



Community-based tsetse fly control minimizes the effect of trypanosomosis on livestock in Metekel zone, Ethiopia

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Abstract

Tsetse-related trypanosomosis threatens integrated crop-livestock production system in Ethiopia. Metekel zone is among the tsetse-infested areas in Ethiopia. Community-based tsetse fly and trypanosomosis control using targets was conducted from June 2011 to May 2012 in the zone. In coordination with the control project, a questionnaire survey was administered to assess the economic importance of the tsetse fly and trypanosomosis control conducted in the Zone. On average, there were 3 livestock deaths/household before control and this was decreased to 0.07 after control. This death was contributed from all possible livestock diseases. A household loss 4380 (95% CI = 4223.98–4541.79) EB (1 US\$ = 17.9 EB) only due to the deaths of his/her livestock was reduced to 90.78 (95% CI = 89.15–92.42) EB after control. Morbidity of oxen in the study areas was significantly decreased by 70.7%. As a result, the monetary loss to rent for healthy draught oxen was decreased by 96.4%. When a household with one cattle harvest 10.9 quintals (1090 kg), his neighbor's household with ten cattle maximize his/her yield to about 50.5 quintals (5050 kg) of crops indicating that trypanosomosis has great economic impact in crop-livestock production system. As the community-based tsetse fly control approach is simple, cost effective, and appropriate for riverine tsetse species, we conclude that farmers can minimize the negative impact of tsetse flies and trypanosomosis in the tsetse-infested areas of African countries.

Keywords Tsetse fly · Trypanosomosis · Economic importance · Metekel · Ethiopia

Introduction

The wide agro-ecological property of Ethiopia contributes to the presence of all the three tsetse fly groups and six tsetse fly species: the riverine group (*G. tachinoides*, *G. fuscipes fuscipes*), the savanna group (*G. pallidipes*, *G. morsitans submorsitans*), and the fusca group (*G. longipennis* and *G. brevipalpis*) all over the country (Pollock, 1982). The Ethiopian government, assisted by the International Atomic Energy Agency (IAEA), initiated a project in 1997 in the Southern Rift Valley called the Southern Tsetse Eradication Project (STEP) with a huge investment which is still ongoing (EAHYB, 2012). However, this project concentrates only in the Southern part of the country (25,000/200,000 km²) where

the other tsetse-infested areas seek at least suppression of the tsetse flies in their localities.

Metekel zone is among the tsetse-infested areas where the disease has been serious for the local community affecting farm activities through reducing draught power of oxen, losses of milk, meat, growth, and finally killing their animals (Tesfaye et al. 2012). Due to shortage of animal health professionals in the zone, farmers have been treating their animals themselves with not enough understanding of drug management, which in turn, leads to drug resistance development in the area (Afewerk et al. 2000).

To alleviate the problem, community-based tsetse fly and trypanosomosis control using deltamethrin-impregnated targets was conducted in three districts of Metekel Zone, Ethiopia, for about 1 year. As a result, the overall average tsetse fly density was decreased by more than six times (from 1.13 fly/trap/day before to 0.18 flies/trap/day after control) and the overall apparent prevalence of trypanosomosis was also decreased from 12.14% before control to 3.61% after control (Girmay et al. 2016). However, the general impact of the control was not known. The objective of this paper was,

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therefore, to assess the economic contribution of the community-based tsetse fly and trypanosomosis control in the zone.

Materials and methods

Study area

Metekel zone is one of the three zones of Benshangul Gumuz Regional State of Ethiopia. The zone is found at 578 km north-west of Addis Ababa and lies between 9.9° and 12.5° North and 34.9° and 36.6° East (Fig. 1). It is bordered on the South with Kamashi and Asosa zones in the West with Sudan and in the North and East by Amhara Regional State. There are seven districts in the zone: Dangur, Guba, Wonbera, Mandura, Dibate, Bulen, and Pawe. Metekel zone covers a total area of 25,705 km² and has a road density of 28.4 km per 1000 km².

The minimum and maximum altitudes of the zone are 300 and 2700 m, respectively. Rainfall in the area has a monomodal pattern extending from May to October with an annual average precipitation of 1200 mm. Mean minimum and maximum annual temperature of the area are 23 and 31.1 °C, respectively. Pawe and Dibate districts have an average altitude of 1100 and 1480 m above sea level, respectively. The topography of the zone is mostly plain, but steep hills and

mountains are also present in some areas. The dominant vegetation cover of the zone is characterized by different types of woodland, such as broad-leaved deciduous woodland, *Acacia* woodland, *Boswellia* woodland, riparian woodland found along the major rivers, and bamboo thicket. The wildlife of the area mainly includes bushbucks, warthogs, baboons, hyena, crocodiles, and hippopotamus (Metekel zone department of Agriculture, 2008).

Study populations

The study was conducted in households of two Metekel Zone Districts (Pawe and Dibate) whose main livestock basis is local cattle breeds. Integrated crop-livestock farming constitutes the major agricultural production system in the area. Currently Pawe district is occupied mainly by people and livestock who settled here after migrating from drought-affected highland areas of Ethiopia. Pawe has a population of 37,711 and a total land area of 567 km² while Dibate has population and land area of 54,180 and 2272 km², respectively (CSA 2008). Livestock populations of the study districts are indicated in Table 1.

Study design

A retrospective pretest-posttest evaluation method was used to assess the economic importance of tsetse flies and

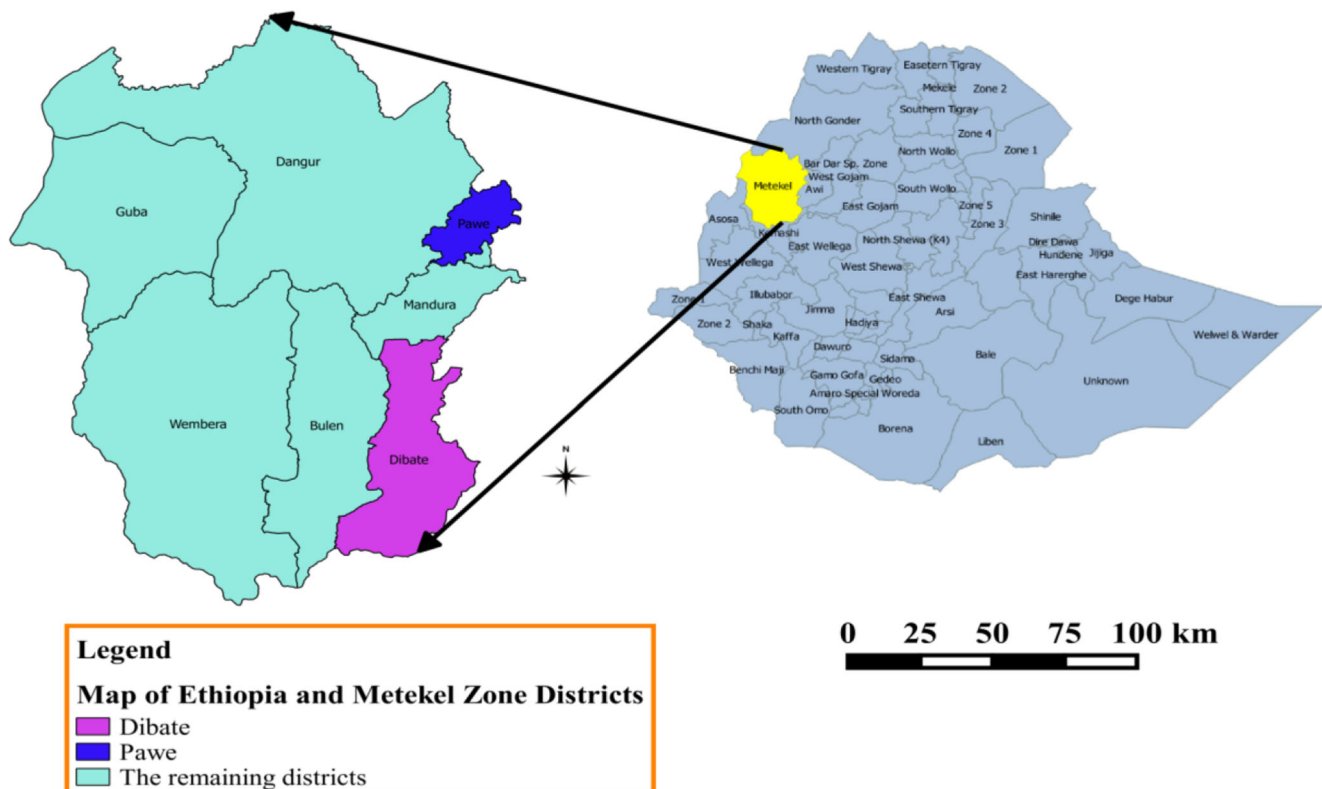


Fig. 1 Map of Ethiopia, Metekel zone, and study districts

Table 1 Livestock population of the study districts

District	Species				
	Cattle	Sheep	Goat	Equids	Poultry
Pawe	31,207	5475	4280	685	32,865
Dibate	30,179	16,710	17,736	1454	44,128

(Source: Metekel zone agricultural bureau, 2009)

trypanosomosis control. A pre-structured questionnaire was pre-tested and administrated in two districts (Pawe and Dibate) where tsetse flies and trypanosomosis control was conducted to assess the economic importance of tsetse flies and trypanosomosis control in August 2013. The questionnaire was designed to have three consecutive years according the agricultural production year of the area. For before control, it took from May 2010 to April 2011 as 2010, from May 2011 to April 2012 as during control, and from May 2012 to April 2013 it was considered as after control. To exploit the annual data, farmers were asked their monthly expense and revenue during the three consecutive years. Before questionnaires were administered to farmers, researchers discussed their relevance and importance and two researchers and three technical assistants from the Pawe Agricultural Research Center were engaged for the work.

Sampling procedure and sample size

Systematic random sampling was employed to get the household individuals. First, a list of farms with at least one animal (cattle) at the time of interviewing was obtained from the development agents of the villages. Then systematic random sampling was employed to select each interviewee. Whenever a selected respondent was not willing, then the next respondent was asked. In order to get better involvement of the interviewees, farmers were interviewed at holidays and weekends whenever they are free of work. A total of 130 respondents (67 from Pawe and 63 from Dibate districts) were included in the questionnaire study. Questions in the questionnaire were focused, going from general information to direct and indirect loss of their economy due to trypanosomosis. Direct losses such as due to death, morbidity of cattle, and indirect losses like the rent of draught oxen or losses because of not being able to plow due to the morbidity of their oxen were included in the questionnaire, which compared the period before and after the tsetse fly and trypanosomosis control in their areas.

Data analysis

Questionnaire survey data were collected and recorded in an excel sheet. The data were refined and analyzed using Stata

software (Stata IC 13). The linear regression model was used to observe the relationship between the crop production and the number of livestock owned by households. Poisson regression model was also used to analyze for variables like number of deaths, morbid, and treated animals as well as money loss due to death and rent of draught oxen before and after the tsetse fly and trypanosomosis control. A questionnaire survey was analyzed using descriptive statistics like means, frequencies, and percentages. In all analyses, *p* values less than 0.05 were considered as statistically significant.

Results

General description

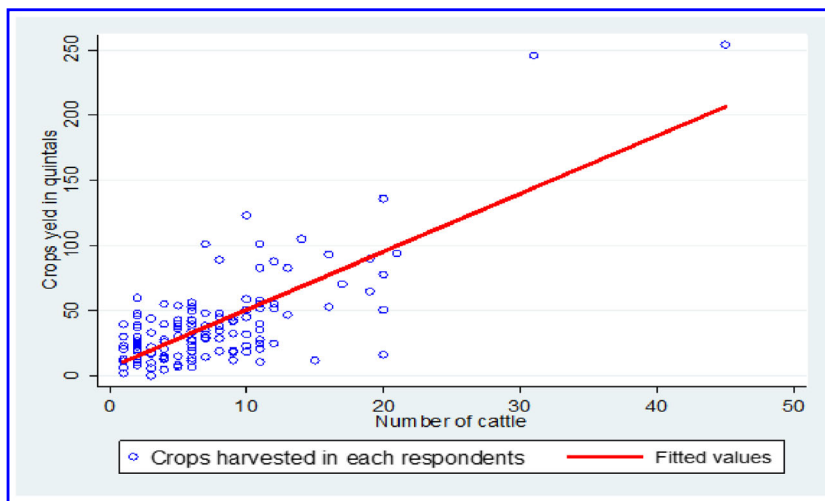
Over 98% (128/130) of the respondents were males and 82.3% were Orthodox Christians and the remaining (17.7%) were Muslims. The average age of the respondents was 40.0 ± 1.08 (95% CI = 37.8–42.1) with a range of 20 to 80 years old. The average family size of the respondents was 6.1 ± 0.22 (95% CI = 5.7–6.6). With regard to the decision maker in the family, 66.9% of the respondents indicated that they were used to take a decision after discussing between wife and husband while 30.8% of the respondents replied that the husbands made the decision. Only 2.3% of the decisions were made by wives which more than half of it may probably come from the female-headed households. The major income source of the respondents was from mixed livestock and crops (78.5%) while the remaining was only from crop-based sources (21.5%). Large and small ruminants, equids, and poultry are the main animals kept by the households. The average land covered by different crops was about 3.7 ha where on average, a household harvested 40.5 quintals per annum (1 quintal = 100 kg) (Table 2).

Table 2 General household (HH) description of the study sites

Category	HH number	Total number	Average	95% CI
Oxen	130	297	2.3	2.0–2.6
Cows	130	270	2.1	1.8–2.4
Heifers and calves	130	428	3.3	2.3–4.0
Goats	130	128	1.0	0.6–1.4
Sheep	130	137	1.1	0.7–1.4
Equids	130	42	0.3	0.2–0.5
Poultry	130	585	4.5	3.7–5.5
Land covered by d/t crops/hectar	130	481	3.7	3.2–4.1
Crop harvested in quintals/annum	130	5265	40.5	34.1–46.9

HH household, CI confidence interval, 1 quintal 100kg

Fig. 2 Relationship between the crop production and cattle number in the study sites (crop yield in quintal = $6.5 + 4.4 \times$ number of cattle, 95% CI = 3.75–5.13, $P < 0.05$)



The major crops grown in the area were sorghum, millet, groundnut, maize, sesame, and soybean. A linear regression analyzing the crops harvested in relation to the cattle of the respondents showed a strong relationship with a correlation coefficient (r) of 0.75.

(crop produced in quintal = $6.5 + 4.4 \times$ cattle numbers, 95%CI = 3.75–5.13, $P < 0.05$) (Fig. 2) (1 quintal = 100 kg).

among the 3 years (before-2010, during-2011, and after the control-2012) had significantly decreased. On average, there was about 3 livestock death in 2010 where as this number decreased to 0.07 in 2012 (Table 3). According the information obtained from the three study areas, only 3 cattle were dead while they had 995 healthy ones in 2012 indicating a mortality rate of 0.3%.

Animal death decrease

According to the information obtained from the respondents, number of livestock deaths (cattle, sheep, goats, and equids)

Reduction of money loss due to death of livestock

According the respondents of the study areas, the money lost due to the death of their livestock was substantially reduced by

Table 3 Livestock death in three consecutive years (2010, 2011, and 2012)

Years	Number of respondents (130 HH)	Number of livestock dead	Average dead livestock/HH	95% CI	IRR	95% CI of IRR
2010	130	393	3.02 A	0.81–11.25	43.67	22.55–84.55
2011	130	38	0.29 B	0.07–1.16	4.22	2.04–8.73
2012	130	9	0.07 C	0.04–0.13	1	
Total	390	440	1.13	1.03–1.24		

HH household, livestock cow, ox, calf, goat, sheep, and equids
Similar letters along column do not have statistically significant difference

Table 4 Money loss due to death of livestock

Years	Number of respondents (130 HH)	Money lost due to death (EB)	Average money lost/HH (EB)	95% CI	IRR	95% CI of IRR
2010	130	569,400	4380.0 A	4224.0–541.8	48.3	47.4–49.1
2011	130	45,900	353.1 B	339.8–366.9	3.9	3.81–4.0
2012	130	11,800	90.8 C	89.2–92.4	1	
Total	290	627,100	1608.0	1604.0–612.0		

Similar letters along column do not have statistically significant difference
EB Ethiopian birr (1 US\$ = 17.9 EB)

Table 5 Money expense for oxen rent

Years	Number of respondents (130 HH)	Total money expense due to morbid oxen in (EB)	Average money expense/HH (EB)	95% CI	<i>P</i> value
2010	130	113,222	870.94A	135.08–5615.52	< 0.001
2011	130	23,160	178.15B	25.11–1263.99	0.002
2012	130	4101	31.55C	12.95–76.82	< 0.001
Total	390	140,483	360.21	358.33–362.10	

Similar letters along columns do not have statistically significant difference

EB Ethiopian Birr (1 US\$ = 17.9 EB)

comparing to the 3 years before and after control of the tsetse and trypanosomosis in their areas. Before the control, every individual household had lost on average 4380 (95% CI = 4223.98–4541.79) EB (Ethiopian Birr) only due to the death of their animals. Whereas, this loss was reduced to 90.78 (95% CI = 89.15–92.42) EB after the control (Table 4). (1 Ethiopian Birr was 17.9 US\$ at the time of data collection).

Expense of money for rent of other oxen to plow

As mentioned earlier, more than 78% of the respondents' source of income are from crop and livestock. Oxen are the main draught animals used to plow the lands. But due to chronic trypanosomosis disease in the oxen, farmers tend to rent other relatively healthier oxen from their neighbors. On average, a household record 0.75 oxen as morbid ($n = 98/130$) (95% CI = 0.34–1.66) per annum in 2010. This serious morbidity of oxen was reduced to 0.22 ($n = 28/130$) (95% CI = 0.15–0.31, $P < 0.05$) in 2012. The respondents reported that the money invested to rent for oxen to plow was significantly decreased from 870.94 (95% CI = 135.1–5615.5) ETB per year per household in 2010 (before control) to 31.55 (95% CI = 13.0–76.8) ETB per year per household in 2012 (after

control) (Table 5). (1 US\$ = 17.9 Ethiopian Birr at the time of data collection).

Frequency of treatment against trypanosomosis

Most farmers explained as they used diminazene aceturate as curative drug. Some of them also used the isomethamidium chloride, which served as both for curative and preventive purpose for about 3 months. Locally, farmers called “Koshkosh” for diminazene aceturate and “Buna Gendi” for isomethamidium chloride. Farmers in the area claimed that they treat their animals every 1.32 ± 0.1 (95% CI = 1.13–1.54) months before tsetse fly and trypanosomosis control (2010). However, this was reduced to every 5.02 ± 0.2 (95% CI = 4.64–5.42) months after control (in 2012) which showed a 73.71% reduction with statistically significant difference ($P < 0.05$) (Fig. 3).

Discussion and Conclusion

Discussion

The number of livestock deaths (cattle, sheep, goats, and equids) during the 3 years (before-2010, during-2011, and after the control-2012) significantly decreased. On average, there were about 3 livestock deaths per household in 2010 whereas this number decreased to 0.07 in 2012 (IRR = 43.67). This reduction substantially reduced the money lost due to deaths of their livestock when comparing the periods before and after control of tsetse and trypanosomosis. Before the control, every individual household had lost on average 4380 (95% CI = 4223.98–4541.79) EB (Ethiopian Birr), only due to the deaths of their animals. This loss was reduced to 90.78 (95% CI = 89.15–92.42) EB after the control. Mortality of cattle in the study area before the control (2010) was 4.4% (Tesfaye et al. 2012) and this was decreased by 93.2% with a mortality rate of 0.3% in 2012 (after the control).

A socioeconomic assessment of a tsetse and trypanosomosis control program in Southwest Ethiopia revealed related results

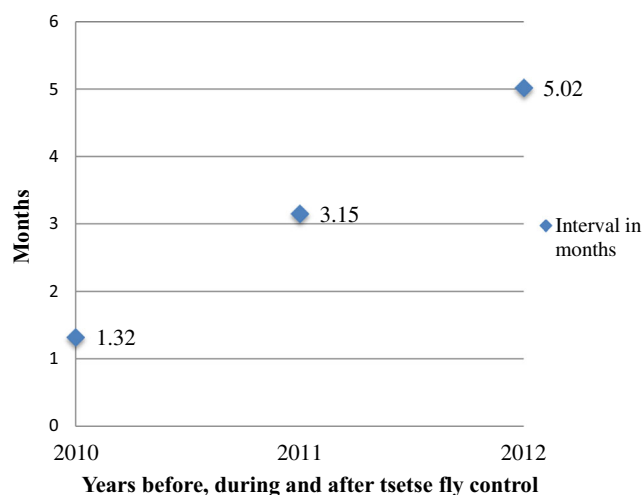


Fig. 3 Intervals in month livestock treated against trypanosomosis in 3 years

(Zelege et al. 2014). Their assessment was conducted at the Chewaka settlement station and the Bikiltu Didessa peasant association: in Chewaka the assessment was to compare before and after tsetse fly control with Bikiltu, the adjacent place where no tsetse fly control was exercised. Cattle mortality in Bikiltu (3.03%) was 97% higher than the cattle mortality in Chewaka (0.09) after tsetse fly control. Another questionnaire survey conducted to assess the impact of the tsetse challenge on herd composition, mortality and lactation, and reproductive performance in tsetse-infested and tsetse-free districts of southern Ethiopia also revealed similar results (Tigicho et al. 2012). Cattle mortality was 96.3% higher in the tsetse challenge (16.04%) than that in the tsetse-free area (0.60). A household interview conducted in southern Burkina Faso, to assess the impacts of a tsetse control using insecticide-impregnated targets, revealed an increase in the number of oxen from 0.1 to 1.1 per household and added a reduction in mortality of their oxen from 63.1 to 7.1%.

According to our result, the morbidity of oxen in the study areas was significantly decreased by 70.7% (from 0.75 to 0.22) because of the intervention and as a result the money lost to rent a healthy and energetic ox was decreased by 96.4%. This is because when oxen get infected by trypanosomiasis, their work efficiency substantially decreased (Zelege et al. 2014).

The effect of trypanosomiasis is not limited only to livestock directly, but it also has a considerable negative impact on crop production, especially in developing countries like Ethiopia which have a mixed crop-livestock production system (Feldmann et al. 2005). Although the specific contribution of livestock to increase the crop production was not studied here, it is predictable that the positive impact to the crop production comes from healthy livestock which serve as draught power and source of natural fertilizer from their dung. The present result supports this in that, according to the linear regression model, when a household who has one cattle harvests 10.9 quintals, his neighbor household who has ten cattle maximize his yield to 50.5 quintals of the major crops grown in the areas. This could be because of the fact that farmers in the study area use manure of their cattle as bio-fertilizers. These bio-fertilizers found in manure have chemical equivalence with the commonly used inorganic fertilizers (Schlecht et al. 1997). Moreover, the contribution of manure to soil physical properties is estimated to improve water-holding capacity and pH and even slows the release of nutrients (Onim et al. 1990).

In the absence of tsetse control schemes, farmers in Ethiopia depend in the trypanocidal drugs (Dagnachew 2004). In endemic regions of trypanosomiasis, the frequency of treatments administered per animal in a year period indicated the magnitude of trypanosome challenge in an area (Uilenberg 1998). Respondents in the study area stated that the treatment frequency of cattle might not exceed 6 weeks

before the tsetse control time. This corresponds with other results from Ethiopia which reported a treatment frequency of 6 weeks in tsetse fly-uncontrolled area (Zelege et al. 2014). However, other investigators reported less frequent treatment intervals of trypanocidal treatment; Afewerk et al. (2000) reported a treatment interval of 4 months while Tewelde et al. (2004) and Dagnachew (2004) reported frequencies ranging from 3 to 4 and 2.5–3.5 per month, respectively. This difference might be due to the variations in the magnitude of the disease among the different study areas.

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Compliance with ethical standards

Statement of animal right The authors declare that all component of the study were conducted in line with the current law of the country.

Conflict of interest The authors declare that they have no conflict of interest.

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