Journal of Animal and Veterinary Advances 4 (7): 630-636, 2005

Comparative Clinical Observations on *Trypanosoma vivax* Infected Pregnant Yankasa and West African Dwarf Ewes

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Abstract: Three groups of pregnant Yankasa (YK) and West African Dwarf (WAD) ewes, made up of 6 pregnant YK and 6 pregnant WAD ewes in each group, were assigned at random to first, second and third trimester of pregnancy, to study the clinical manifestation of. T. vivax infection at each trimester of pregnancy. A fourth group made up of 3 pregnant YK and 3 pregnant WAD ewes served as the non-infected controls for the study. Pre- infection mean rectal temperatures of the YK and WAD ewes were 38.6 °C and 38.7°Crespectively, while post-infection temperatures were as high as 41.5 °C and 41.6 °C for the YK and WAD ewes respectively. The infection was severe in the infected YK and WAD ewes in the second and third trimesters of pregnancy and most severe in YK than in the WAD ewes. The infected YK and WAD ewes exhibited pyrexia, signs of anaemia shown by pale mucus membrane, decrease in packed cell volume (PCV) values, decrease in total plasma protein (TP) values, weight loss, lethargy, dullness, abortions and death of ewes. The severity of the infection increased as the pregnancy advanced in the ewes. WAD ewes in the first trimester were least susceptible to the infection and self-cure was observed in one WAD ewe. The infected WAD ewes controlled the effects of the infection on abortions and mortality more than the YK ewes. It was concluded from the study that the trimester of pregnancy and breed of ewe influenced the clinical manifestation of T. vivax infection on pregnant YK and WAD ewes.

Key words: Trypanosomosis, trimester of pregnancy, breed of ewe

INTRODUCTION

Animal trypanosomosis caused by *Trypanosoma vivax. T. brucei. T, congolense* is one of the most important diseases of livestock in West Africa. *T. vivax* is regarded as the predominant cause of bovine trypanosomosis in Nigeria[1] and probably the most pathogenic[2]. Trypanosomosis is partially responsible for nomadism, transhumance and their attendant socio-economic problems in Nigeria[3]. Trypanosomosis is also responsible for restricting some breeds of livestock especially cattle, sheep and goats to the Sahel and Northern Sudan vegetation zones, where rainfall and pastures are limited [trypanosomosis non endemic areas] and for rendering the lush pastures of the South vegetative zones not available for grazing [trypanosomosis endemic areas].

The susceptibility / tolerance of livestock breeds to trypanosomosis, is influenced by several factors, these include immunologic response of the host to the infection[4,5], transfer of maternal antibody from dam to offspring and constant exposure to the parasite in endemic areas, inter current infections, nutrition, stress of migration, pregnancy and management[4,6]. Others are high concentration of O-acetylated Sialic acids in animal's erythrocytes[7]. Anaemia is reported as the most characteristic finding in trypanosomosis in domestic animals[8,6,9]. Failure to gain weight, loss of weight, abortions and reduced growth rate have also been reported in *T. vivax* infected ruminants[6,10,11]. Abortions and foetal mummification have also been reported in *T. vivax* infected second and third trimester pregnant YK and WAD ewes[12].

In Nigeria, the effects of pregnancy on clinical manifestations of trypanosomosis in Zebu cattle have been described[13]. Preliminary studies on clinical manifestation of *T. vivax* infection on second and third trimester pregnant YK and WAD ewes, have also been described[12]. Detailed studies on the clinical manifestation of *T. vivax* infection on various stages of pregnancy of YK and WAD ewes, the predominant breeds of sheep in Nigeria is however lacking. This study was therefore designed to comparatively study the clinical manifestation of *T. vivax* infection on pregnant YK and W AD sheep, infected in their first, second and third trimesters of pregnancy.

MATERIALS AND METHODS

Animals and experimental design: This study was carried out at the National Animal Production Research Institute, Ahmadu Bello University, Shika Zaria, Nigeria. Shika Zaria, is located in the Sudan Savanna zone of Nigeria. Seventy-five (75) normocyclic ewes made up of forty-five (45) YK and Thirty (30) WAD ewes, with average weights of 29.8 + 2.1kg and 21.0 + 1.3kg respectively, were acquired for the study. The ewes were between the ages of 9 to 12 months. The YK ewes were acquired from the tsetse fly-free Sudan Savanna zone of Nigeria (Trypanosomosis non endemic), while the WAD ewes were acquired from the tsetse fly-infested Forest zone of Nigeria (*Trypanosomosis endemic*). The ewes were housed in fly proof pens.

Before the commencement of the study, the WAD ewes were allowed to acclimatize for six months. During the period of acclimatization, baseline haematological data, progesterone (P4) values and cyclicity of the YK and WAD ewes were evaluated. Cyclicity was monitored in the ewes using vasectomized rams. The ewes were also checked for blood and intestinal parasites at monthly intervals. They were grazed daily, on improved pastures and supplemented daily with a concentrate mixture of 60% maize bran and 40% cotton seed cake. The concentrate mixture was fed to the ewes at the rate of 300.0 gms per ewe per day. Water, hay and mineral salt licks were provided adlib.

The ewes were subjected to adequate veterinary care, which included de-ticking and de-worming. They were trypanosomes free and were also treated twice against common haemoparasites with long acting Terramycin (Pfizer Ikeja Lagos Nigeria.) containing 216.0 mg Oxytetracycline dihydrate. The drug was administered intramuscularly at 20.0 mg /Kg body weight.

To get all the ewes in the same phase of reproduction, they were synchronized for estrus using intravaginal sheep sponges (Veramix^{R}, Up John Ltd, U.K.), containing 60.0mg of Medroxy-progesterone acetate as active ingredient. The sponges were removed at thirteen (13) days post insertion. Forty eight, (48) hours after sponge withdrawal, proven fertile YK and WAD rams were introduced to naturally breed the YK and WAD ewes respectively, at a ratio of 1 ram to 5 ewes. Radioimmunoassay (RIA) technique for Progesterone levels determination[14] and non- return to estrus by 21 days after natural breeding by the rams were use to diagnose pregnancy in the ewes.

Forty-two (42) healthy uniparous ewes made up of 21 YK and 21 WAD that were earlier confirmed pregnant by RIA technique and non return to oestrus 21 days post natural breeding by proven fertile rams, were selected for the study. The ewes were assigned at random to first, second and third trimester of pregnancy groups, consisting of 6 pregnant YK and 6 pregnant WAD per group, to study the clinical manifestations of. *T. vivax* infection at each trimester of pregnancy. A fourth group made up of 3 pregnant YK and 3 pregnant WAD ewes served as the non-infected controls for the study.

Infection: Stabilate of *T. vivax* (Stabilate 150) was obtained from the Department of Veterinary Parasitology and Entomology Faculty of Veterinary Medicine, Ahmadu Bello University Zaria, to infect donor goats. Trypanosomes were transferred from the donor goats to the experimental ewes at each trimester of pregnancy. Each experimental ewe was infected with 2.0ml of the blood by jugular vein-puncture containing approximately 2×10^6 trypanosomes. Ewes in the first, second and third trimesters of pregnancy were infected at 23, 52 and 106 days of pregnancy respectively. The ewes in the control group were left uninfected.

Following infection the ewes were monitored daily for clinical signs, rectal temperatures, parasitaemia, abortions or mortality. Packed cell volume (PCV) values and Total Plasma (TP) protein values were monitored twice weekly, while body weights were recorded weekly.

Blood samples for determination of Parasitaemia, PCV and TP values, were taken between 8 a.m to 10.0 a.m, in test tubes containing 10% Ethylene diaminetetracetate (EDTA), as anticoagulant. Parasitaemia in the ewes was determined within 30 minutes of collection, using the microhaematocrit centrifuge technique (HCT). The degree of parasitaemia was classified as described by Woo (1969). [1]+, occasional trypanosomes seen; [2]++, 1-2 trypanosomes seen; [3]+++, 3-20 trypanosomes seen; [4]++++, more than 20 trypanosomes seen per microscopic field. The PCV values of the samples were determined using the microhaematocrit technique[15] the values were read on a Gelman Hawskley micro haematocrit reader (Gelman. Hawksley Ltd. England) and recorded as percent (%). TP values were determined using the refractometric method, according to Coles[15], to evaluate the nutritional status of the animals. Rectal temperatures of the ewes were taken between 8.00 to 10.00am using a centigrade thermometer. Body weights were determined in the morning before feeding the animals. A top loading scale model `D' was used for the determination of body weights and recorded in kilograms (kg). Percentage change in body weights post infection were calculated and recorded for each of the ewes.

Table 1: Clinical observations on pregnant Yankasa and West African Dwarf (WAD) ewes infected with Trypanosoma vivax in their First, Second and Third Trimesters of pregnancy.

Trimester of pregnancy when infected	First Trimester [0 to 50] days		Second Trimester [51 to 101] days		Third Trimester [102 to 152] days		Uninfected Controls	
Sub-groups of ewes	YK	WAD	YK	WAD	YK	WAD	YK	WAD
	Clinical observations							
Nature of infection	Mild	Mild	Severe	Severe	V.Severe	Variable	None	None
Highest % change in. body weights pi	-8.31	+23.3	-23.0	-30.4	-35.5	-15.2	+6.8	+16.0
Abortion	0	0	6	1*	6	4	0	0
Mortality	0	0	6	1	6	0	0	0
Parasitaemia								
Range	0 to 4	0 to 4	0 to 4	0 to 4	0 to 4	0 to 4	0	0
Mean + SD	3.4±3.7	2.2±1.7	2.7±1.1	2.8±1.1	2.3±1.2	2.3±1.9	0	0
Rectal Temp ^{O} C								
Range	36.0-41.5	39.1-41.2	38.1-41.3	38.1-41.6	38.3-40.9	38.2-39.8	38.2-39.2	38.2-39.4
Mean + SD	39.6±1.2	39.8±1.7	39.2±0.8	39.5±1.2	39.2±0.7	38.8±0.4	38.7±02	38.8±0.3
Percent PCV								
Range	15.0-29.0	14.0-29.0	11.0-30.0	10.0-35.0	10.0-31.6	15.0-29.9	8.0-36.0	28.0-40.0
Mean + SD	21.3±3.6	21.7±4.3	22.2±4.3	22.4±6.3	19.9±6.8	20.5±5.1	30.0±2.0	30.9±3.5
Total Plasma Protein g/dL								
Range	5.0-8.3	5.0-7.7	5.3-9.1	4.9-9.3	5.0-8.3	5.8-8.2	6.2-9.0	6.1-8.0
Mean + SD	6.3±0.8	6.3±0.8	6.7±0.9	6.7±0.9	6.5±0.8	6.5±0.5	7.4±0.4	6.9±0.1

STATISTICAL ANALYSIS

Statistical analysis of Parasitaemia levels, Percent change in body weights, PCV, TP and Rectal Temperature values were carried out using SAS proc GLM procedure (Steel and Torrie, 1980).

RESULTS

First Trimester

Clinical signs and symptoms: The infection was not severe in both the YK and WAD ewes in this trimester and was characterized by raised hair coats, lethargy, enlarged pre-scapular lymph nodes, fluctuating parasitaemia and pyrexia. The infected YK loss weights (-8.31) in contrast to the infected WAD ewes, that showed increase in body weights (+23.3) just as the uninfected control ewes (Table 1).

Parasitaemia: The onset of parasitaemia was within 3-4 days post infection in both the YK and WAD ewes. High peaks of parasitaemia were observed within 6 9 days post infection in the YK and WAD ewes respectively. Thereafter the parasitaemia fluctuated until the termination of study at 28 days post infection (50 days of pregnancy) i.e. the end of the first trimester period. The levels of parasitaemia in the infected YK and WAD ewes were not significantly ($P \geq 0.05$) different (Table 2).

Table 2: Least Square means of clinical data of Yankasa WAD ewes infected with *T. vivax* in First Trimester of Pregnancy

Treatments	Clinical observations: Parasitaemia scores	TP	Temperature ^{0}C	% PCV	% Change in body weight
Yankasa control	0.0^{a}	7.10^{a}	38.80^{a}	29. 10^{a}	2.0^{a}
WAD Control	0.0^{a}	7.20^{a}	38.90^{a}	29. 60^{a}	3.86^{a}
Yankasa infected	1.3^{b}	6.50^{b}	39.20^{b}	22.80^{b}	-2.2^{b}
WAD infected	1.0^{b}	6.40^{b}	39.30^{b}	23.60^{b}	4.1^{a}
SEM	0.27	0.12	0.14	0.70	1.1

Rectal Temperatures: All the YK and WAD infected ewes showed pyrexia. The onset of high pyrexia coincided with the first wave of high parasitaemia. Thereafter the ewes developed fluctuating pyrexia until the termination of the first trimester study at 28 days post infection. The highest temperature recorded in the YK infected ewes in the first trimester, was 41.5 °C with a mean of 39.6 ± 1.2°C. In the WAD infected ewes it was 41.2 °C with a mean of 39.8±1.7 (Table 1).

The rectal temperatures of the YK and WAD infected ewes were not significantly ($P \geq 0.05$) different (Table 2), but were significantly higher ($P \leq 0.05$) than the rectal temperatures of the non-infected YK and WAD control ewes (Table 2). Indicated pyrexia in the infected YK and WAD ewes.

Packed Cell Volume (PCV) values: Decline in PCV values were observed in both the YK and WAD infected ewes. The PCV values of the infected YK ewes post infection ranged from 15.0% to 29.0%. For

the infected WAD ewes it ranged from14.0% to 29.0% (Table 1). There were no significant differences (P≥0.05) between the PCV values for infected YK and WAD ewes (Table 2). On the other hand the PCV of the non-infected YK (27.1±0.70) and WAD (28.6±0.70) control ewes, were within normal range and significantly higher (P≤0.05) than those of the infected YK (22.8±0.70) and WAD (23.6±0.70) ewes (Table 2).

Total plasma protéin (TP) values: Decline in TP values were observed in both the infected YK and WAD ewes in this trimester. The TP values of the infected YK and WAD ewes were however not significantly (P≥0.05) different. The TP values of the non-infected YK and WAD control ewes were significantly higher (P≤0.05) than those of the infected ewes. (Table 2)

Percent change in body weights (%): The infected YK ewes in the first trimester loss weights (-8.31%), while the infected WAD ewes gain weights (+23.3%) over the experimental period despite the infection (Table 1). The body weights of the infected WAD ewes were significantly (P≤0.05) higher than those of the infected YK ewes, but were not significantly (P≥0.05) different, from those of the non-infected YK and WAD control ewes (Table 2).

Abortions and/or mortality: Abortions or mortality were not observed in the infected YK and WAD ewes within the first trimester of pregnancy i.e. 0 to 50 days of pregnancy (27 days post infection). The same was observed in the non-infected YK and WAD control ewes

SECOND TRIMESTER

Clinical signs and symptoms: In this trimester, the infection was severe in both the YK and WAD ewes, but more in the YK than in the WAD. The severity was characterized in the YK, by high parasitaemia and pyrexia, severe lethargy, emaciation, anaemia, rough hair coats nasal and ocular discharges, droopiness, anorexia and atrophy of the pre-scapular lymph nodes in chronic cases. Severe diarrhea and pneumonia, were observed in three of the severely affected YK ewes. One of the severely affected YK ewes died, 11 days post infection. The WAD infected ewes, showed signs of the infection similar to the YK, however diarrhea, pneumonia, atrophies of pre-scapular lymph nodes and mortality within 11 days post infection were not observed in the infected WAD ewes..

Parasitaemia: The onset of parasitaemia was within 3-4 days post infection in the YK ewes and 4 to 9 days in the WAD ewes. High levels of parasitaemia were observed within the first two weeks post infection thereafter the parasitaemia fluctuated until death of the ewes. No significant differences (P≥0.05) were observed in parasitaemic levels between the YK and WAD infected ewes (Table 3).

Rectal Temperatures: The highest temperatures recorded in the YK and WAD infected ewes in the second trimester, were 41.3 °C and 41.6 °C respectively (Table 1). There was no significant difference (P≥0.05) in rectal temperatures, between infected ewes, however the rectal temperature of the infected ewes was significantly (P≤0.05) higher than that of the non-infected YK and WAD control ewes (Table 3). Indicated pyrexia in the infected ewes.

Packed Cell Volume (PCV) values: Marked decline in PCV values were observed in both the YK and WAD infected ewes from 9 to 35 days post infection. Thereafter the PCV values of the WAD infected ewes showed increase towards pre-infection levels However the PCV of the WAD and YK infected ewes were not significantly (P≥0.05) different (Table 3). The PCV values of the non-infected YK and WAD control ewes were significantly (P≤0.05) higher than those of the YK and WAD infected ewes (Table3). Indicated of anaemia due to Trypanosomosis in both the YK and WAD infected ewes.

Total plasma proteins (TP) values: In this trimester, the TP values of the non-infected YK and WAD control ewes were significantly higher (P≤0.05) than those of the infected ewes. The TP values of the YK and WAD infected ewes were not significantly (P≥0.05) different (Table 3).

Changes in body weights (%): The infection was severe in both the Yankasa and WAD infected ewes. Consequently no significant differences (P≥0.05) were observed in the loss of body weights in both the infected YK and WAD ewes (Table 3). However the body weights of non-infected YK and WAD control ewes were significantly (P≤0.05) higher than those of the infected ewes (Table 3).

Table 3: Least Squares means of clinical data of Yankasa and WAD ewes infected with *T. vivax* in Second Trimester of Pregnancy.

	Clinical observations				
Treatment	Parasitaemia scores	TP	Temperature °C	%PCV	% Change in body weight
Yankasa control	0.0[a]	7.3[a]	38.7[a]	30.2[a]	2.4[a]
WAD Control	0.0[a]	7.1[a]	38.8[a]	31.8[a]	0.4[a]
Yankasa infected	1.80[b]	6.9[b]	39.1[b]	22.4[b]	-3.2[b]
WAD infected	1.60[b]	6.8[b]	39.20[b]	24.2[b]	-0.01[a]
SEM	0.27	0.14	0.12	1.0	1.7

Abortions and /or mortality: Abortions and mortality were observed in all the infected YK within the second trimester period by 38 days post-infection. In contrast, only one infected WAD died within the second trimester period by 41 days post infection as a result of dystocia related complications

THIRD TRIMESTER

Clinical signs and symptoms: The infection was very severe in the YK ewes in the third trimester as observed in the infected YK in the second trimester. However, the diarrhea and pneumonia observed in the YK in the second trimester were absent in the infected YK in the third trimester. 50% of the infected YK aborted within 10 to 12 days post infection. These ewes also died within 2 to 3 days after aborting, the remaining 50% of the infected YK ewes aborted live but weak foetuses that died within 24 to 48 hours. In the WAD ewes, the infection was severe in 50% of the infected ewes. These ewes aborted within 12 to 14 days post infection, however, none died after aborting, in contrast to the YK ewes. The remaining 50% of the infected WAD ewes, showed mild signs of the infection and did not abort until at 46 days post infection when one aborted, 3 days before the termination of the study at 49 days post infection.

Parasitaemia: The onset of parasitaemia varied from 3-4 days post infection in the YK and 4-9 days post infection in the WAD ewes. High levels of parasitaemia were observed within the first two weeks post infection. Thereafter the parasitaemia fluctuated until death. No significant differences ($P \geq 0.05$) were observed in parasitaemic levels between the infected YK and WAD ewes (Table 4).

Rectal Temperatures: High peak of pyrexia that coincided with high levels of parasitaemia were observed in both the infected YK and WAD ewes. Significant ($P<0.05$) differences were observed between the infected YK and WAD ewes (Table. 4). The rectal temperatures of the infected YK and WAD ewes were also significantly ($P0.\leq 05$) higher than those of the non-infectd YK and WAD ewes (Table 4).

Table 4: Least Squares means of clinical data of Yankasa and WAD ewes infected with *T. vivax* in Third Trimester of pregnancy.

	Clinical observations				
	Parasitaemia		Temperature		
Treatment	scores	TP	°C	% PCV	% Change in body weight
Yankasa control	0.0[a]	7.1[a]	38.6[a]	30.4[a]	1.2[a]
WAD Control	0.0[a]	7.0[a]	38.7[a]	31.5[a]	3.7[a]
Yankasa infected	1.5[b]	6.8[b]	39.2[b]	22.6[b]	-9.3[b]
WAD infected	1.6[b]	6.7[b]	38.9[b]	22.3[b]	-5.2[b]
SEM	0.24	0.11	0.10	1.0	2.2

Packed Cell Volume (PCV) values: Marked decline in PCV values post infection was observed in the YK and WAD infected ewes. Lowest PCV values of 10.0%, and 14.7% were observed in the infected YK and WAD ewes respectively within 31 days post infection The PCV values of the YK and WAD infected ewes were not significantly different ($P \geq 0.05$) (Table 4). The PCV values of the non-infected Yk and WAD control ewes were significantly ($P \leq 0.05$) higher than those of the infected ewes (Table 4).

Total plasma proteins (TP) values: The TP values of the non infected YK and WAD control ewes in the third trimester were significantly higher ($P \leq 0.05$) than those of the infected ewes, however the TP values of the infected YK and WAD ewes were not significantly ($P \geq 0.05$) different(Table 4).

Percent changes in body weights (%): In the third trimester the infection resulted in loss in body weights in both the infected YK and WAD ewes. The body weights of the non-infected YK and WAD control ewes were significantly ($P \leq 0.05$) higher than those of the infected YK and WAD ewes (Table 4).

Abortions and/or mortality: Abortions and mortality were observed within 49 days post infection in all the YK infected ewes in the third trimester. Abortions without mortality were observed within the same period in 66.6% of the infected WAD ewes in the third trimester.

DISCUSSIONS

The results of the present study showed that both YK and WAD ewes are susceptible to Trypanosomosis. Anaemia, pyrexia and loss in body weights were common findings in the infected ewes, once the infection is able to establish in the ewes. The severity of the infection in the YK ewes increased as pregnancy advanced in the ewes. This finding concurs with earlier reports[16] in trypano-susceptible Zebu cattle. The abortions and mortality observed in the second and third trimesters of pregnancy occurred more in the YK than in the WAD ewes. This showed that the outcome of the infection varied with breed and trimester of pregnancy. Abortions and mortality due Trypanosomosis in Nigeria, have been reported in Zebu cattle[17,16] and in YK and WAD ewes[12].

High peaks of parasitaemia at the onset of the infection were observed in the infected groups in all the trimester of pregnancy and were similar to previous observations made in Zebu cattle[6]. The WAD ewes in the first trimester however showed better ability in controlling the parasitaemia than the YK. One WAD ewe in the first trimester had self-cure from the infection. The ability to control parasitaemia has been attributed to tolerance[18] and has been linked with the ability to develop effective and consistent immune response by the animal, which is antibody mediated[5].

Consistently elevated IgM levels have been reported in Trypanotolerant Ndama cattle, infected with trypanosomes[4,5]. IgM have been reported to be more effective than IgG at neutralizing, agglutinating and lysis of trypanosomes *in vitro* and providing protection *in vivo*[19,18,20,21]. Although various antibody levels were not determined in this study, the ability of one WAD ewe in the first trimester to control parasitaemia and self-cured may possibly be associated with the ability of this WAD ewe to mount effective antibodies mediated immune response that eliminated the parasite.

Anemia as indicated by low PCV values observed in the infected groups at each trimester of pregnancy, corresponded with the severity of the infection at that trimester. This finding gives credence to previous reports[22], who reported that the severity of the infection influenced the degree of anaemia observed in *T. vivax* infected sheep and goats.

Loss in body weights as observed in the YK infected ewes in the three trimesters of pregnancy and in the WAD infected ewes in second and third trimesters, concurs with earlier reports[16,10,11]. The infected WAD ewes in the first trimester however gain weight despite the infection. This showed that WAD ewes in the first trimester were more resistant to the pathogenic effects of *T. vivax* infection on body weights than the YK ewes. This may be attributed to the ability of WAD ewes in the first trimester to control parasitaemia better than the YK and also self-cured, as observed in one of the WAD ewes in the first trimester.

Abortion and mortality due to the infection were observed in 100% the YK infected ewes, in the second and third trimesters of pregnancy. This may suggest that prophylactic treatment against trypanosomosis during the first trimester of pregnancy may be effective enough to enable pregnant YK carry their pregnancy to term.

In the WAD ewes, abortion and mortality were observed in one WAD ewe (16.7%) in the second trimester and abortions without mortality were observed in 66.7% of the infected WAD ewes in the third trimester. This may suggest that the second and third trimesters of pregnancy are the most critical periods of pregnancy in the WAD ewes. The infected WAD ewes generally survived the infection.

This study has shown that the clinical manifestation of trypanosomosis in pregnant trypano-susceptible breeds (YK, Uda and Balami) and pregnant trypano-tolerant breeds (WAD) of sheep in Nigeria is likely to be similar in nature in the second and third trimesters of pregnancies, once the infection is able to establish in the ewes.

It is suggested from this study that small-scale farmers in trypanosomosis endemic zones of Nigeria, where the WAD is the predominant breed of sheep in this ecological zone, should be watchful for possible infection of their pregnant ewes in the second and third trimesters of pregnancy, to avoid abortions and other complications of pregnancy.

ACKNOWLEDGEMENT

The authors are grateful to the International Atomic Energy Agency Austria Vienna for providing the Radio immunoassay kits used in this study under the Technical Cooperation Project NIR/05/029 to National Animal Production Research Institute, Ahmadu Bello University Zaria, Nigeria..

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