that there was no big difference between all the selected concentrations throughout the experimental periods.

Comparison of the day of experiment with exposure time had shown the absence of significance difference (P>0.05) at day 1 as it was observed at 5, 10 and 15 minutes of exposure across the rows (table 2). All targets were equally effective at day one in the fly knockdown effect although impregnated with different concentration. Because the targets impregnated were no longer exposed to extreme weathers. When day of experiment progress the number of fly knockdown have shown significance variation (P<0.05) starting from day 15 (table 2), because of decreased concentration of impregnated deltamethrin through time. For instance, at day 85, almost 50% of the flies were knocked down at 5 minutes of exposure as compared to day 1 with 100% knockdown effect. In other words as the number of days increases, the number of flies survived increased (fig. 5).

Generally, when the entire efficacy of the insecticide and the longevity of the targets considered, the insecticide was found very effective from the beginning upto the end of the experiment in all the selected concentrations. Although little reduction of fly knockdown effect have been observed. Similar to our finding Jordan [2] found out that increasing the concentration of deltamethrin applied to a substrate increases the relative persistence of the insecticide i.e. increasing the concentration of insecticide applied to targets increased the initial amount of insecticide on the targets and decreased the subsequent rate of loss. Experiment one was considered as effective in fly knockdown at 5 minutes exposure to the target in all concentration, since it was the time when the insecticide was a week after just applied to the targets with respective concentration. Therefore, the current finding revealed that the insecticide was effective throughout the experiments starting from the first day of application upto the end of experiments at 15 minute exposure time. The use of deltamethrin impregnated targets has a number of advantages in that they are cheap, technically simple, and environmentally friendly and largely target specific. It was believed that this strategy will reduce the tsetse fly density by 95% [2].

The result of this experiment indicated that deltamethrin 20% was effective in all selected concentration against tsetse flies and longevity of targets throughout the experimental periods. The present study has clearly indicated that deltamethrin impregnated targets were equally effective in all the three different concentrations and exposure times throughout the experimental periods.

It was noted that, the knockdown effect of the insecticide was good in all selected concentration although different proportions have been recorded on different concentration with in different exposure times. As the number of day's increased, the number of fly knockdown decreased which indirectly confirmed that, the concentration or the longevity of deltamethrin declined through time. The longer the exposure time, the highest number of knockdown flies was recorded. It can be recommended that deltamethrin 0.2% concentration can be effectively used in tsetse fly control since it is as effective as the 0.8% concentration. Based on this finding, we recommend conducting further study on

animals to realize the effect of season on the efficacy and longevity of deltamethrin.

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