

Full Length Research Paper

Prevalence study of bovine trypanosomosis and tsetse density in selected villages of Arbaminch, Ethiopia

Wondewosen Teka¹, Dechasa Terefe² and Anteneh Wondimu³

¹Department of Veterinary Epidemiology, College of Veterinary Medicine, Microbiology and Public Health Haramaya University, Ethiopia.

²Department of Parasitology and Pathology, College of Veterinary Medicine, Haramaya University, Ethiopia.

³Department of Clinical Studies, College of Veterinary Medicine, Haramaya University, Ethiopia.

Accepted 23 March, 2012

A cross-sectional study was carried out aimed at determining the prevalence of bovine trypanosomosis and apparent tsetse density in two selected villages of Arba Minch Woreda, from November, 2009 to April, 2010. Blood samples were collected from 384 randomly selected cattle to detect the prevalence of trypanosomes using buffy coat method. The overall infection rate 4.43% (N=17) was recorded. The cattle are invariably infected with different species of trypanosome parasite and among these *Trypanosoma congolense* is the commonest (82.35%) followed by co-infection of *Trypanosoma vivax* and *T. congolense* (11.76%), and *T. vivax* (5.88%). This study showed a significant difference ($p < 0.05$) in trypanosomosis infection rate among poor, medium and good body condition animals. Poor body condition animals were highly affected compared to medium and good body condition. The mean PCV value of parasitemic and aparasitaemic animals was recorded as 20.94 and 23.55%, respectively. In each study area, entomological surveys were conducted using NGU trap and it indicated that *G. pallidipes* were the only tsetse fly species caught in the study area along with other biting flies like *Stomoxys* and *tabanus*. Apparent tsetse flies density of 0.312 and 29.624 flies/trap/day were recorded in Fura and Eligo villages, respectively and the overall apparent density of tsetse flies in the study area was 14.97 flies/trap/day. Due to its impact on livestock production, emphasis should be given for the control and prevention of trypanosomosis infection and its vectors.

Key words: *Bovine trypanosomosis*, prevalence, NGU trap, Tsetse fly, Southern Ethiopia.

INTRODUCTION

In Ethiopia, trypanosomosis is one of the major impediments to livestock development and agricultural production contributing negatively to the overall development in agriculture in general and to food self-reliance efforts of the nation in particular. While tsetse-borne trypanosomosis is excluding some 180,000 to 200,000 km² of agriculturally suitable land in the west and south west of the country, 14 million heads of cattle, an equivalent number of small ruminants, nearly 7 million equines and 1.8 million camels are at risk of contracting trypanosomosis at any one time (Langridge, 1976; MoARD, 2004).

Trypanosomosis is a complex disease caused by

unicellular parasites (trypanosomes) found in the blood and other tissues of vertebrates including cattle and man (Tesfaye, 2002; Uilenberg, 1998). The diseases are caused by flagellate protozoa called trypanosomes, which are transmitted by a number of different arthropod vectors but mainly by biting flies (Urquhart et al., 1996). The most important trypanosome species affecting livestock in Ethiopia are *Trypanosoma congolense*, *Trypanosoma vivax* and *Trypanosoma brucei*, in cattle, sheep and goats, *Trypanosoma evansi* in camels and *Trypanosoma equiperdium* in horses (Getachew, 2005).

Three elements influence the epidemiology of the disease, namely the distribution of the vectors, the virulence of the parasite (trypanosome) and response of the host (Urquhart et al., 1996). Tsetse flies (the vector) are in the genus *Glossina* species, *Glossina morsitans* usually is found in savanna country, *Glossina palpalis*

*Corresponding author. E-mail: anteneha7@gmail.com.

prefers areas around rivers and lakes and *Glossina fusca* lives in high forest areas. All three species transmit trypanosomes in various mammals (Aiello and Mays, 1998) and also biting flies may act as mechanical vectors, which requires only that blood containing infectious trypanosomes to be transferred from one animal to another but their significant in Africa is still undefined. In the case of *T. vivax*, *Tabanus* species and other biting flies seem to be the primary mechanical vectors (Aiello and Mays, 1998).

The life cycle of trypanosome is complex in both tsetse fly vector and the mammalian host; trypanosomes undergo a series of transformations into different forms (Seifert, 1996). Most tsetse-transmission is cyclical and begins when blood from a trypanosome infected animals are ingested by the fly. The trypanosome loses its surface coat, multiplies in the fly, then reacquire a surface coat and becomes infective. *T. brucei* species migrate from the gut to the proventriculus to the pharynx and eventually to the salivary glands; the cycle for *T. congolense* stops at the hypopharynx and the salivary glands are not invaded; the entire cycle for *T. vivax* occurs in the proboscis. The animal infective form in tsetse salivary gland is referred as the metacyclic form. The lifecycle in the tsetse may be as short as one week with *T. vivax* or extend to a few weeks for *T. brucei* species (Aiello and Mays, 1998).

The clinical signs of the disease depend up on the species and strain of trypanosome, the vector and resistance of the affected breed animal. Trypanosomosis can be diagnosed based on either detection of the parasite by the light microscope (parasitological) or demonstration of the circulating antibody (serological) in conjunction with clinical observation (Paris et al., 1979). The stained thin blood smears afford the best means of identifying species of trypanosomes (Stephen, 1986). Tsetse control currently relies on two bait systems; the first is trap and targets, which are treated with insecticide which kills tsetse on contact. The second is insecticide-treated livestock. Both systems have little direct damage to the environment (Vale, 1993) and of being very effective if applied properly in the appropriate circumstances.

The objective of this study is to determine the prevalence of bovine trypanosomosis and apparent tsetse density in two selected villages of Arba Minch Gamo Gofa Zone of Ethiopia.

MATERIALS AND METHODS

Study area

The study was conducted from November 2009 up to April 2010 at Fura and Eligo villages of Gamo Gofa Zone which was located in the Southern rift valley of Ethiopia, in between 5° 57'N latitude and 37° 32'E longitude. The area has a sub-humid climate with a moderately hot temperature. The vegetation is dominantly occupied by wood- grass land (WGL) especially along the sides of grazing

area and drainage lines and there is a high gallery of forest along the rivers. *Acacia* spp. is the most common woody vegetation in the area.

Study population and design

A cross-sectional study was conducted to determine the prevalence of bovine trypanosomosis by selecting the villages purposively as convenient. The study animals were selected by using simple random sampling method by taking age, sex and body condition into account.

Sample size determination

Sample size was calculated using Thrusfield (1995) formula.

$$N = \frac{1.96^2 [P_{exp} - (1 - P_{exp})]}{d^2}$$

where N is the required sample size, P_{exp} was the expected prevalence and d is the desired absolute precision.

An expected prevalence of 50% was used to increase the degree of precision and considering a 5% absolute precision and at 95% confidence level gave us 384 sample sizes.

Study methodology

Parasitological survey

For parasitological examination, blood sample were collected from ear vein of animal using microhaematocrit capillary tube and the packed cell volume, PCV was determined. The Buffy coat zone prepared in a microhaematocrit capillary was filled with 2/3 volume of blood and centrifuged for 5 min at 12,000 rpm and examined for trypanosomes by cutting the capillary tube to include 1 mm of the erythrocytes and 1 cm of the plasma. The Buffy coat is poured on a slide and covered with a 22x22 mm cover slip and examined using a microscope with a phase contrast and dark ground illumination. This technique is the most sensitive of the parasitological tests for the detection of *T. vivax* and *T. congolense* (Murray et al., 1983).

Entomological survey

For the entomological study, tsetse flies were collected by 32 NGU trap in different positions of the study areas near Abaya (16 traps) and Chamo (16 traps) lakes. Phenol was used as a bait to attract the flies. Traps were positioned at approximate intervals of 100 to 200 m for 72 h in watering and grazing points in which the animals and the vector are believed to have frequent contacts (FAO, 1992). Fly catch per trap per day (f/t/d) was determined to calculate the fly density and distribution (Leak et al., 1987). The species of the dominant tsetse fly was determined following the standard procedures (Pollock, 1982) and biting flies according to their morphological characteristics such as size, color, wing venation structure, and proboscis at the genus level (Walle and Sheare, 1997).

RESULT

Entomological survey

A total of 1723 flies were caught at the time of the study,

Table 1. The prevalence of Trypanosomosis on the basis of study site.

Study site	Test result		Total	Prevalence (%)
	Negative	Positive		
Fura	171	5	176	2.84
Eligo	196	12	208	5.77

Pearson χ^2 (1) = 1.9321 Pr = 0.165.

Table 2. The prevalence of Trypanosomosis on the Basis of Trypanosome species Involved.

Trypanosome species	Rate of infection	Prevalence (%)
<i>T. congolense</i>	14	82.35
<i>T. vivax</i>	1	5.88
<i>T. brucei</i>	0	0
<i>T. congolense</i> and <i>T. vivax</i>	2	11.76
Total	17	4.43

Table 3. The prevalence of Trypanosomosis on the basis of body conditions.

Body condition	Test result		Total	Prevalence (%)
	Negative	Positive		
Poor	79	11	90	12.22
Medium	42	1	43	2.32
Good	246	5	251	2

Pearson χ^2 (2) = 16.8916; Pr = 0.000.

out of these 1467 (85.142%) belong to *G. pallidipes* which characterized by narrow, yellow to dark brown flies and having long proboscis and hatchet cell in wings. The remaining is shared by two genera namely *Tabanus* and *Stomoxys* with score of 150 (8.705%) and 106 (6.152%) respectively. An overall apparent tsetse flies density in study area is 14.97 flies/trap/day.

The apparent tsetse fly density obtained in the study was 0.312 and 29.625 flies/trap/day in Fura and Eligo site respectively. From total tsetse fly trapped, females occupied large ratio. Out of total of 1467 tsetse flies captured, 479 (32.65%) flies where males and the rest 988 (67.35%) flies where females.

Parasitological survey

From the total of 384 blood samples collected in Fura and Eligo village, 17 (4.43%) samples were found to be positive for trypanosomes with the lowest prevalence was observed in Fura (2.84%) and the highest was recorded in Eligo (5.77%) villages as indicated in Table 1.

As shown in Table 2. *T. Congolense* 14 (82.35%) was

the most prevalent trypanosome species followed by *T. vivax* has causing mixed infection with *T. congolense* 2 (11.76%) and *T. vivax* 1 (5.88%) and 0 (0%) prevalence of *T. brucei*. Depending on body conditions, (11) 12.22%, (1) 2.32% and (5) 2% was recorded in poor, medium and good body condition of animals with statistically significant difference in the infection rate between poor, medium and good body condition ($p < 0.05$) (Table 3).

The animals examined were categorized in five groups according their skin color as red, white, mixed, black and gray skin colors to observe whether skin color of animal have any influence on the disease prevalence. The trypanosome infection prevalence was found to be 4.88, 1.56, 7.27, 3.57 and 0% in the animals of red, white, mixed, black and gray skin color respectively as indicated in Table 4.

Hematological finding

The analysis of PCV value in the animals examined for trypanosome infection showed that the mean PCV value for the parasitemic cattle was 20.94% whilst the mean

Table 4. The Prevalence of Trypanosomosis on the basis of skin color.

Skin color	Test result		Total	Prevalence (%)
	Negative	Positive		
Red	214	11	225	4.88
White	63	1	64	1.56
Mixed	51	4	55	7.27
Black	27	1	28	3.57
Gray	12	0	12	0

Pearson χ^2 (4) = 3.0116 Pr = 0.556.

Table 5. Apparent density of flies caught during the study period.

Study site	Altitude	Types of flies			Total	Flies/trap/day
		Species	Sex			
			M	F		
Fura	1223 mater	<i>G. pallidipes</i>	2	13	15	0.312
		<i>Tabanus</i>	-	-	89	1.854
		<i>Stomoxys</i>	-	-	51	1.062
Eligo	1119 mater	<i>G. pallidipes</i>	477	975	1452	29.625
		<i>Tabanus</i>	-	-	61	1.27
		<i>Stomoxys</i>	-	-	55	1.145

Table 6. The prevalence of Trypanosomosis on the basis of hematological finding.

PCV value (%)	Test result		Total	Prevalence (%)
	Negative	Positive		
PCV \leq 24	215	13	228	5.70
PCV $>$ 24	152	4	156	2.56

Pearson χ^2 (1) = 2.1552; Pr = 0.142.

PCV value for the aparasitemic cattle was 23.55% and cattle having PCV \leq 24% (anemic) was 5.70% whilst in the cattle having PCV $>$ 24% (non-anemic) was 2.56% as indicated in Table 6.

DISCUSSION

The present study revealed that from a total of 384 randomly selected cattle's in study area, 17 (4.43%) of animals were positive of which 12(5.77%) and 5(2.84%) in Eligo and Fura was recorded respectively. Generally, the highest prevalence of the disease was found in place where highest tsetse fly density is present (Table 5). This result is in agreement with previous result obtained by Soud (2008) who conclude that both the apparent density and prevalence of trypanosomes are positively correlated. The study indicates an overall apparent tsetse fly density of 14.97 flies/trap/day. This result is in disagreement with the study of Muturi et al. (2000) which

reported about 1.4 flies/trap/day in the southern rift valley of Ethiopia and the apparent tsetse fly density obtained in the study was 0.3125 and 29.625 flies/trap/day in Fura and Eligo village, respectively; this dramatic reduction of mean apparent density of the tsetse flies at Fura village is because of the presence of considerable suppression of flies population by the use of insecticide impregnated targets and insecticide-treated livestock undertaken in the area.

Among the different spp. of trypanosomes detected in study period, *T. Congolense* 14 (82.35%) was the most prevalent trypanosome species followed by *T. viviax* causing mixed infection with *T. congolense* 2 (11.76%) and *T. vivax* 1 (5.88%) and 0 (0%) prevalence of *T. brucei*. The dominance of *T. congolense* (82.35%) in the present study is in agreement with previous results of Tewelde et al. (2004) at Kone (75%) and Village I (93%) settlement areas of West Ethiopia, Woldeyes and Aboset (1997) at Arbaminch zuria districts (85.2%) and Rowland

et al. (1993) in Ghibe valley, south West Ethiopia (84%). The predominance of *T. congolense* infection in cattle may be due to the high number of serodemes of *T. congolense* as compared to *T. vivax* and the development of better immune response to *T. vivax* by the infected animal (Leak 1999). Moreover, the results of Muturi (1999) at Mereb Abaya, South Ethiopia (66.1%), Takele (1985) in Gamo-gofa (50%), Langridge (1976) in tsetse infested areas of Ethiopia (60%) and Terzu (2004) in selected sites of southern region (63.4%) had shown lower results of *T. congolense* than the present findings.

During the study period, the prevalence of bovine trypanosomosis was assessed between sexes of animals and among 17 trypanosome positive animals; 9 (4.35%) of them were female animals and 8 (4.52%) of them were male animals. The trypanosome infection in male animals is slightly higher than in the female animals; this shows that both male and female cattle were equally susceptible to trypanosomosis infection. This result is similar with previous results of which coincides with the results of Getachew (1993), Tefera (1994), Daya and Abebe (2008), Adane (1995) and Wellde et al. (1979) who obtained no significant difference in susceptibility between the two sexes.

The occurrence of disease in three different body condition (poor, good and medium) animals shows the highest prevalence in poor body condition (12.22%) followed by in medium (2.32%) and good body condition (2%). Due to poor body condition; animals are highly susceptible to diseases. Comparison conducted between the different skin color of cattle indicated that slightly higher prevalence was observed in cattle's having mixed skin color (7.25%) followed by 4.88% in red, 3.57% in black, 1.56% in white and 0% in gray skin color. Tsetse flies by nature are attracted toward a black color, so in animals having black skin color there is high prevalence of trypanosomosis recorded. The possible suggestion for the low prevalence in black skin color animals in the current study may be the low number of samples taken from black skin color animals.

During the study period, cattle with PCV \leq 24% were considered anemic (Van den Bossche et al., 2000) which is said to be the principal sign of trypanosomosis in livestock (Hemobade et al., 1979; Gardiner, 1989). In the present study, the highest proportion (76.47%) of parasitaemic cattle has PCV \leq 24. This result is in agreement, though relatively lower than the previous results reported by Afework (1998) at Pawe, North West Ethiopia (90%) and Muturi (1999) at Merab Abaya, South Ethiopia (88.9%).

In the present study, the mean PCV value for the parasitemic cattle was 20.94% whilst the mean PCV value for the aparasitemic cattle was 23.55%; however, trypanosomosis infection and mean PCV values obtained in this study of parasitemic and aparasitemic cattle were in agreement with the report of Rowlands et al. (1993) in Ghibe valley at South Western Ethiopia, in which was

stated that the average PCV of parasitologically negative animals was significantly higher than the average PCV of parasitological positive animals (Table 6).

From the total cattle populations sampled during study period, 59% of cattle populations have PCV \leq 24%. Almost 94.30% cattle's having PCV \leq 24% but they react negatively for trypanosomosis infection and this may have occurred due to the inadequacy of detection method used (Murray et al., 1977) or delayed recovery of anemic situations after recent treatment with trypanocidal drugs or may be due to the compound effect of poor nutrition and hematophagus helminth infection such as haemonchosis and bunostomiasis (Afework, 1998). However, PCV values can be affected by many factors other than trypanosomosis, but these factors are likely to affect both trypanosomosis negative and positive animals (Van den Bossche and Rowlands, 2001).

The present study also revealed that almost 2.56% of the cattle have a PCV value in the normal range (PCV $>$ 24%) but they react positively to trypanosomosis infection and this may have occurred due to recent infection with trypanosomosis. This result agree with the previous result of Garoma (2009) who conclude that cattle's having PCV value of normal range were shown to be infected with trypanosome parasite.

The animals examined were categorized in two age groups as young (\leq 3 years old) and adults ($>$ 3 years old). The trypanosome infection prevalence was found to be 6.02% in the young age group and 3.59% in the adult animals as indicated in Table 6. However, statistically there is no significant difference in infection rate among the different age groups ($p>$ 0.05).

CONCLUSIONS AND RECOMMENDATIONS

The results of bovine trypanosomosis and apparent tsetse density survey in two villages of Arba Minch Zuria Woreda indicated that an overall 4.43% (95% CI = 2.6 to 7.0%) prevalence of the disease and presence of high density of tsetse flies with an overall apparent density of 14.97 flies/trap/day. During entomological survey, only one species of tsetse fly was identified. This was *G. pallidipes*. Higher prevalence of trypanosomosis infection was observed in animal with poor body condition.

Based on the conclusion, the following recommendations are forwarded:

1. Strategic control of bovine trypanosomosis including vector control should be strengthened to improve livestock production and agricultural development in the area.
2. Attempt should be made to expand government and private veterinary services to serve the community properly.
3. Further surveys and studies should be conducted and appropriate, feasible control of trypanosomosis and/or

vector should be implemented.

4. Educating animal owners on the problems of trypanosomosis infection and on its control measure is more essential.

REFERENCES

- Adane M (1995). Survey on the prevalence of bovine trypanosomosis in and around Bahir Dar. DVM Thesis, AAU, FVM, Debre Zeit, Ethiopia.
- Afework Y (1998). Field investigations on the appearance of drug resistant population of trypanosome in Metekel ditrict, Northwest Ethiopia. Msc Thesis, AAU with Freie University, Berlin.
- Aiello E, Mays A (1998). Tsetse transmitted Trypanosomosis. In: Merck Veterinary Manual, eighth edition. Merck and co., Inc.
- Daya T, Abebe G (2008). Seasonal Dynamics of Tsetse and Trypanosomosis in selected sites of Southern Nation, Nationalities and Peoples regional State, Ethiopia. *Ethiop. Vet J.*, 12(2): 77-92.
- FAO (1992). Training manual for tsetse control personnel. FAO, Vol. 5, Rome, Italy.
- Gardiner N (1989). Recent study on the biology of *T. vivax*. *Adv. Parasitol.*, 28: 230- 279.
- Garoma D (2009). The prevalence of bovine trypanosomosis in Gari settlement area of East Wollega Zone. DVM Thesis Jimma University, FVM, Jimma, Ethiopia.
- Getachew T (1993). Prevalence of bovine trypanosomosis in two districts of western Gojjam province. DVM Thesis AAU, FVM, Debre Zeit, Ethiopia.
- Getachew A (2005). Trypanosomosis in Ethiopia, Addis Ababa University, Faculty of Veterinary Medicine. *Debre Zeit, Ethiop. J. Biol Sci.*, 4(1): 75-121.
- Langridge WP (1976). A tsetse and trypanosomiasis survey of Ethiopia. UK Ministry of Overseas Development, London, pp. 118.
- Leak SGA, Woume KA, Colardeue C, Duffera W, Feron A, Mulingo M, Tikubet G, Toure M, Yangari G (1987). Determination of tsetse challenge and its relationship with trypanosomosis prevalence. In: livestock production in tsetse infested areas of Africa. Nairobi, Kenya, ATLN, pp. 43-52.
- Leak SGA (1999). Tsetse Biology and Ecology: Their role in the Epidemiology of Trypanosomosis. CAB International, Nairobi, Kenya. pp. 568.
- Ministry of Agriculture and Rural Development of the Government of Ethiopia (MoARD) (2004). Tsetse and trypanosomiasis prevention and control strategies. Amharic Version. October 2004 (Tikimt, 1997 Eth. Cal). Paper presented on Farming Tsetse Controlled Areas (FITCA), Ethiopia. Final Work Shop, December, 27- 28, 2004. Adama, Ethiopia. Unpublished Work Shop Proceedings.
- Murray M, Trial TCM, Stephen LE (1983). Livestock productivity and trypanosomosis, ILCA, Addis Ababa, Ethiopia.
- Muturi KS (1999). Epidemiology of bovine Trypanosomosis in selected sites of the Southern rift valley of Ethiopia. MSc thesis, Addis Ababa University with Freie University, Berlin.
- Muturi KS, Msangi S, Munstermann S, Clausen P, Getachew A, Getachew T, Bergeine B, Assefa M (2000). Trypanosomosis risk assessment in selected sites of the southern rift valley of Ethiopia. In: International Scientific Council for Trypanosomosis Research and Control (ISCTRC). Proceedings of the 25th meeting held in Mombassa, Kenya. OAU/STRC Publication, p. 120.
- Paris J, Murray M, Agure R (1979). Report of the expert consultation on research of Trypanosomosis FAO. Rome.
- Pollock, J. N. (1982). Training manual for tsetse control personnel, Ecology and behavior of tsetse. FAO, Rome. 2: 101.
- Rowlands GJ, Mulatu W, Authie E, D' ieteren GDM, Leak SGA, Nagda SM, Peregine AS (1993). Epidemiology of bovine trypanosomosis in the Ghibe Valley, South- West Ethiopia. *Acta. Trop.*, 53: 135- 150.
- Seifert SHH (1996). Tropical animal health; second edition, Dordrech: Kluwer Academic Publisher, pp. 78-170.
- Soud M (2008). Efficacy of deltamethirin treated cattle on the control of tsetse and trypanosomosis at Genta Murchie village, Gamo Gofa district of SNNPR. DVM thesis, Mekelle University, Mekelle, Ethiopia. p. 14.
- Stephen LE (1986). Trypanosomosis a Veterinary Prospective program on Press Oxford.
- Takele A (1985). Survey of trypanosomosis, its economic impact in Gamo Gofa, DVM Thesis. AAU, FVM, Debre Zeit, Ethiopia.
- Tefera S (1994). Prevalence of bovine trypanosomosis in Arba Minch districts. DVM Thesis. AAU, FVM, Debre Zeit, Ethiopia.
- Terzu D (2004). Seasonal Dynamics of Tsetse and Trypanosomosis in selected sites of Southern Nation, Nationalities and Peoples Regional State (SNNPRS), Ethiopia.
- Tesfaye M (2002). Report of Trypanosome infection rate, in *G.m.submoristans* and *G. tachinoides* in Didessa Valley from July 29 to September 26/2002, Bedelle.
- Tewelde N, Abebe G, Eisler M, Mcdermott J, Greiner M, Afework Y, Kyule M, Munstermann S, Zessin KH, Clausen PH (2004). Application of field methods to assess isomethamidium resistance of trypanosomes in cattle in Western Ethiopia. *Acta. Trop.*, 90: 163-170.
- Thrusfield M (1995). Veterinary Epidemiology, 2nd Edition. Blackwell Science Ltd., UK. pp. 182-198.
- Uilenberg G (1998). A field guide for diagnosis, treatment and prevention of African animal trypanosomosis. Adapted from the original edition by Boyt. W. P. Food and Agriculture organization of United Nations (FAO), Rome, pp. 43-135.
- Urquhart GM, Armour J, Duncan JL, Dunn AM, Jennings FW (1996). Veterinary parasitology 2nd edition. Black Well Science Ltd., London UK, pp. 212-219.
- Vale GA (1993). Development of baits for tsetse flies (Diptera: Glossinidae) in Zimbabwe. *J. Med. Entomol.*, 30: 831- 842.
- Van den Bossche P, Rowlands GJ (2001). The relationship between the parasitological prevalence of trypanosome infections in cattle and helped average packed cell volume. *Acta Trop.*, 78: 168- 170.
- Woldeyes G, Aboset G (1997). Tsetse and trypanosomosis distribution, identification and assessment of socio-economic viabilities of the new vector control approaches in Arbaminch Zuria Woreda. EVA. Proceedings of the 11th conference. pp. 143-154.
- Welde BT, Hockmeyer WT, Koyatch LM (1979). Immunity in bovine to *Trypanosoma congolense* induced by self cure or chemotherapy. In Losos, G. and Chounad, A. pathogenesis of trypanosomosis.