Bovine and equine trypanosomosis in Northwest Ethiopia: Prevalence, density of vectors and control measures

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A cross-sectional study was carried out from November 2016 to May 2017 in selected districts of Northwest Ethiopia (Jawi, South Achefer, Dembecha and Jabitehenan) with the aim of determining the prevalence of bovine and equine trypanosomosis, estimating the apparent density of vectors and assessing the effectiveness of control measures of the disease. A total of 1257 animals of which 803 bovine and 454 equine were examined for the determination of prevalence using blood sample collected from ear vein of animals. The buffy coat technique was employed to determine the prevalence and the packed cell volume (PCV) value. During sampling animals were categorized into age, body condition score, sex and haircoat color. A total of 40 monoconical traps 10 per district were deployed to estimate the apparent density of vectors. To assess control measures representative number of farmers were interviewed with a prepared questionnaire and using secondary data from veterinary offices. The overall prevalence of trypanosomosis was 7.47% and 4.40% for bovine and equine species, respectively. The prevalence of bovine trypanosomosis was 9.46%, 6.13%, 8.11% and 5.98% while prevalence in equine was 7.8%, 5.3%, 2.7% and 1.8% in Jawi, South Achefer, Dembecha and Jabitehenan districts, respectively. Significance differences in the prevalence of trypanosomosis were observed in hair coat color, age and body condition score in bovine while only body condition was significant in equine. The mean PCV value of parasitemic animals was significantly (P < .001) lower than that of aparasitaemic animals. The apparent densities of vectors were 1.04, 0.97, 0.32 fly/trap/day for Glossina, Stomoxys and Tabanus respectively. Glossina m. submorsitans and G. tachinoides were the species of tsetse identified. The questionnaire response indicated that trypanosomosis was observed in hair coat color, age and body condition score in bovine while only body condition was significant in equine. The mean PCV value of parasitic animals was significantly (P < .001) lower than that of aparasitaemic animals. The apparent densities of vectors were 1.04, 0.97, 0.32 fly/trap/day for Glossina, Stomoxys and Tabanus respectively. Glossina m. submorsitans and G. tachinoides were the species of tsetse identified. The questionnaire response indicated that trypanosomosis was observed to be a serious constraint on livestock health in the study areas. The application of continuous trypanosomosis control measures particularly in Jawi and South Achefer districts which were showed an increasing trend in livestock number might be attributed to control effectiveness. In conclusion the presence of trypanosomes and potential vectors necessitate the application of sustainable and integrated control methods in the study areas.

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1. Introduction

Trypanosomosis which is the main haemoparasitic disease in domestic animals and human caused by the protozoan parasite *Trypanosoma* (Holmes, 2013). The parasite is transmitted biologically by the tsetse (*Glossina* species) and mechanically by biting flies (*Stomoxys, Tabanus* and *Hematopota*). The ‘tsetse belt’ region covers an area which extends approximately 10 million km² across 37 countries in sub-Saharan Africa (Parryet et al., 2004; Ilemobade, 2009). In Ethiopia, tsetse transmitted trypanosomosis is arguably the single most important disease, which excludes over 150,000–220,000 km² of fertile land in the Northwest and Southwest of the country from agricultural production (Abebe, 2005; Dagnachew et al., 2017).

In Ethiopia, the disease is economically important and livestock found below 2000 m above sea level (m.a.s.l.) are exposed to various levels of trypanosome risk (Molalegne et al., 2010). As a result, a total of 14.8 million cattle, 6.12 million sheep and goats, 1 million camels and 1.3 million equine are at risk of contracting trypanosomes in Ethiopia (NTTICC, 2000). More than 20,000 heads die per year and annual loss attributed to the disease is estimated to be over US$ 236 million, whereas losses due to reduced meat, milk and draft power are not computed in this fig. (OAU, 2001). The most important *Trypanosoma* species are *T. congolense*, *T. vivax* and *T. brucei* in cattle, sheep, goats and equines. Camels are affected by *T. evansi* which is the common species in camel rearing areas of the country while equines mainly horses are affected by *T. equiperdum* in some highland parts of the country (Abebe, 2005). Tsetse is widely distributed in the Southwestern and Northwestern low lands and river valleys. Fifteen percent of the land believed to be suitable for livestock production is affected by one or more of the following species of tsetse; *Glossina morsitans submorsitans* (*G. m. morsitans*), *Glossina pallidepes* (*G. pallidipes*), *Glossina tachinoides* (*G. tachinoides*), *Glossina fuscipes fusipes* (*G. f. fuscipes*) and *Glossina longipennis* (*G. longipennis*) (Abebe, 2005). Apart from cyclical transmission of trypanosomosis by *Glossina* species, mechanical transmission is a potential threat to livestock productivity in wide areas of Ethiopia (Abebe and Jobre, 1996). For instance mechanically transmitted *T. vivax* is reported from northwest Ethiopia (Cherenet et al., 2006; Sinshaw et al., 2006).

In western part of Amhara region including West Gojjam, Awi, North Gondar and East Gojjam Zones bordering the Abay river valley is one of the tsetse belt areas of Ethiopia, tsetse transmitted trypanosomosis is becoming a serious threat for livestock production and agricultural activity (Cherenet et al., 2006; Dagnachew et al., 2005). Accordingly tsetse and trypanosomosis control programs have been carried out by the application of pour-on, traps, targets and trypanocidal drugs (NTTICC, 2000). The control practices were implemented two times per year i.e. before and after rainy season. However, the control program is not sustainable due to various challenges encountered during implementation (Cherenet et al., 2006; Dagnachew et al., 2005). As a result tsetse transmitted trypanosomosis threat, a large proportion of the livestock population is forced to reside in tsetse free highland and due to climate changes tsetse expands to previously tsetse free areas. Hence regular assessments of trypanosomosis have a paramount importance to plan and implement evidence based interventions. Therefore, the objectives of this study were to determine prevalence of bovine and equine trypanosomosis, estimate apparent densities of vectors and to assess control measures in the study areas.

2. Materials and methods

2.1. Study areas

The study was conducted in four districts namely Jabitehenan, Dembecha and South Achefer from West Gojjam Zone and Jawi district from Awi Zone of Amhara region (Fig. 1). The districts were selected purposively to include tsetse and trypanosomosis control measures implemented starting from 2000 (NTTICC, 2000). The districts climate alternates with long summer rainfall (June–September) and winter dry season (December–March) with mean annual rain fall of 1200–1600 mm and mean temperature of 10–20 °C. The altitude ranges from 1100 to 1500, 1400–2300, 1500–2500 and 648–1300 m.a.s.l. for Jabitehenan, Dembecha, South Achefer and Jawi districts respectively. The areas are occupied by savanna grass land, cultivated land, grazing land, bush and woodland, rivers and water bodies and the remaining is engaged by settlement population. The livestock population includes cattle, equines and small ruminants which are an integral part of the livelihood of the people (CSA, 2017).

2.2. Study animals

The study animals include bovine species (Zebu cattle) and equine (donkeys and mules), which were usually kept in an extensive husbandry system. The herd size of farmers living in a village ranged from 30–40 animals which grazed freely during the day and were housed in a common barn at night.

2.3. Study design and methodology

2.3.1. Cross-sectional study

Cross-sectional was conducted from November 2016 to May 2017 to estimate the prevalence of trypanosomosis, measure packed cell volume (PCV) and to determine the apparent density of tsetse and other biting flies.
2.3.1.1. Sampling method and sample size determination. Four districts were selected purposively from western Amhara region to represent tsetse infested areas and where control measures have been implemented. From each district Peasant Associations (Kebeles the administrative branches of districts) were selected randomly. The sampling strategy was cluster sampling method and herds were considered as clusters to sample animals from each Kebele. Herd is defined as a group of animals which constitute on average 30–40 animals (cattle and equines) owned by people living together in a village and their animals share the same barn at night and the same grazing area and watering points. Clusters were selected randomly and about 36 herds were required to determine the optimum sample size. Accordingly the sample sizes were determined based on the expected prevalence of 20% for bovine (Dagnachew et al., 2005) and 10.7% for equine (Bedada and Dagnachew, 2012), absolute desired precision of 5% at confidence level of 95%. Consequently a total of 246 bovine and 147 equine were needed to be sampled (Thrusfield, 2005). But in case of cluster sampling the subjects are not independent and hence larger sample is required. Therefore, as rule of thumb triples the numbers of animals required for simple random sample are needed (Martin et al., 1987). Consequently a total of 1257 animals, 803 bovine and 454 equine were used for the study. All equine species (354 donkeys and 20 mules) were adults and males because the areas are not favourable for breeding. Parameters like sex, age, body condition score and color coat of animals were recorded during sample collection. The age of animal was determined by dentition (DeLahunta and Habel, 1986; Caren, 1997) and categorized into adult and young. The body condition score was grouped in to poor, medium and good conditioned animals (Nicholson and Butterworth, 1986; NEWC, National Equine Welfare Council, 2005). The research project was approved by the ethical research review committee of the College of Veterinary Medicine and Animals Sciences of University of Gondar and the owner of the animals were agreed for the objectives of the study and verbal consent were obtained before sampling. Samples from animal were taken by qualified veterinarians.
2.3.1.2 Parasitological and haematological examination. Blood samples were obtained by puncturing of the ear vein with a lancet and collected directly into a haematocrit capillary tubes, sealed one end with ‘Cristaseal’ (Hawksely) and examined by dark ground buffy coat technique to detect the presence of trypanosomes according to Murray and McIntyre (1977). The capillary tubes were placed in microhaematocrit centrifuge at 12,000 rpm for five minutes. The centrifuged tubes were placed in haematocrit reader where the reading was expressed as a percentage of packed red cells to the total volume of whole blood. Haematocrit tubes were cut by diamond tipped pencil few millimeters below the junction of the buffy coat, the contents homogenized onto clean slide and covered with a 22 × 22 mm cover slip. The slides were examined under a microscope using 40 x magnification for movement of parasite. Thin blood smears stained with Giemsa were made from positive samples (Murray et al., 1982) for species identification. However, the molecular technique which might help species specific identification was not applied because of the limitation in facility and resources.

2.3.1.3. Entomological survey. To assess the apparent density and species of tsetse and other biting flies monochoncal type of traps were deployed for 72 h in different vegetation types (savanna grass land, riverine, bush woodland and cultivated land) parallelly with the parasitological study. The traps were baited with acetone and cow urine (Brightwell et al., 1987) which were placed on the ground about 30 cm upwind of the trap. About 40 traps 10 per district were deployed uniformly in each vegetation types of the selected sites. The species and sex of the captured flies were identified based on morphological characteristics (FAO, 2009; Walle and Shearer, 1997). The apparent densities of tsetse and biting flies were determined based on the daily mean number of flies captured and recorded as fly per trap per day (F/T/D) (Leak et al., 1987). However, fly dissection to determine the infection rates of trypanosomes was not done as it requires fresh tsetse for the detection of motile parasites.

2.3.2. Questionnaire survey

A questionnaire survey was conducted to assess the problems of trypanosomosis and the effectiveness of disease control measures implemented in the study areas. A structured questionnaire format was administered on 200 representative farmers, 50 per district. The farmers were selected randomly from owner of animals sampled for the parasitological examination. The amount and types of trypanocidal drug used, practice of treatment in the control of trypanosomosis for the last five consecutive years were assessed from the data record in the veterinary office of each district.

2.4. Data analysis

Data recorded during sample collection includes parasitological examination, PCV measurement, flies caught as well as questionnaire responses and secondary data were entered into Excel Spread Sheets and imported to SPSS version 20 for analysis. Descriptive statistics, student t-test and logistic regression were used to explain results and analysis of variables. Trypanosome infection rates with variables of age, sex, body condition score and coat color were compared by using univariate and multivariate logistic regression analysis to determine the strength of the associations. The apparent fly density with variables considered (district, altitude level and vegetation types) were analyzed using Wilcoxon signed ranks test. Student’s t-test was employed to compare the mean PCV of parasitaemic with that of aparasitaemic animals. Data was checked for normality before comparing means of the variables measured. Descriptive statistics was used for the questionnaire survey. The test result was considered significant at P < .05.

3. Results

3.1. Parasitological survey

3.1.1. Trypanosome prevalence

The overall prevalence of bovine and equine trypanosomosis was 7.47% and 4.40%, respectively. The prevalence of bovine trypanosomosis at district level was 9.46%, 6.13%, 8.11%, 5.98% while that for equine was 7.8%, 5.3%, 2.7% and 1.8% in Jawi, South Achefer, Demebecha and Jabitihan, respectively. Cattle was 1.7 times more likely to be affected by trypanosomosis than equine and the difference (Table 1) was significant (P = .034).

Trypanosoma congolense and T. vivax were the only trypanosome species identified during the study period (Fig. 2A). T. congolense was more prevalent (80%) than T. vivax (20%) in bovine species. Similarly T. congolense account (95%) compared to T. vivax (5%) in equine. From sampled animals severely affected cow with T. congolense infection was found (Fig. 2B) during the study period.

Adult cattle were 4.2 times more likely to be affected by trypanosomosis than young cattle. Poor body conditioned animals were 5.8 times more likely to be affected by trypanosomosis than good body conditioned animals while medium body conditioned animals were 1.9 times more likely to be affected by trypanosomosis than good body conditioned animals. Black colored animals were 6.2 times more likely to be affected by trypanosomosis than white colored animals while red colored animals were 1.7 times more likely to be affected by trypanosomosis than white colored animals. The prevalence of bovine trypanosomosis with respect to age, BCS and color coat groups showed a significant difference (P < .05) but the difference was insignificant in districts and sex (P > .05) categories (Table 2).

From a total of 454 equines (434 donkeys and 20 mules) examined 20 (4.4%) all donkeys were positive for trypanosome infections. Poor body conditioned equine were 8 times more likely to be affected by trypanosomosis than good body condition
equine while medium body conditioned equine were 4.7 times more likely to be affected by trypanosomosis than good body conditioned equine. The prevalence of equine trypanosomosis with respect to BCS showed a significant difference \( (P < .05) \) with poor body condition equine were among medium and good condition animals whilst the prevalence among districts was not significant \( (P > .05) \) as shown in Table 3. Since the majority of equines were male and adult these parameters were not considered as risk factors of trypanosome infections.

### 3.1.2. Haematological findings

The PCV value in bovine species ranges from 14 to 46% and the mean PCV value in parasitaemic animals was 20.97 ± 2.82SD while in aparasitaemic animals 27.71 ± 3.78SD with a significant difference \( (P < .001) \). The PCV value in equine species ranges from 18 to 47% and the mean PCV value in parasitaemic animals was 23.75 ± 4.66SD while in aparasitaemic animals 34.02 ± 2.97SD with a significant difference \( (P < .001) \). When anaemic condition was measured by mean PCV of parasitaemic animals,
both *T. congolense* and *T. vivax* infections reduced PCV, however, the PCV reduction in *T. congolense* infection was significantly higher (*P* < .001) compared to *T. vivax* infection (Table 4). The majority of trypanosome infection in equine was *T. congolense* and hence comparison on haematological effects with *T. vivax* was not done.

### 3.2. Entomological survey

A total of 187 flies were caught from deployed traps; out of these, 44.4% belonged to tsetse of the genus *Glossina*, and the remaining were biting flies shared by two genera namely *Tabanus* and *Stomoxys* which accounts 13% and 41.7%, respectively (Tables 5 and 6). Two species of tsetse were identified; *G. tachinoides* (62.65%) and *G. m. submorsitans* (37.35%). The tsetses caught were examined for sex. Accordingly 66.3% and 33.7% were females and males, respectively.

### Table 2

The prevalence of bovine trypanosomosis with host related risk factors in selected districts of western Amhara region, Northwest Ethiopia during the study period.

| Risk factor | Number examined | Number positive | Prevalence (%) | OR | 95% CI | Lower | Upper | *P*-value |
|-------------|-----------------|-----------------|----------------|----|--------|-------|-------|-----------|
| **Districts** |                 |                 |                |    |        |       |       |           |
| Jabitehenan  | 184             | 11              | 5.98           | 3  | 3.3    |       |       |           |
| South Achefer| 212             | 13              | 6.13           | 3  | 4      | 0.380 |       |           |
| Dемbecha     | 185             | 15              | 8.11           | 3.8| 4.1    | 0.708 |       |           |
| Jawi         | 222             | 21              | 9.46           | 3.8| 4.7    | 0.185 |       |           |
| **Sex**      |                 |                 |                |    |        |       |       |           |
| Female       | 376             | 25              | 6.6            | 2.4| 2.6    |       |       | 0.069    |
| Male         | 427             | 8.2             | 1.7            | 2.5| 2.7    |       |       |           |
| **Age**      |                 |                 |                |    |        |       |       |           |
| Young        | 148             | 4               | 2.7            | 2.5| 2.6    |       |       |           |
| Adult        | 655             | 56              | 8.5            | 2.1| 8.6    | 0.008 |       |           |
| **BCS**      |                 |                 |                |    |        |       |       |           |
| Good         | 194             | 5               | 2.6            | 0.2| 7.7    |       |       |           |
| Medium       | 312             | 17              | 5.4            | 2.7| 8.8    | 0.024 |       |           |
| Poor         | 297             | 12.8            | 5.8            | 10 | 16.1   | 0.000 |       |           |
| **Color coat** |               |                 |                |    |        |       |       |           |
| White        | 130             | 4               | 3.1            | 1.7| 7.1    |       |       |           |
| Red          | 466             | 22              | 4.7            | 2.1| 6.8    | 0.035 |       |           |
| Black        | 207             | 16.4            | 6.2            | 12 | 19.1   | 0.000 |       |           |

* a BCS-Body condition score.

### Table 3

Prevalence of equine trypanosomosis with different risk factors in selected districts of western Amhara region, Northwest Ethiopia during the study period.

| Risk factor | Number examined | Number positive | Prevalence (%) | OR | 95% CI | Lower | Upper | *P*-value |
|-------------|-----------------|-----------------|----------------|----|--------|-------|-------|-----------|
| **Districts** |                 |                 |                |    |        |       |       |           |
| Jabitehenan  | 113             | 2               | 1.8            | 2.5| 5.1    |       |       |           |
| Dемbecha     | 112             | 3               | 2.7            | 1.6| 6      | 0.142 |       |           |
| South Achefer| 113             | 6               | 5.3            | 1.1| 8.7    | 0.271 |       |           |
| Jawi         | 76              | 8.6             | 1.5            | 3.6| 11.1   | 0.453 |       |           |
| **BCS**      |                 |                 |                |    |        |       |       |           |
| Good         | 107             | 1               | 0.93           | 3.8| 4.7    |       |       |           |
| Medium       | 173             | 3               | 1.73           | 1.0| 7.1    | 0.041 |       |           |
| Poor         | 174             | 9.19            | 8.0            | 3.8| 10     | 0.001 |       |           |

### Table 4

Comparison of mean PCV values in parasitaemic bovine between trypanosome species.

| Parasite species | Number examined | Mean PCV ± SD | *t*-value | *P*-value |
|------------------|-----------------|---------------|-----------|-----------|
| *T. congolense*  | 48              | 20.23 ± 2.354 | −4.723 | 0.000     |
| *T. vivax*       | 12              | 23.92 ± 2.678 |         |           |

both *T. congolense* and *T. vivax* infections reduced PCV, however, the PCV reduction in *T. congolense* infection was significantly higher (*P* < .001) compared to *T. vivax* infection (Table 4). The majority of trypanosome infection in equine was *T. congolense* and hence comparison on haematological effects with *T. vivax* was not done.
flies ($P < .001$). Similarly altitude showed significant difference on the apparent densities in both tsetse and biting flies ($P < .001$) as shown in Fig. 4.

### 3.3. Questionnaire survey

#### 3.3.1. Animal production constraints and status of trypanosomosis

The majority of livestock reared in the study area were cattle followed by small ruminants and equine. The response of farmers on the constraints of livestock production were explained as diseases followed by lack of grazing land, watering points and scarcity of veterinary services. From livestock diseases the respondents indicated that trypanosomosis was the first animal health problem in the study areas. The majority of farmers (59%) responded that trypanosomosis was occurred from September–November followed by April–June (21%), July–August (12%) and October–May (8%).

#### 3.3.2. Trypanosomosis and tsetse control measures

The respondents of the questionnaire indicated that trypanosomosis and tsetse control measures started before 5 years in South Achefer and Jawi districts while in Jabitehenan and Dembecha districts it started before 10 years but the control practice was not sustainable. The control measures were carried out by using trypanocidal drugs, and pour-on, traps and targets.

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**Table 5**

Apparent density (F/T/D) of flies in four districts of Western Amhara region, Northwest Ethiopia during the study period.

| Districts    | Number of traps | Fly species caught | F/T/D* |
|--------------|-----------------|--------------------|--------|
|              |                 | Glossina | Tabanus | Stomoxys | Total |        |
| Jawi         | 10              | 32       | 5       | 21       | 58    | 2.9    |
| South Achefer| 10              | 20       | 6       | 15       | 41    | 2.05   |
| Jabitehenan  | 10              | 15       | 5       | 13       | 33    | 1.65   |
| Dembecha     | 10              | 16       | 10      | 29       | 55    | 2.75   |
| Total        | 40              | 83       | 26      | 78       | 187   | 2.34   |

F/T/D* = Fly/Trap/Day.

**Table 6**

Mean catches of *Glossina* species based on sex in four districts of Western Amhara region, Northwest Ethiopia during the study period.

| Districts    | Number of traps | G. m. submorsitans | Glossina tachinoides | Total | F/T/D* |
|--------------|-----------------|---------------------|----------------------|-------|--------|
|              |                 | Female | Male | Female | Male |        |
| Jawi         | 10              | –      | –    | 20     | 12   | 32     | 1.6    |
| South Achefer| 10              | –      | –    | 13     | 7    | 20     | 1      |
| Jabitehenan  | 10              | 11     | 4    | –      | –    | 15     | 0.75   |
| Dembecha     | 10              | 11     | 5    | –      | –    | 16     | 0.8    |
| Mean (F/T/D) |                 | 0.28   | 0.11 | 0.41   | 0.24 | 1.04   |

F/T/D* = Fly/Trap/Day.

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Fig. 3. Apparent densities of tsetse and other biting flies in different vegetation types.
According to the respondents, trypanocidal drugs were mainly obtained from private drug shops followed by veterinary clinics and both. In South Achefer district about 75% and 25% of the treatment was delivered by farmers and veterinary personnel while in Jawi 46%, 13% and 41% by farmers, veterinary personnel and both, respectively. In Dembecha district about 30% and 70% of the treatments were given by farmers and both farmers and veterinary personnel, respectively while in Jabitehenan district 25%, 10% and 65% by farmers, veterinary personnel and both, respectively.

Similarly the respondents indicated that tsetse control was carried out by pour-on application, traps and targets two times per year i.e. before and after the long rainy season (in the months of May and October), respectively in Jawi and South Achefer district districts. However, in Dembecha and Jabitehenan districts tsetse control was interrupted before 8 years. All the interviewed farmers confirmed that the tsetse control program was essential and effective as it was reflected in the reduction of fly population and disease prevalence particularly in South Achefer and Jawi districts. The respondents also suggested as a witness, the targets that were deployed on the river side and in savanna grassland (Fig. 5) played a significant role in the reduction of fly population.

The respondents revealed that tsetse and trypanosomosis distribution were decreased after the implementation of control measures by 90% and 76% in South Achefer and Jawi, respectively. Furthermore, the farmers in South Achefer and Jawi districts were observed several changes including increased number of livestock, decreased mortality rate and treatment expenses, improvement in body condition and milk production, increased working efficiency and agricultural production. The livestock population number obtained from secondary data of district veterinary offices starting 2012–2016 was summarized in Table 7. Consequently the trend of livestock number showed increment mainly in South Achefer and Jawi districts.

The trend of costs incurred for trypanocidal drugs per year for 5 consecutive years (2012–2016) in the four districts of Western Amhara region is indicated in Fig. 6. As clearly shown on the figure in Jawi and South Achefer districts the cost incurred for treatment is minimal and showed reduction with time which might be associated with control practice while in Jabitehenan and Dembecha districts the drugs proportion terms of costs is increasing with time.

4. Discussion

4.1. Parasitological findings

The current study indicated that trypanosomosis is a major constraint to cattle and equine production in the study areas. The parasitological examination revealed a prevalence of 7.47% for bovine trypanosomosis and 4.4% for equine trypanosomosis with *T. congolense* and *T. vivax* being the trypanosome species identified during the study period. The prevalence in equine was lower than that in bovine which might be associated with the fact that the preferred host for tsetse could be cattle and usually the latter graze over long distance (Radostits et al., 2007).

The prevalence of bovine trypanosomosis in the study districts was 9.46%, 6.13%, 8.11% and 5.98% for Jawi, South Achefer, Dembecha and Jabitehenan, respectively. Previous reports by Wolde-Mariam (1997) showed higher prevalence of 23.36% and 24.5% in Dembecha and Jabitehenan, respectively and Dagnachew et al. (2005, Dagnachew et al. (2011) with a total prevalence of 14.68% for Dembecha and Jabitehenan, and 11.3% in Jawi districts. On the other hand the current finding was in agreement with Kebede and Animut (2009) who reported 10.1% from Awi zone. The variation could be associated with the sampling season particularly shortly after rainy season the prevalence is higher as the density of vectors is expected to be high during this period.
Other possible explanation could be the treatment and control measures implemented in all districts, even though, the sustain-
ability is questionable in Jabitehenan and Dembecha districts. The prevalence of equine trypanosomosis (4.4%) in the present
study is lower than that of previous reports of 18.2%–28.5% in different district of Southern Ethiopia and 6.3% in Assosa and
Homosha districts in Benishangul Gumuz, Northwest Ethiopia (Abebe and Wolde, 2010). The reduction in prevalence from previ-
ous reports might be attributed to season and control measure of tsetse and trypanosomosis.

The present study indicated that the prevalence of \(T. \ congolense\) was (80%) higher than the prevalence of \(T. \ vivax\) (20%) for
bovine trypanosomosis. The high proportion of \(T. \ congolense\) detected in the study districts agreed with previous reports by
Dagnachew et al. (2007) which was 58% due to \(T. \ congolense\). That \(T. \ congolense\) was the dominant trypanosome species in equine
was in agreement with the reports of Abebe and Wolde (2010) and Assefa and Abebe (2001). \(T. \ congolense\) in donkeys causes

![Fig. 5. Target deployed for tsetse control in South Achefer district at Zehebest PA’s.](image)

![Fig. 6. The trend of costs in year incurred for trypanocidal drugs in the study areas.](image)

| Year | Species | District          |
|------|---------|------------------|
|      |         | South Achefer    | Jawi | Dembecha | Jabitehenan |
| 2012 | Bovine  | 164,844          | 91,359 | 129,686 | 128,923 |
|      | Equine  | 21,351           | 6351  | 13,547  | 10,304  |
| 2013 | Bovine  | 186,540          | 97,449 | 133,027 | 143,489 |
|      | Equine  | 21,985           | 8246  | 15,847  | 11,326  |
| 2014 | Bovine  | 191,791          | 128,233 | 135,296 | 163,238 |
|      | Equine  | 22,764           | 12,216 | 16,638  | 12,975  |
| 2015 | Bovine  | 198,320          | 139,445 | 141,107 | 237,905 |
|      | Equine  | 24,550           | 24,845 | 16,769  | 15,628  |
| 2016 | Bovine  | 206,524          | 213,544 | 147,798 | 242,726 |
|      | Equine  | 24,949           | 32,880 | 20,007  | 42,478  |
chronic infection with longer persistence in the blood (Mattioli et al., 1994). The higher prevalence of T. congoense may also suggest that the major cyclical vectors or Glossina species (G. m. submorsitans and G. tachinoides) are more efficient transmitters of T. congoense than T. vivax in East Africa (Langridge, 1976).

All the mules examined in this study were found to be negative for trypanosome infection. Other than small sample size, this might be attributed to less contact of mules with the tsetse vectors as they are usually kept around villages unless needed for riding purposes. Unlike mules, donkeys are the major type of pack animals and often travel long distances across tsetse challenge areas during the day time when fly activity is high and might expose to tsetse fly bite.

Recently Leta et al. (2015) conducted a comprehensive meta-analysis of bovine trypanosomosis in Ethiopia and estimated it to be 8.12% which is in agreement with our finding. Previous and on-going tsetse control activities in the present study areas could be the reason for the observed reduction in the prevalence of trypanosomosis.

In the current study significant association (P < .05) was observed between age, body condition and hair color coat categories. Body condition is also an important indication for trypanosome infection both of the individual animal and of the herd level (Murray, 1979). Our finding is also agreed with the previous works by Solomon and Fitta (2010) in Awi and Metekel zones in Northwest Ethiopia. Similarly in equine body condition score was significantly associated with trypanosome infection i.e. poor BCS had higher prevalence than medium and good BCS. According to Seifert (1996), trypanosome infection causes a progressive loss of condition, weight loss and the animals become easily exhaustible. Since adult animals travel long distance for grazing and watering areas might contribute higher infection rates. Animals with black coat color were found to be highly infected than red and white coat color might be associated for Glossina species, the strongest landing responses were found to be on black surfaces (Leak, 1999).

One of the main symptoms of trypanosomosis is anemia (Murray, 1979), consequently, the present study also confirmed significant difference between mean PCV values of parasitaemic and aparasitaemic animals. Similar findings were reported by several researchers (Abebe and Wolde, 2010; Rowlands et al., 2001; Ali and Bitew, 2011; Bayisa et al., 2015; Mamoudou et al., 2015). Comparison of the mean PCV of infected animals between species of trypanosome indicated T. congoense infected animals had more reduced PCV than was the case with T. vivax infected animals. Mostly T. vivax invades other tissues in addition to blood such as lymph nodes, eyes and heart (Whitelaw et al., 1988) but T. congoense confinement in the blood might result in low PCV values.

4.2. Entomological survey

The entomological survey revealed that tsetse species in the study areas were G. m. submorsitans in Dembecha and Jabitehenan, and G. tachinoides in Jawi and South Achefer districts. This finding is in agreement with the report of Dagnachew et al. (2005) G. m. submorsitans the only species of tsetse in Dembecha and Jabitehenan. Similarly G. tachinoides and G. m. submorsitans were detected by Langridge (1976) and by (Tikubet and Gemechu) in the Abbay, Beles and Didessa river valleys.

The overall mean catch of tsetse was 1.04 F/T/D during the study period. Our finding was not in agreement with the previous reports by Tilahun et al. (1997) who reported 16 F/T/D in Tana Beles valley and by Abebe and Regassa (2009) who reported 10.68F/T/D in upper Didessa valley. Such wide variations could have resulted from differences in season and density of vegetation cover and the control practices targeting the vectors in the current study areas. It may also be explained by the migration of reservoir game animals as a result of climate and habitat changes (Leak, 1999). Typical habitat pattern were found in the study area for the savannah species G. m. submorsitans which had preference for savanna grass land and G. tachinoides which prefer along the river side. Both of the identified tsetse species in the present study are among the five Glossina species recorded in Ethiopia (Keno, 2005). In the present study most of the tsetse were caught in the lowland area so that the apparent density decreases as altitude increases (P < .05). This finding supports earlier works by (35, 46, 40, 12) who indicated that climate, which is largely influenced by altitude has an impact on tsetse population. The presence of other biting flies such as Stomoxys and Tabanus in our study, which are potential vectors for the mechanically transmitted T. vivax in wider areas of the region where the tsetse are not found, has also been supported by previous researchers (Cherenet et al., 2006; Sinshaw et al., 2006).

4.3. Questionnaire survey

In the present study areas livestock diseases mainly trypanosomosis, lack of grazing land, watering points and scarcity of veterinary services were found to be the challenges for livestock production. This finding is supported by Dagnachew et al. (2005) who reported the same constraints in the Abbay basin areas of Northwest Ethiopia. Though, the level of precision depends on the experience of livestock keepers, most farmers could determine clinical signs suggestive of trypanosomosis that are commonly described for the disease (Holmes et al., 2004).

Farmers acknowledged that tsetse and trypanosomosis control program were present in their area. Consequently introduction of the intervention program reduced the infection and improved the productivity of animals. Similar observations in other areas indicated that tsetse control in Arbaminch Zuria district significantly reduced the prevalence of trypanosomosis and fly density (Seyoum et al., 2013). However, due to the long history of the disease in the study areas they accustomed the habit of frequent treatment of animals with diminazene acetate and isometamidium chloride. Similar practices about the drugs used were reported by previous researches in many parts of the country (Dagnachew et al., 2017; Gechere et al., 2012). The amount of trypanocidal drugs utilized in 5 years record data indicated that there was reducing trend in Jawi and South Achefer districts.
that could be associated with the active control measures implemented compared to Dembecha and Jabitehenan districts wherein only trypanocidal drug treatment was used while vector control program was not continued. This is partly substantiated with increased number of livestock observed from 2012 to 2016 which might be attributed to reduction in the prevalence trypanosomosis in the former districts.

5. Conclusion

Trypanosomosis is found to be the major livestock health constraint in the study areas, even though, different control measures has been implemented. The dominant species of trypanosomes identified in the study areas was *T. congolense*. Age, BCS and hair coat color in bovine while only BCS in equine were found to be significant risk factors in trypanosome infection rates. Similarly trypanosome infected animals had reduced mean PCV value as compared to non-infected animals. The species of tsetse fly caught in the study areas were *G. m. submorsitans and G. tachinoides*. Farmers in the study areas were familiar with trypanosomosis and control methods. Consequently, reduction in prevalence and vector densities as well as farmers perception on the control measures of the disease is promising to improve the productivity of livestock in the study areas. However, sustainability of control measures should be given emphasis.

Declaration of Competing Interest

No conflict of interest among authors and any interested persons concerning to this manuscript.

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