Prevalence and Ranking of Bovine Trypanosomiasis

In Unity State, Sudan By Participatory Epidemiological, Clinical and Laboratory Testing

By

Husameldin Omer Elnasri

(B.V.Sc 2001 University of Khartoum)

Supervisor

Dr. Khitma Hassan Elmalik

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Department of Preventive Medicine and Veterinary Public Health,
Faculty of Veterinary Medicine,
University of Khartoum

April 2005
To Mother Africa First,

My Family and

To My Dearest

Friends
Acknowledgment

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I also would like to thank Dr. Stephen Blakeway and Dr. Andy Catley for their help in the design and analysis of the Participatory Survey.

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At last I would like to thank Dr. John Beliu Nganhok and Dr. Johnson Bol from the Ministry of Animal Resources, Unity State for their kind help in characterization of the common diseases local names and terms.
Abstract

This study was designed to avail base line information about the epidemiology of the African Animal Trypanosomiasis in the area of Unity State, Southern Sudan and the role of ethno-veterinary practices in the area of study in identification of the disease.

300 blood films were prepared during the dry and wet seasons of 2003 from Thoan, Rubkona, Dandok and Abiemnom villages in Unity State. Parallel with the parasitic survey a clinical data from three different clinics in Thoan, Dandok and Mirmir were analyzed. A participatory survey also was conducted, using techniques of, participatory mapping, seasonal calendars and proportional piling.

The results from the parasitic survey showed only *T. vivax* in all of the positive smears with a rate of 15% in the dry season compared to 6% in the wet season. Comparing the rates of African Animal Trypanosomiasis (AAT) between the breeds and seasons gave the result of 4% of the samples collected from Nilotic cattle breed during the dry season were positive compared to 13% positive samples collected from the Baggara cattle breed. This is while 3.13% samples were positive from the Nilotic breed during the wet season compared to 11.11% positive samples from the Baggara breed.

Most of the fly samples collected were identified as *Tabanus taeniola* and quite few *Atylolus agrestis*.

The results from the clinical data analysis revealed a proportional morbidity rate of 44.11% in the dry season and 26.24% in the wet season.

The results from the participatory epidemiological investigations revealed that AAT is very well identified in the ethno-veterinary knowledge of both of the Nuer informant groups (disease name *Lieei*) and Misseria informant groups (Disease name is *El. Fasokh*). They both use different
integrated methods for controlling the AAT in their areas, but the Misseria are more depending on the modern AAT treatments like Ethidium while the Nuer are more in using the husbandry methods first and then the Ethidium when available. The proportional morbidity rate from the proportional piling results was 7 % for the Misseria compared with 20.5 % for the Nuer. The informant group from the Misseria ranked the AAT according to its importance to be in the fourth place while the Nuer groups ranked it in the third place.

The study suggested a seasonal pattern of prevalence of AAT in the study area to be more prevalent during the dry season than the wet season. The study also suggested that may be the Nilotic cattle breeds have more tolerating capacity for AAT than the Baggara cattle breed.
ملخص البحث

هِدفت هذه الدراسة إلى توفير قاعدة معلومات عن داء المثقيبات في الأبقار
بمنطقة ولاية الودح بجنوب السودان مع الوضع في الإعتبار دور المعرفة البيطرية التقليدية في التعرف على المرض.

جُمعت 300 شريحة دم في خلال الفصلين الجاف و الماطر من عام 2003 و
ذلك من قرى ثوان، ركوبا، داندوك و أبيمند بولاية الودح. استُصِبِح ذلك بمعالجة و تحليل لسجلات الحالات المرضية الواردة على ثلاث مراكز بيطريات واقعة بقرى ثوان، داندوك و مرمر في نفس الفترة الزمنية. و أخيرا تم استخدام طرق المسمح الوبائي
بمشاركة المجتمعات مثل الخرط التشاركية، التقديم الفصلي والتراكم النسبي.

نتائج المسمح الميكرسكوبى أوضحت أن كل الشرائح الموجبة كانت تحتوي فقط
على 6% كان معدل الإصابة 15% في موسم الجفاف مقارنة ب 6% في موسم الأمطار. و في مقارنة بين معدلات الإصابة بالمرض بين السلالات و المواسم
وجد أن 4% من العينات التي جمعت من أبقار السلالات النيلية خلال فصل الجفاف كانت موجبة مقارنة بنسبة 13% لأبقار سلالة البقره خلال نفس الموسم. أما في موسم الأمطار فوجد أن 3.13% من الشرائح التي جمعت من أبقار السلالات النيلية كانت موجبة مقارنة ب 11.11% لأبقار سلالة البقرة. كل عينات الذباب التي تم جمعها من
Atylotus agrestis و Tabanus taeniola
المنطقة تم تعريفها على أنها

بعد تحليل سجلات المراكز البيطرية أوضحت النتائج معدل انتشار 44.11%
لموسم الجفاف مقارنة ب 26.24% لفصل الأمطار.

نتائج المسمح الوبائي بمشاركة المجتمعات أوضحت أن داء المثقيبات في الأبقار
معروف بصورة واضحة من خلال المعرفة البيطرية التقليدية بالنسبة لسكان المنطقة.
الدراسة إقترحت أن لمرض المثقيبات بالمنطقة سلوك موسمي في الظهور، حيث يكون معدل المراضة أعلى خلال موسم الجفاف منه خلال موسم الأمطار. كما إقترحت الدراسة أيضا أن سلالات الأبقار النيلية ربما تتمتع بقدرة أكبر على مقاومة داء المثقيبات من سلالات أبقار البقرة.
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Introduction

Livestock are the backbone of the socioeconomic systems of most of the rural communities in the continent of Africa. This can be noted more clearly with those who are adopting the Pastoral and Semi pastoral way of living. These people own approximately 50% of Africa's livestock, equivalent to approximately 225 million animals (De Leeuw et al., 1995). The number of pastoralists in sub-Saharan Africa has been estimated at more than 50 million people (Coughenour et al., 1985) while Sudan, Ethiopia, Eritrea, Djibouti, Somalia, Kenya and Uganda support around 16.5 million pastoralists (Bonfiglioli, 1992). Typically, pastoralists derive at least 50% of their food and income from their livestock (Swift, 1988).

The African Animal Trypanosomiasis (AAT) also called Nagana is one of the major threats for the Livestock in Africa. The disease is transmitted cyclically by Tsetse fly (Glossina Species) bites, or transmitted mechanically by other biting flies (Tabanus spp. and Stomoxys spp.); this extends the affected area with the disease in over 10 million km² in the Sub-Saharan Africa which is inhabited by most of the pastoral and semi pastoral African tribes. It is estimated that about 46 million cattle are at risk of tsetse-transmitted Trypanosomiasis in an area of about 8.7 million km² (Murray and Gray, 1984).

This distribution and seasonality of the disease and the flies interfere noticeably with the seasonal movement of the pastoralists from one area to another searching for the pasture. Those people and all of the African stockmen had noticed ages ago the relation between the Tsetse fly, the disease and the seasonality of both of them; this was even long time ago
before the modern science identified the disease and its vector. This observation led them to believe that they should avoid the habitats of the fly especially during the wet season.

People of southern Sudan are a good example of the African pastoral and semi pastoral life. The Nilotic tribes including the Dinka, Nuer and Shulluk are adopting this system. In this study we are to concentrate on the disease in the Nuer area stretched in Unity State in Southern Sudan.

Livestock have a special importance in the life of the Nuer, not only in their understandable role as food provider but also in the social, cultural, economical and political life as well. Cattle are involved in the wealth status, political decision making including the election of the local chiefs and almost all of the social events such as birth, marriage, death and even sicknesses; events require livestock to be involved in the ceremonies. All these complex systems formulate the great value of livestock in the Nuer life. The value that emphasises the significance of the AAT effect in the life of the Nuer as well.

Among the impacts of the AAT is the economical impact that is considered to be the most imposing. The disease directly affect the milk and meat productivity of animals, reduces birth rates, increases the abortion rates as well as mortality rate; all of these affect the herd size and herd composition.( Swallow 1999). Besides the disease and the fly affect directly the seasonal movement and the human settlement process. Winrock (1992) judged that the sub-humid zone and wetter portions of the semi-arid zone - areas in which the greatest numbers of cattle are at risk of contracting the disease - hold the continent’s greatest potential for expansion of agricultural output. This affects indirectly the agricultural crop resulting in changes on land use, vegetation cover, the environment, food security and human
welfare. All of these have implications for resource use patterns, investments in natural capital (e.g. planting of tree, shrubs and herbaceous legumes, construction and maintenance of conservation structures), social institutions that govern resource use (formal and informal conventions, norms and rules). Swallow (1999).

The long civil war in southern Sudan on the other hand has enhanced the impact of the AAT in many ways, such as forcing the cattle owners to change their traditional grazing areas, which means to keep their animals in the fly area for longer time. The war and insecurity have also kept the area not covered with the relevant research and disease control programs for a long time. However, all of this also led the cattle owners to develop their own methods to minimize the effect of the fly and the disease.

The overall aim of this study is to avail base line information about the epidemiology of the African Animal Trypanosomiasis in the area Unity State, Southern Sudan (Fig. 2.1) and the role of ethno veterinary practices in the area of study in identification of the disease.

This aim is to be fulfilled through the following objectives:

- To conduct a participatory epidemiological survey in the chosen study area of Unity State in order to investigate the presence of the disease and the local veterinary knowledge about it.
- To verify the disease causes and identify the vectors through a thorough laboratory survey using standard parasite detection methods.
- To compare disease prevalence and conception of the permanent residents (Nuer tribe) and transitional residents (Misseria tribe) communities.
Chapter 1

Literature preview

1.1 The Trypanosome:

The Trypanosoma is classified as a Flagellate Protozoa from the genus Trypanosoma of the Family Trypanosomatidae which Belong to the Order Kinetoplastida of the class Zoomastigophora. The Zoomastigophora is classified under the Phylum Sarcomastigophora. Soulsby (1982).

The genus Trypanosoma is further divided into two sections: The Salivaria; which contains the subgenera, Duttonella, Nannomonas, Pycnomonas and Trypanozoon.

The other section is the Sterocoraria which include three subgenera, Megatrypanum, Herpetsoma and Schizotrypanum.

Each of the two sections contains many species, and here in the following is a summarized classification assumed from Soulsby (1982), Table (1).

Recent studies based on isoenzymatic differences and molecular techniques, resulted in new subdivisions of the species of trypanosomes into several types; T. congolense it has been divided into four types T. congolense savannah type, T. congolense Tsavo type, T. congolense forest type and T. congolense kilifi type. T. godferyi has been separated lately from T. congolense in Gambia on isoenzymatic and molecular bases; although it has the same morphology as T. congolense and causes more chronic disease in pigs. (Uilenberg, 1998)
<table>
<thead>
<tr>
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<th>Sarcomastigophora</th>
<th>(Honigberg and Balmuth, 1963)</th>
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<td>Mastigophora</td>
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<td>Zoomastigophora</td>
<td>(Calkins, 1909)</td>
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<td><strong>Order</strong></td>
<td>Kinetoplastida</td>
<td>(Hongberg, 1963)</td>
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<tr>
<td><strong>Suborder</strong></td>
<td>Trypanosomatina</td>
<td>(Kent, 1880)</td>
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<td>Trypanosomatidae</td>
<td>(Ement and Grobben, 1905)</td>
</tr>
<tr>
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<td>Trypanosoma</td>
<td>(Kent, 1880)</td>
</tr>
<tr>
<td><strong>Section</strong></td>
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<td>(Hoare, 1964)</td>
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<tr>
<td><strong>Salivaria</strong></td>
<td>Duttonella</td>
<td>(Chalmers, 1918)</td>
</tr>
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<td><em>T. (D) vivax</em></td>
<td>(Zieman, 1905)</td>
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<td><em>T. (D) uniforme</em></td>
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<td>(Borden, 1904)</td>
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<td><em>T. (N) simae</em></td>
<td>(Bruce et al., 1911)</td>
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<td><strong>Subgenus</strong></td>
<td>Pycnomonas</td>
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<tr>
<td><strong>Species</strong></td>
<td><em>T. (P) suis</em></td>
<td>(Ochmann, 1905)</td>
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Continued Table 1.1. Summarized classification of the Trypanosomes
Soulsby (1982)

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<tr>
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<tr>
<td>T. (T) brucei and the subspecies T. (T) brucei brucei (Plimmer and Bradford, 1899)</td>
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<tr>
<td>T. (T) brucei gambiense (Dutton, 1902)</td>
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<tr>
<td>T. (T) brucei rhodesiense (Stephen and Fantham, 1910)</td>
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<tr>
<td>T. (T) brucei evansi (Steel 1885)</td>
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<td>T. equiperdum (Doflein, 1901)</td>
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<td>T. equinum (Voges, 1901)</td>
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<td>Posterior Station Group (Hoare, 1964)</td>
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<td>Subgenus</td>
<td>Megatrypanum (Hoare, 1964)</td>
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<tr>
<td>T. (M) theileri (Laveran, 1902)</td>
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<td>T. (M) iragilaphi</td>
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<td>T. (H) muscle</td>
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<td>Schizotrypanum (Chagas, 1909)</td>
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<tr>
<td>Species</td>
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1.2 The African Animal Trypanosomiasis:
The African Animal Trypanosomiasis (AAT) is a disease complex caused by the species of the genus *Trypanosoma* (*T. congolense*, *T. b. brucei* and *T. vivax*). The disease can be transmitted cyclically by the Tsetse flies or mechanically by other biting flies resulting in sub acute, acute or chronic disease characterized by intermittent fever, anaemia, occasionally diarrhoea rapid loss of body condition and often terminates in death. (Mare, 1998)

1.3 Epidemiology of the AAT

The AAT is widely distributed in Africa, the fact that the disease is transmitted mechanically as well as cyclically has certainly expanded the disease distribution out of the tsetse belt area.

The disease has a quite wide host range. It can affect cattle, sheep, goats, pigs, dogs and cats. All of these species are susceptible to the AAT and may suffer syndromes ranging from sub clinical mild or chronic infections to acute fatal disease.

Besides there is more than 30 species of the wild animals that can be infected with the pathogenic trypanosomes but many of these remain carriers of the organism. Ruminants are widely known as active reservoirs of the trypanosomes. Wild Equidae, lions, leopards and wild pigs are all susceptible and can also serve as carriers of the disease. (Ashcroft, 1959)

1.3.1 AAT in Sudan:

Early reports of bovine trypanosomiasis and tsetse flies in southern Sudan include 87 cases moved form Upper Nile to Khartoum in 1904 (Karib 1961). Then successive reports about diagnosed AAT in different types of livestock around Khartoum and Yei (Balfour, 1913) Koalib Hills of the Nuba Mountains (Archilbald, 1927) and 1943, in Malakal (Karib, 1961). In 1946, a major epidemic of AAT in Upper Nile due to *T. congolense* was associated with heavy
flooding and caused the death of 50% of the Shilluk cattle, the epidemic that prompted a mass treatment campaign (Karib, 1961).

El Karib, (1961) had noted that outside the tsetse zone *T. congolense* is widespread and predominates in Bor, Central Nuer and Malakal Districts of Upper Nile Province. *T. congolense* is also reported to be recognized in other areas far north of tsetse zone; it was diagnosed in cattle in Gedaref (latitude 14) and Aba Island, Kosti District (latitude 13), two apparently tsetse-free areas (Karib, 1961). In 1973-1974, surveys in south Kordofan provinces adjacent to Upper Nile indicated bovine trypanosomiasis prevalence of up to 8.6% (Rahman et al., 1991a) whereas fly surveys detected large Tabanid populations, but no tsetse (Rahman et al., 1991b).

More recently, bovine trypanosomosis was reported in the Jonglei Canal area (Mefit-Babtie, 1983 sited by Catley *et al.*, 2000). Using the indirect fluorescent antibody test in two locations, trypanosomosis seroprevalence was reported at 68% (n=119) and 45% (n=58). Parasitological diagnosis by examination of buffy coats indicated prevalence between 0% (n=48) and 10% (n=159). Further north in Upper Nile, use of the relatively insensitive thin and thick blood smear diagnostic methods revealed trypanosomosis prevalence between 3.7% (n=27) and 22.2% (n=45) in Eastern and Western Upper Nile respectively (Fison, 1993). Reports from the UNICEF/SCF laboratory in Lokichokio indicated that trypanosomosis was widespread in southern Sudan. Between 1994 and 1999, examination of thin blood smears revealed the disease in Eastern Equatoria, Upper Nile, Western Upper Nile (Unity), Bor County, Akobo and northern Bahr el Ghazal.

In 1996 a trypanosomiasis survey was conducted in Khartoum and central Sudan that revealed 2% *T. vivax* infection rate in dairy cattle in those places. *Tabanids* and *Stomoxys* were captured during this survey. (A, Razig, 1998)

180,775 cattle were treated against trypanosomiasis in 1996 by the Community Based Animal Health Workers in the risk areas of southern Sudan within the Operation Lifeline Sudan/Southern Sudan programme (A. Razig 1998)

**1.3.2 Tsetse distribution in Sudan:**

Lewis (1949) described seven species of *Glossina* in Sudan, these species are: *G. morsitans submorsitans*, *G. tachiniodes*, *G. pallidepes*, *G. fuscipes*, *G. longipennis*, *G. fuscipleuris*, *G. fusca*. Lewis also presented a map (1949) that showed a northern Limit of tsetse at about 9°50’ N. In 1972 Abdel Razig and Yagi reported on a survey begun in Southern Darfur 1967 which indicated a northward movement of *G. morsitans* which had engulfed Radom and El Hugeirat on the headwaters of Bahr Elarab between 9°50’ and 10°13’ N. They had reported *G. morsitans* near Umm Dafog on the border with the Central African Republic approximately 10°30’ N.

**1.3.3 Tabanus Distribution in Sudan:**

Yagi and Abdel Razig reported in (1972) that *Tabanus taeniola* was prevalent throughout the year, while *Atylotus agrestis* have a predisposition to appear at the end of the rainy season. *Atylotus fuscipes* has the same ecological preferences as *A. agrestis* and usually appears at the same season. It was also mentioned that *Tabanus biguttatus* was also common throughout the year, while *Ancala latipes* occurs during the rainy season together with *Philoliches magrettii*, but its flight season was very short.

Suliman (1992) reported that seven species were collected from Sinnar area including: *Tabanus Taeniola, T. gratus, T. biguttatus, T.sufis, Atylotus agrestis, A. fuscipes and Philoliche magrettii*. He stated that the first three were found in all of the surveyed areas (Central State) while *T. bigutattus* was found
in Kenana Dairy Farm only. The other species were obtained from sites at El Renk area. He also reported that *Atylotus agrestis* is the dominant *Tabanid* species, while *Philoliche magrettii* is caught in Sinnar area.

**1.4 Pathology of the AAT:**

The incubation period of the disease for *T. congolense* varies from 4 to 24 days; for *T. vivax* from 4 to 40 days and for *T.brucei* from 5 to 10 days (Uilenberg, 1998).

The trypanosomes affect firstly the bite site or in other words the inoculation site in the animal skin causing a swelling and a chancre. The fly deposits during the blood sucking process the metacyclic proliferating trypanosomes in a limited number of metacyclic variant antigenic types. This stimulates the immune response causing the chancre. The chancre not only forms a site for the establishment of the infection but also is a focus for multiplication and persistence of trypanosomes before their dissemination into bloodstream. (Naessens, *et. al.* 2003). The parasites there after spread to the lymph nodes and blood then continue to replicate. *T.congolense* localizes in the endothelial cells of small blood vessels and capillaries. *T.b. brucei* and *T. vivax* localize in tissues like Lymph nodes. (Uilenberg, 1998)

Anaemia is one of the major effects of the AAT pathogens. The PCV of the affected animals falls rapidly due to erythrophagocytosis, but an equal rapid recovery takes place following trypanocidal drug treatment.

The AAT affects the productivity of animals not only by increasing the mortality and the abortion rates but it affect directly the reproductive system and fertility of the infected animals. Infection of cattle with *T. vivax* or *T. congolense* causes lesions in the male reproductive organs of cattle. *T. congolense* appears to cause more severe effects than *T. vivax* and caused highly significance and drastic decrease in sperm concentration and volume and also increases in sperm morphological defects which results in complete infertility of
bulls in the late stages of infection (Sekoni et al., 2004). Novidium treatment was sometimes ineffective, leading to regeneration of the lesions caused, and infertility in bulls could persist following chronic trypanosomosis (Sekoni et al., 2004).

Antibodies developed to the glycoprotein coat of the trypanosomes kill the trypanosome and result in the development of immune complexes. These antibodies do not clear the infection totally, the trypanosome has genes that can code for many different surface – coat glycoprotein and change its surface coat to evade the antibodies. Thus there is a persistent infection that results in a continuous trypanosome replication, antibodies production, immune complex development and changing surface coat glycoprotein. (Losos et al. 1972)

Immunologic lesions are significant in AAT, it has been suggested that many of the lesions (e.g. anaemia and glomerulonephritis) in these diseases may be the result of the deposit of the immune complexes, that interfere with or prevent normal organs functions. The most significant and complicated factor in pathogeneses of the AAT is the profound immunosuppression that occurs following the infection with these parasites. This marked immunosuppression lower the host resistance to other infections thus resulting in secondary diseases, which greatly complicate both the clinical and pathological features of the AAT. (Mare, 1998)

1.4.1 Clinical signs:

It is very common for one animal to be infected with not only more than one species of Trypanosomes but also infected simultaneously with other blood parasites (Babesia spp., Theilria spp., Anaplasma spp. and Ehrlichia spp). This makes it difficult to conclude which clinical signs are attributed to a given parasite. Few adequately controlled studies have been made, and thus a typical clinical response to any trypanosome is difficult to construct. What follows is a
summation of syndromes in field and experimental cases of AAT caused by each of the three trypanosomes (Maré 1998).

The cardinal sign observed in the AAT is the anaemia. Within a week of infection with the haematic trypanosome (*T. congolense* and *T. vivax*) there is usually pronounced decrease in packed cell volume, haemoglobin, red blood cells, and white blood cells levels and within 2 months these may drop to below 50 percent of their preinfection values. (Mulligan, 1970) The severity of clinical response is depending on the species and the breed of the affected animals and the dose and virulence of the infecting trypanosome. Stress such as poor nutrition and concurrent disease plays a prominent role in the disease process and in experimental conditions where stress may be markedly reduced, it is difficult to elicit clinical diseases. (Suliman, et. al., 1989)

*T. congolense* is a haematic trypanosome found only in the blood vessels of the infected animal. It does not localize or multiply out side the blood vessels. Infection with *T. congolense* may result in per acute, acute or chronic disease in cattle, sheep, goats, horses and camels. Pigs often develop a milder disease; chronic disease is common in dogs. The incubation period is followed by intermittent febrile episodes, depression, lethargy, weakness, loss of condition, anaemia, salivation, lacrimation, and nasal discharges. As the disease progresses, loss of condition and hair colour changes from black to metallic brown are seen. Accelerated pulse and jugular pulsation and breathing are difficult. Anaemia is a prominent sign. Early in the infection, the organisms are readily demonstrated in lymph node smears. (Maré, 1998).

*T. vivax* has a variable incubation period, and, although it is considered to be less virulent for cattle than *T. congolense*, mortality rate of over 50% can occur. There seems to be a marked variation in the virulence of different strains of *T. vivax* but it remains the most important causes of the AAT of cattle, sheep and goat in West Africa. It causes mild disease in horse and chronic disease in
dogs. *T. vivax* is often difficult to find in blood smears and can also be demonstrated in lymph node smears.

*T. brucei brucei* has a relatively short incubation period and causes severe to fatal infection in horses, camels, dogs and cats. It usually causes mild, chronic or sub-clinical disease in cattle, sheep, goat and pigs. A febrile response occurs in horse 4 – 14 days after infection, followed by recurrent febrile reactions. The heart beat and respiration may be accelerated, and the loss of condition and weakness are seen, whereas the appetite remains good. Progressive anaemia, icterus, and oedema of the ventral regions, specially the male genitalia, are characteristic. The organisms are not always easily detected in blood smears and are best demonstrated in tissue smears and sections (e.g. lymph nodes). Infected animals die in few weeks or several months, depending on the virulence of the strain of *T. b. brucei*. (Suliman *et. al.*, 1989)

As mentioned before the marked immunosuppression resulting from trypanosome infection lowers the host’s resistance to other infections and causes in secondary disease, which greatly complicate the impact of the disease in the animal health.

1.4.2 Lesions:

No pathognomonic change is seen in AAT. Anaemia, oedema, and serous atrophy of fat are commonly observed. Subcutaneous oedema is particularly prominent and is usually accompanied by ascites, hydropericardium, and hydrothorax. The liver may be enlarged, and oedema of lymph nodes is often seen in the acute disease, but they may be reduced in size in the chronic disease. The spleen and lymph nodes may be swollen, normal, or atrophic. Necrosis of the kidneys and heart muscle and sub serous petechial haemorrhages commonly occur. Gastroenteritis is common, and focal polioencephalomalacia may be seen. A localized lesion (chancre) may be noted at the site of fly bite, especially in goats. The anaemic blood changes are anisocytosis, poikilocytosis,
polychromasia, and punctate basophilia. All, some, or none of the above may be seen. (Losos et al., 1972)

The lesions caused by the trypanosomes in susceptible host species vary considerably, depending on the species and strain of trypanosome and the species and breed of host animal affected. The haematic trypanosomes (T. congoense and T. vivax) cause injury to the host mainly by the production of severe anaemia, which is accompanied in the early stages of the disease by leukopenia and thrombocytopenia. In the terminal stages of the disease caused by the haematic trypanosomes there is focal polioencephalomalacia probably resulting from ischemia due to massive accumulation of the parasites in the terminal capillaries of the brain.

The lesions resulting from T. b. brucei (a tissue parasite) are remarkably different from those seen with the haematic trypanosomes. Anaemia is an important lesion, but much more dramatic are the inflammation, degeneration, and necrosis resulting from cellular invasion of various organs. Marked proliferative changes reflecting immunologic response are observed in most body tissues.

1.5 Diagnostic techniques:

The diagnosis of Trypanosoma infection is based on clinical signs and on the demonstration of the parasites by direct or indirect methods. The clinical signs of the AAT are indicative but are not sufficiently pathognomonic and diagnosis must be confirmed by laboratory methods. The classical direct method for the diagnosis of trypanosomosis led to the original discovery of the parasite. It is still employed for examining blood or lymph node material, but rarely with extracts of other tissues. In the Tsetse belt where many Trypanosoma species are found, a specific identification on blood smears by microscopy is very difficult.
1.5.1 Direct methods

1.5.1.1 Wet blood films
A small drop of blood is placed on to a clean glass slide and covered with a cover-slip to spread the blood as a monolayer of cells. This is examined by light microscopy (x200) to detect any motile trypanosomes. But still it will not be enough to identify the species of the trypanosome properly.

1.5.1.2 Stained thin smears
A drop of blood is placed 20 mm from one end of a clean microscope slide and a thin film is drawn out in the usual way. The film is air-dried briefly, fixed in methyl alcohol for 2 minutes and allowed to dry. The smears are then stained by Giemsa. This technique permits detailed morphological studies and identification of the trypanosome species. Rapid staining techniques also exist like Field’s stain. The same technique can be used with Lymph node biopsies.

1.5.1.3 Haemocrit centrifugation
In the mild clinical or sub clinical cases (carriers) with low parasitaemia in which it is difficult to demonstrate the parasites concentration methods become necessary.

Blood is collected (70 µl) into heparinised capillary tubes (75 x 1.5 mm), which are then sealed at the dry end and centrifuged, sealed end down. Then capillary tube is placed under microscope and the buffy coat junction where the trypanosomes will be concentrated is checked for trypanosomes. The buffy coat can also be placed on a slide and checked under dark field microscope. (Wernery et al., 2001)

1.5.1.4 Animal inoculation
Laboratory animals may be used to reveal subclinical (nonpatent) infections in domesticated animals. Trypanosoma spp. has a broad spectrum of infectivity for small rodents, and so rats and mice are often used. In studies of T. evansi infections in camels, comparisons have been made between thick blood film
examinations and rat or mouse inoculation methods; the latter animal inoculation gave 15.2% and 17%, respectively, more positive results than thick smears alone. However, even mouse inoculation is not 100% sensitive (Monzen et al. 1990). Sensitivity of this in-vivo culture system may perhaps be increased by use of immunosuppressed laboratory animals. Drugs such as cyclophosphamide or hydrocortisone acetate and X-ray irradiation or splenectomy are used for this purpose. (Monzen et al., 1990)

1.5.2 Serological tests

Methods to detect specific humoral antibodies to trypanosome antigens include complement fixation (CF), indirect haemagglutination and precipitation tests. These have not been applied in large-scale surveys. More recently, indirect fluorescent antibody, ELISA and card agglutination tests (CATT) have been employed. Extensive evaluation of ELISA and CATT has been carried out.

1.5.2.1 Indirect fluorescent antibody test

The test is used to detect trypanosomes antibodies. It has proven to be sensitive test but it has the disadvantage of that it can only be carried out in laboratories and the procedure is rather long and complicated as well as some extent subjective (i.e. titration bu different operators may give somewhat different results). (G.Uilenberg, 1998)

1.5.2.2 Enzyme-linked immunosorbent assay

An immunodiagnostic method based on a direct sandwich enzyme-linked immunosorbent assay (ELISA), using monoclonal antibodies, has been examined in a number of African laboratories for its suitability for monitoring tsetse control and eradication programmes. Generally, the direct sandwich ELISAs for the detection of trypanosomal antigens in serum samples have proved to be unsatisfactory with respect to diagnostic sensitivity when compared with traditional parasitological methods such as the dark ground/phase contrast buffy-coat technique. Consequently, antigen-detection
systems exploiting various other direct, indirect and sandwich ELISA systems and sets of reagents are being developed to improve diagnosis. In addition, an existing indirect ELISA for the detection of antibodies has been improved and is being evaluated in the field in order to detect cattle that are or have been recently infected with trypanosomes. (De Rebeski et al, 1999)

**1.5.2.3 Card agglutination tests**

It is well known that certain predominant variable antigen types (VATs) are expressed in common by different strains of salivarian trypanosomes from different areas. On this basis, a field test for the diagnosis of Gambian sleeping sickness, the card agglutination test - CATT/T. brucei gambiense - was developed at the Laboratory of Serology, Institute of Tropical Medicine, Antwerp. For the diagnosis of T. evansi infections, a similar test system has been developed. CATT/T. evansi. (Nantulya, 1995)(Van den Bossche et al.,1999)

**1.5.3. Detection of trypanosomal DNA**

During the past few years, several research centres have been working on the development of polymerase chain reaction procedures for the detection of minute amounts of trypanosomal DNA sequences.

PCR assays for diagnosis of trypanosome infection in cattle were evaluated for their ability to detect trypanosome DNA in blood spots samples collected from cattle in four different provinces from the Bolivian lowlands and the results compared with those obtained with standard parasitological Micro Haematocrit Centrifugation Technique (MHCT) and stained smears and serological methods (Card Agglutination Test for T. evansi (CATT), and Antibody ELISAs for T. vivax and T. congolense). Kappa agreement analysis showed a significant agreement between PCR assays and results from parasitological methods but there was no agreement when PCR was compared with serological assays. Some samples from T. vivax smear positive animals were negative by PCR, therefore modifications to the PCR assay conditions
were undertaken to try to improve agreement between PCR and parasitological assays. Changes in the template DNA concentration or the use of an alternative primer set resulted in improvements in the PCR detection rate, but not all the parasitologically positive samples were detected by PCR. Results from PCR assays for *T. vivax* and *T. evansi* were combined with results from parasitological and serological assays to provide information on prevalence rates for the four provinces from where the samples were obtained. (Gonzales *et al.* 2003)

So far the method is still being evaluated and may be in the future it will be widely used in the field.

1.6 Control:

1.6.1 Parasite control:

1.6.1.1 Immunization:

Due to the fact of that the trypanosome has genes that can code for many different surface – coat glycoprotein and change its surface coat to evade the antibodies it has been very difficult to produce vaccine immunization from trypanosome; lots of researches have been done but still no vaccine (Mare, 1998, Uilenberge, 1998).

1.6.1.2 Chemotherapy:

The use of drugs for the prevention and treatment of trypanosomiasis has been important for many decades, but the rapidity with which the trypanosomes have developed resistance to each drug introduced has tremendously complicated this approach to control the disease. In spite of this, some of the older chemoprophylactic drugs such as the Quinapyramine derivatives Antrycide and Antrycide Prosalt are still used and give effective protection against *T. b. brucei* infection in horses, camels, and cattle for up to 3 months. The drug Pyrithidium bromide (Prothidium and AD2801) is useful in the prophylaxis of *T. vivax* and *T. congolense* infections in cattle, sheep, and goats and can give protection for up to 6 months. The most widely used of the newer
chemoprophylactic drugs (and also the least expensive) is Isometamidium chloride. This drug, in use for over 20 years and sold under the trade names Samorin, Trypamidium, and M&B is effective for the prophylaxis of all three African animal trypanosomes, and gives protection for 3-6 months. The development of resistance to this drug has been reported in both east and West Africa. Homidium bromide has also been found to be an effective chemoprophylactic drug in Kenya, and the newly introduced arsenical Cymelarsan is effective in treatment of *T. b. brucei* infection.

A very widely used chemotherapeutic drug is Diminazine Aceturate (Berenil), which is effective against all three African animal trypanosomes. The Isometamidium drugs are also excellent chemotherapeutic agents as are the quaternary ammonium trypanocides Antrycide, Ethidium and Prothidium.

While Trypanocidals are used in trypanosomiasis control, as chemotherapy and for chemoprophylaxis (although they are time-consuming and expensive), there is a growing concern that their future effectiveness may be severely curtailed by widespread drug resistance. In addition to the 11 countries (Burkina Faso, Chad, Côte d'Ivoire, Ethiopia, Kenya, Nigeria, Somalia, the Sudan, the United Republic of Tanzania, Uganda, and Zimbabwe) reported by Peregrine (1994), the Central African Republic (Kongo) (Finelle and Yvore, 1962) and Zambia (Mubanga and Sinyangwe, 1997) should be included. In eight of the 13 countries, multiple resistances have been reported.

Here in Sudan drug resistance has been reported against Humidium (Ethidium Bromide) for *T. congoense*, *T. vivax* and *T. brucei* (Abdel Gadir *et al.*, 1981).

For Human trypanosomiasis the WHO has recommended a two phased treatment according to the disease stage, first phase treatments:
• Suramine: discovered in 1921, it is used in treatment of the initial phase of *T.b. rhodesiense*. There are certain undesirable effects, especially on the digestive tract.

• Pentamidine: discovered in 1941, it is used in treatment of the initial phase of *T.b. gambiense* sleeping sickness. In spite of a few undesirable effects, it is well tolerated by patients. Future production is guaranteed by an agreement between WHO and Aventis.

Then when the disease enters the neurological phase comes the second phase treatments:

• Melarsoprol: discovered in 1949, it is at present the only drug available on the market to treat the advanced stage of sleeping sickness, no matter which parasite is the cause. It is the last arsenical derivative in existence. The undesired effects are drastic; they include reactive encephalopathy (a hyperacute neurological complication of an allergic nature) - often fatal - in 3% to 10% of cases; those who survive the encephalopathy suffer serious neurological sequelae. Furthermore, there is considerable resistance to the drug, rising to 30% in parts of central Africa.

• Eflornithine: this molecule, which was registered in 1990, is the alternative to melarsoprol treatment. It is effective only against *T.b. gambiense*. The regimen is strict and hard to apply. Production ceased in 1999. Aventis company gave the licence to WHO, which has undertaken several initiatives to seek a new source of production. (Burchmore, 2004)

1.6.2 Vector control:

The nature of the life cycle, with few offspring per female and a large investment per offspring, means that a tsetse population cannot survive under sustained regular mortality above natural levels. It has been calculated that an extra 4% mortality of females per day over a sustained period will cause
extinction of a tsetse population. While it is possible to achieve eradication of
tsetse in particular areas, these attempts often fail in the long-term because of
reinvasion of tsetse-flies from adjacent regions. It is up to individual countries,
or countries working together, to ensure that tsetse-flies are controlled
sufficiently or eradicated. "The availability of the technology to reach a
successful conclusion is usually not the limiting factor" (Nevill 1997a).

An essential part of a control program is to understand the biology and
ecology of the *Glossina* species involved. Especially important is to understand
their movement, density and distribution and to use trapping methods to monitor
what is going on as the control campaign progresses.

The main control methods are as follows.

1.6.2.1 Removal of vegetation:

In savanna areas, larvi position occurs in shaded places, so one control
method is to remove trees and bushes so one is just left with grass. This
method was used quite extensively with success in the past but is labour
intensive and requires that there be reslashing of vegetation on an annual
basis. The method fell into disuse with the advent of insecticides. However,
removal of vegetation for fire wood and urbanization has sometimes
achieved the same effect.

1.6.2.2 Killing of wild animals.

The object here is to remove reservoirs of infection in the wild animal
populations. This method was used extensively in the past.

1.5.2.2 Spraying of insecticides.

Two main approaches have been used:
(a) Spraying of residual insecticides that persist in the environment for at least 2-3 months.

(b) Spraying of non-residual aerosols that kill adult tsetse at the time of spraying but which must be repeated at regular intervals in order to kill newly emerged adults.

Both ground and aerial application methods have been used. Aerial methods are expensive but have been used with success. For instance, in Zululand (northern KwaZulu-Natal, South Africa), between 1946 and 1953, the savanna tsetse-fly species *Glossina pallidipes* was totally eradicated mainly through the use of aerially applied DDT and BHC. However, consider the detrimental environmental effects of using these residual insecticides. In addition, the tsetse-fly problem still remains in Zululand due to two other cryptic species *G. austeni* and *G. brevipalpis* (Nevill, 2003). Ground spraying of residual insecticides can be a feasible and economical control strategy if it is applied to selected sites where there are concentrations of tsetse-flies.

1.6.2.4 **Trapping.**

A number of different traps have been developed for capturing tsetse-flies in large numbers.

a. The NG2G trap was designed for economy, simplicity and efficiency. It was optimised for the tsetse *Glossina pallidipes* in Kenya following the development of the F3 and Epsilon trap for this species in Zimbabwe. It performs well for many tsetses, and for tabanids, but it is a poor trap for stable flies. The NG2F with the large blue "wing" split into equal wings on both sides of the trap body is now more popular.
b. Biconical traps for the Riverine Tsetse that was the first practical cloth trap designed for tsetse in West Africa. It is an efficient trap for most riverine tsetse. It has been used for fly surveys for many years, even though it is a poor trap for tabanids and stable flies, and most savannah tsetse. It is a difficult trap to sew due to the use of complicated inner screens and its conical shape.

c. The Vavoua trap was designed as an economical alternative to the pyramidal trap for large-scale control of riverine tsetse. There are many similar designs that employ hanging screens. These designs are efficient for both riverine tsetse and stable flies. Traps like the Vavoua are straightforward to sew and assemble. They can be adapted to hang from simple wooden supports or trees. Trap styles with this open concept are generally poor for tabanids and savannah tsetse.

d. Canopy for Horse Flies & Deer Flies. This is a large trap that evolved from the original Manitoba trap developed for horse flies in Canada. Traps based on the concept of a large, dark canopy (with or without a suspended, shiny black ball) are often used for tabanids in temperate environments. A commercial option is the horsefly trap. A simple, practical design for the control of *Tabanus nigrovittatus* is the Greenhead Box trap. For research purposes, large Malaise traps are often used for catching tabanids, especially deer flies *Chrysops*.

e. In the USA, stable flies are often sampled with sticky "traps". A commercial adaptation of the cylindrical Alsynite trap. It uses disposable sticky sleeves attached to a special type of fibreglass panel.

Some of these traps are impregnated with insecticides to insure the death of the fly.
1.6.2.5 **Sterile insect technique (SIT).**

This method involves breeding of male *Glossina* which are sterilized using radiation and then released at regular intervals, thus swamping the population with males that are unable to fertilize females successfully. *Glossina austeni* has been successfully eradicated from Zanzibar using this method. During this campaign, 60,000+ irradiated male flies were being released per week. From 1995-1996, 5.5 million sterile males were released in total. To get this number of males per week involved rearing a colony of 700,000+ female flies (Dyck et al. 1997).

All of these control methods has been criticized either as non environmentally friendly techniques (killing of wild animals, spraying of insecticides and removal of vegetation) or very expensive such as the sterile male technique. (Saini, 2003)

A new approach for the fly control has been adopted recently which is the concept of community participation in the fly control. The approach has been called the community based tsetse control. (Barrett, 1998) Locals are trained on how to make their own fly traps and how to work together with the scientists to eradicate the fly from their areas. The greater community involvement in project design might help to avoid inappropriate and non sustainable interventions. Specifically, the high level of collective and sustained action that is often expected of communities in tsetse control projects needs to be compared with the methods that people are already using to control trypanosomosis. This comparison of options is particularly relevant when private, individual action to control the disease is well established and widespread. (Catley, 2000)
1.6.3 Host Protection:

Rationally one of the methods to prevent the animals from being infected with AAT is to reduce contact with the fly. And this is the exact way the nomads use to avoid AAT. These practices have been developed through ages of systemic movement crossing the AAT area after the graze from a place to another. The Fulani and Maasi from West Africa, Nuba, Dinka, Shulluk and Nuer from Sudan are the best in this field. (Catley, 2000). Even when they have to keep their animals in the fly area for many reasons (starvation, long dry season or insecurity) they have their techniques to protect their animals. They avoid grazing during the fly feeding time of the day or they keep their cattle in camps and protect them from insects bite using smoke and fire. (Lewis, 1949).

Innate resistance or trypanotolerance have been observed early when the ability of indigenous taurine cattle in West Africa to survive and be productive under trypanosomiasis risk was observed. Both acquired and innate resistance to AAT can occur in cattle. The two most important trypanotolerant breeds are B. taurus subtypes N’Dama and Baoulé, while a degree of trypanotolerance has also been shown to occur in some B. indicus zebu and with breeds; for example the Orma Boran(Dolan, 1994) and Maasi zebu(Akol et al., 1986). The tolerance of trypanosomiasis of N’Dama was compared with zebu /N’Dama crosses (Dempfle L., 1993). The N’Dama only accounts for 5% of the total cattle population of the sub-Saharan Africa and there is now considerable interest in their conservation.

At least two characteristics are in resistance of trypanosome:

- The ability to regulate parasites population expansion.
- The capacity to resist anaemia.

Murray and Morrison (1982) reviewed the means by which those factors operate in the host animal. The trypanotolerance observed in the wild animals, particularly the African buffalo, may be different from that observed in trypanotolerant breeds of cattle. In the African buffalo, xanthine oxidase in the
serum and plasma kills blood stream stages of all pathogenic trypanosomes. The serum and plasma of a variety of other animals tested, including N’Dama, waterbuck and yellow-fronted duiker does not kill the trypanosomes (Mulla et al., 1988).

Murray et al. (1990) had investigated into the genetic basis for trypanotolerance and have shown that the ability to control parasitaemia and the capacity to resist anaemia during infection in trypanotolerant N’Dama cattle are highly inheritable criteria and genetically correlated with production.

Trypanotolerant cattle breeds have been suggested as an alternative for livestock production in the tsetse fly areas. (D’Ieteren G., 1994)

1.7 Ethno Veterinary Knowledge about AAT in Sudan:

Ethno veterinary knowledge (EVK) - or Existing Veterinary Knowledge as called in some references - is concerned with clinical and epidemiological manifestations of disease. EVK terms do not necessarily correspond to specific disease entities of western medicine. As the livestock, owners are mainly concerned with the clinical, gross pathological and epidemiological observation of disease in some ways their terms correspond to clinical case definitions. It is useful to prepare traditional case definitions or profiles that list the criteria for application of each traditional term. Further, disease terminology can vary from one community to another or even within clans of the same community. Thus, the epidemiologists must define local terms carefully (Leyland and Catley 1995).

Schwabe and Majok (1981) described four kinds of local healers among the Dinka. They all practiced as both human and veterinary healers and were paid according to the success of their treatments and the value of the animal or wealth of the person. These were the Atet (a term for experts in various practical skills ranging from rope making to bone-setting), the Tiet (exorcists and exponents of religious-based healing), the Ran Wal (herbalists) and the Ran Cau (witch-doctors who countered the curses of witches). The main areas of Atet practice were bone setting, wound surgery (including suturing with giraffe
or cattle tail hairs), lancing of abscesses, blood-letting, castration, horn surgery, bone setting (including grafting), obstetrics, retained afterbirth removal and replacement of prolapsed uterus. Schwabe and Majok also described the Atet's knowledge of anatomy, physiology, epidemiology and recognition by signs of individual diseases and go on to suggest the possibility of integrating local healers into the Medical and Veterinary Services.

Participatory Approaches to Veterinary Epidemiology (PAVE) Project, 1996, had implemented a survey concerning the so called Chronic Wasting Disease (CWD) in the cattle of southern Sudan. The survey comes with different causes of the syndrome and 45% of the tested cattle were suffering from *T. congolense*. The Nuer and Dinka called the disease Liei - also the Nuer call it Nnoi or Anoi (central Upper Nile and Zeraf), Guau, Luot or Loth, Tarau (Zeraf) and the Dinka call it Luac (Bor county), Luac mou (Bor county), Luac anoi (Bor county), Luac aguak (Bor County), Maliei and Manyai or Manyiei (BEG), Mou (BEG) but Liei is more common to be used- that means steal slowly referring to the gradual loss of animal weight and then its death.(Blakeway et. al. 2001).

The Nuer have connected the Disease to the biting flies (Tabanus) which they call Rom. While the Dinka named the tsetse fly as Luang and sometimes referred to as Luang Mou.

The Nuer have described the infection as it starts with one cow and spreads to other cows one by one, but it does not move from animal to human beings. They described the signs of Liei as: it steals body of the cow, bones showing, too much urine, watery diarrhoea (but not bloody) slow loss of weight, step by step, one year and it becomes dry, bones stand out; breathes quickly; hair standing; tail becomes big gradual loss of condition, fever on and off, sunken eyes, may show lacrimation and photophobia, seeks shade, no hair on tail; the cow doesn't graze, gets thin and the eyes gets in. the sick sheep have
pot belly, unkempt coat, diarrhoea, and may have bottle jaw. (Blakeway et al., 2001)

They also do not favour the meat of the Liei diseases cow because the meat is watery and very pale. (Catley, 2000)

The Nuer use for traditional treatment of Liei a seasonal, reddish plant they called Yith Lual / Jith Lual. They use roots, chopped and soaked, then given as a drench. (Blakeway et al. 2001)

1.8 The socio-cultural value of Livestock in southern Sudan

Despite of the low contribution in the accounts of national income; Livestock have a greater socio-cultural role in live style of people of southern Sudan.

Livestock ownership affects wealth, status, decision-making power, and social events such as births, marriages and deaths often involve ceremonies, which require livestock. The close links between livestock, wealth and social interaction outlined above are reflected in the strong social support mechanisms, which are a feature of pastoral communities (Catley, 1999). These systems are often complex and involve gifts or loans of animals or animal products to poorer members of the community. Cattle play an essential role in Dinka and Nuer society, providing not only milk and dowry, but performing important social functions and determining a man's position and influence in the community. A song bull, while not productive in the sense of providing milk and meat, is a source of great pride, prestige and possible influence. The value of a song bull is determined by an animal's size, colour and shape of the horns. To be Dinka you must own cattle. Cattle provide the means by which kinship ties are made and maintained, a process for ensuring the long term viability of the household and a means of receiving support and animals in the event of disaster." (Catley, 1999).
1.9 The Economic Impact of the AAT:

The Food and Agricultural Organization of the United Nations states, “Trypanosomiasis is probably the only disease which has profoundly affected the settlement and economic development of a major part of a continent.” Of the approximately 7-10 million km2 of land that are infested by tsetse fly, only 20 million cattle are raised. Under different circumstances, this land could support more than 140 million cattle and increase meat production by 1.5 million tons. (Reid, 1997).

The Program Against African Trypanosomiasis (PAAT) (1998 – 1999) estimated the number of the cattle population at the risk of AAT in Sudan by 3,208,907 of cattle out of the total estimated number of cattle population in Sudan (22,500,000 of cattle), the program also estimates the number of cattle not kept because of the AAT by 5,440,724 of cattle.

Compared to animals kept in trypanosomiasis free areas, animals kept in areas of moderate risk of trypanosomiasis have lower calving rates, lower milk yields, higher rates of calf mortality, and require more frequent treatment with preventive and curative doses of trypanocidal drugs. At the herd level, trypanosomiasis reduces milk off take, live animal off take and the work efficiency of oxen used for cultivation. Herds of trypanosusceptible livestock can be devastated by sudden exposure to high levels of trypanosomiasis risk. (Table 1.2 & Table 1.3)

Trypanosomiasis also affects where people live, the way they manage their livestock and the number of animals that they keep. In the tsetse-infested areas as a whole, trypanosomiasis reduces the off take of meat and milk by at least 50%. And by generally constraining farmers from the overall benefits of livestock to farming, less efficient nutrient cycling, less access to animal traction, lower income from milk and meat sales, less access to liquid capital, trypanosomiasis reduces yields, area cultivated, and the efficiency of resource
allocation. It is estimated that a 50% increase in the livestock population would increase the total value of agricultural production by 10%. (Swallow, 1999)

The potential benefits of trypanosomiasis control thus appear to be highest in areas where there is good potential for integrating livestock into profitable and sustainable mixed crop-livestock farming systems. This conclusion has clear implications for the development and implementation of the Action Plan for the Programme Against African Trypanosomiasis PAAT.
Table 1.2: Impacts of trypanosomosis on productivity of trypanosusceptible and mixed breeds of cattle (adopted from Brent M. Swallow, 1999)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Location</th>
<th>Prod. system</th>
<th>animal type</th>
<th>tsetse species</th>
<th>Type of analysis</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmedin and Hugh-Jones, 1995; Slingenbergh, 1992</td>
<td>south-west Ethiopia</td>
<td>Traction, milk &amp; meat, moderate inputs</td>
<td>susceptible cattle</td>
<td>m.submorsitans, tachinoides (palpalis)</td>
<td>cross-site comparison (recall data for 62 herds)</td>
<td>low risk 80% high risk 60% calving rate abortion rate crude mortality rate</td>
</tr>
<tr>
<td>Camus (1981)</td>
<td>Côte d'Ivoire</td>
<td>Milk &amp; meat, moderate inputs</td>
<td>comparison of cattle breeds</td>
<td>palpalis, tachinoides</td>
<td>across-herd comparison</td>
<td>not infected infected calving rate - Baoule 45 43 - N’Dama 40 41 - N’Dama x Baoule 41 44 - Zebu x Baoule 47 41 calf mortality - Baoule 12 19 - N’Dama 9 13 - N’Dama x Baoule 5 10 - Zebu x Baoule 12 21</td>
</tr>
<tr>
<td>Camus (1995)</td>
<td>Côte d'Ivoire</td>
<td>Milk &amp; meat, moderate inputs</td>
<td>mixture of breeds</td>
<td>palpalis, tachinoides</td>
<td>before &amp; after regime of preventive drug treatment</td>
<td>before 35% after 17% calf mortality rate</td>
</tr>
<tr>
<td>Fox et al. (1993)</td>
<td>Tanzania</td>
<td>Specialized meat, high inputs</td>
<td>susceptible cattle</td>
<td>morsitans, pallidipes, brevipalpis austeni</td>
<td>ave. 3 years before and 1 year after tsetse control</td>
<td>before 58% after 77% calving rate weaning weights 124kg 145kg calf mortality rate 14% 5%</td>
</tr>
<tr>
<td>Gemechu et al. (1997)</td>
<td>southern Ethiopia</td>
<td>Traction, milk &amp; meat, low inputs</td>
<td>susceptible cattle</td>
<td>Pallidipes</td>
<td>before and after tsetse control, recall data from 7-15 farmers</td>
<td>before 16% after 5% crude mortality rate calf mortality rate 58% 8% abortion rate 20% 2%</td>
</tr>
<tr>
<td>Rowlands et al. (1995)</td>
<td>southern Ethiopia</td>
<td>Traction, milk &amp; meat, low inputs</td>
<td>susceptible cattle</td>
<td>pallidipes,fuscipes</td>
<td>comparison by proportion of times parasitaemic (320 animals over 3 yrs)</td>
<td>0 14-50% 60-100% calving rate 81% 78% 72% 1st calving age 40mo 41mo 44mo</td>
</tr>
</tbody>
</table>

28
### Table 1.3: Summary of studies of the impacts of trypanosomosis infection on productivity of trypanotolerant cattle (adopted from Brent M. Swallow, 1999)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Location</th>
<th>production system</th>
<th>animal type</th>
<th>tsetse species</th>
<th>Type of analysis</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agyemang et al. (1990; 1993)</td>
<td>Gambia</td>
<td>Traction, meat &amp; milk, low inputs</td>
<td>tolerant cattle</td>
<td>m. submoritans, palpalis</td>
<td>comparison by parasitaemia (110-226 records)</td>
<td>0 times calving rate 63% 1 or more 56%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 mos. milk offtake 176kg 140kg</td>
</tr>
<tr>
<td>Feron et al. (1987)</td>
<td>Zaire</td>
<td>Specialized meat, high health inputs</td>
<td>tolerant cattle</td>
<td>Tabaniformis (fusca)</td>
<td>across-site comparison (36 mos on 600 records)</td>
<td>low risk calving rate 86% high risk 74%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cow weight 330kg 296kg</td>
</tr>
<tr>
<td>ITC (1997)</td>
<td>Gambia</td>
<td>Traction, meat &amp; milk, low inputs</td>
<td>tolerant cattle</td>
<td>m. submorsitans, palpalis gambiensis</td>
<td>comparison by parasitaemia (461 births)</td>
<td>0 times calf mortality 8% 1 or more 15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lactation offtake 260kg 236kg</td>
</tr>
<tr>
<td>Thorpe et al. (1987)</td>
<td>southern Togo</td>
<td>Specialized meat, low inputs</td>
<td>tolerant cattle</td>
<td>Palpalis</td>
<td>comparison by parasitaemia (145 animals)</td>
<td>0 times calving rate 92% 1 or more 81%</td>
</tr>
<tr>
<td>Thorpe et al. (1987)</td>
<td>northern Côte d’Ivoire</td>
<td>Milk &amp; meat, moderate inputs</td>
<td>tolerant &amp; susceptible cattle</td>
<td>palpalis, tachinoides</td>
<td>comparison by parasitaemia (82 animals)</td>
<td>0 times calving rate 78% 1 or more 71%</td>
</tr>
<tr>
<td>Thorpe et al. (1987);</td>
<td>Zaire</td>
<td>Specialized meat, moderate inputs</td>
<td>tolerant cattle</td>
<td>tabaniformis (fusca)</td>
<td>comparison by times parasitaemic (188 animals)</td>
<td>0 times calving rate 75% 1 or more 67%</td>
</tr>
<tr>
<td>Trail et al. (1991)</td>
<td>Zaire</td>
<td>Specialized meat, moderate inputs</td>
<td>tolerant cattle</td>
<td>Tabaniformis (fusca)</td>
<td>comparison by times parasitaemic (146 animals)</td>
<td>below ave calving rate 88% above ave 76%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>weaning weight 138kg 135kg</td>
</tr>
</tbody>
</table>
Chapter 2

Materials and methods

2.1 The study area:

Southern Sudan has an area of approximately 650,000 square km, bordered by Central African Republic, Chad, Democratic Republic of Congo, Uganda, Kenya, and Ethiopia. It is divided into several ecological zones; rainforest, savannah forest, flood plains, swamps and semi-desert. Its estimated population of 5.5 million is made up of many tribes of which the Dinka, Nuer, Shulluk, Murle, Mundari, Toposa and Boya are the main agro-pastoralist groups, keeping cattle, goats, sheep, and chickens. The cattle population is estimated to be approximately 5 million with twice as many sheep and goats. Southern Sudan has a history of underdevelopment and conflict. Since independence was granted to Sudan in 1956, there has been almost continuous civil war. Millions of people have been killed, displaced or are refugees. Southern Sudan is controlled partly by the Government and mainly by several rebel groups. The prolonged conflict has created a chronic, complex emergency; no development, infrastructure destroyed, trade disrupted, no schools or health services, and administrative structures are minimal and have few resources. Droughts have been exacerbated by the conflict, causing periodic famines.

Although it was renamed Unity or El Wihda state by the Government of Sudan in the early 90s in an administrative re-division of the south; it is still referred to as Western Upper Nile or Liech state by SPLM and many southern Sudanese. Western Upper Nile lies in central southern Sudan. The area expands from north of the Bahr el Ghazal river, bordering the Nuba Mountains, some 200 miles south to Ganyiel, with the Bahr el Jebel river bordering the region on its eastern side and Bahr el Ghazal on its western side. (Figure2.1)
Fig. 2.1 General Map of Unity State
2.2 Ecosystem: the ecosystem in Unity state is varies between savannah forest in the north, flood plains in the central part and swamp in the south. (Fig. 2.2, Fig. 2.3)

2.3 Rain fall and Temperature:
According to the records of PETRONAS CARIGALI WHITE NILE LTD- Oil Company operating in Unity State- weather record, taken at Rubkona Base Camp:

2.3.1 Rain fall:
The wet season starts on April of each year and ends in November. The peak of the rainy season is during July, August and September.

2.3.2 Humidity:
The higher percentage of humidity registered was 97 % in August and September and reaches 9 % as the lower humidity in March and February.

2.3.3 Temperature:
The lower temperature registered was 8 °C and that was during January and the higher temperature 48 °C during August.

2.3.4 Wind speed:
The lower wind speed was 2 knots in February and the higher wind speed was 104 knots registered in August.

2.4 Animal species and breeds:
2.4.1 Cattle: There is no accurate information about the cattle numbers in the State, but the Government estimation is 1,500,000. This is not including the cattle of the nomadic Arab tribes coming from western Sudan. The cattle breed in the area is predominantly the Nilotic breed which is known with a relatively small size (250 – 400 Kg for adult) and big horns and the coat can be in many different colours (fig. 2.4). There is also the Arab Nomads cattle breed called the Baggara cattle which has a relatively large size.
(400 -800 Kg for adult) and the colour of the coat is brown. (Fig. 2.5)

2.4.2 Small ruminants: There is also no accurate information about the real numbers of small ruminants, although the Government estimates it as 2,500,000 (goats and sheep only). The predominant breed of goat in this area is the Nilotic Dwarf. Which is a small sized breed with a high reproductive rate (twins two times annually). (Fig. 2.6 and Fig. 2.7)

2.4.3 Poultry: The predominant breed in the area is the Baladi breed. There are no poultry production units in the area except a newly established unit, which is part of the community development program of Talisman Oil Company. They breed the Bovan chicken for laying eggs.

2.4.4 Equines: Donkeys are much more common than horses in the state. And they are only available at Rubkona and Bentiu.

2.4.4 Fish: There is a huge fish stock in the area both in the rivers and swamps although there is no estimation of numbers. The fishing systems is quite primitive with the locals using small nets and spears and then preserve the catch by salting and drying method. Lately some investment in fishing was introduced at the northeast part of the State in the area of Munga at the western bank of the river Bahr Eljabel. Motorboats, modern fishing nets and refrigerators are utilized in the operations to transfer the catch to the cities (up to Khartoum some times).
Figure 2.2  The Swamps Echo System Southern Unity State

Figure 2.3. The Rich Savannah Forests in the Middle Areas of Unity State.
Figure 2.4 Nilotic cattle breed

Figure 2.5 Baggara cattle breed
Figure 2.6 Nilotic goat breed

Figure 2.7 Nilotic sheep breed
2.4.4 Wildlife: There are no official record about Wild life population in the area; the locals have described a wide range of wild life species in the area which varies from large animal such as Elephants *Loxodonta africana*, Buffaloes *Syncerus caffer*, Giraffes *Giraffa camelopardalis*, hippopotamus *Hippopotamus amphibius*, wild cats such as Lions *Panthera leo*, Leopards *Panthera pardus*, cheetah *Acinonyx jubatus* and serval cat *Felis serval*, small ruminants such as sitatunga *Tragelaphus spekei* and water buck *Kobus defassa*. Spotted hyena *Crocuta crocuta* is quite common in the area. Many primates were also observed such as baboons *Papio anubis* and green monkey *Cercopithecus aethiopicus*. Reptiles’ species are very common in the area and the locals described crocodile *crocodylus niloticus*, Pythons *Python sebae*, Vipers *Causus rhombeatus* and some other lizard’s species.

2.5 Vegetation:

The trees are tall and broadleaved and thorny ones are rare. Coarse tall tussocks of perennial grasses predominate and hence fires are generally fiercer than in the low rainfall woodland savanna. Forest species easily recolonize areas with high rainfall when fire protection is provided. Two types have been described:

- *Anogeissus-Khaya-Isoberlinia* woodland is found on ironstone soils with rainfall of 900 to 1 300 mm. It is far from homogeneous due to variations in climate, different types of soil that occur from ridge top to valley bottom and the effect of different degrees of human disturbance.
- The driest parts, with a rainfall of 900 to 1 000 mm, have such species as *Sclerocarya birrea*, *Diospyros mespiliformis*, *Tamarindus indica*, *Balanites aegyptiaca* (Lalob) with a good deal of *Combretum ghasalense* and many *Acacia* species. Mahogany (*Khaya senegalensis*) is sporadic on the ridges and near seasonal watercourses. With a
slightly increased rainfall, these more drought-resisting species become rather rare. The ridge tops are denuded of soil in some places to form almost bare ironstone pans. But where the soil is deeper, they carry vegetation characterized by tangles of evergreen shrubs and lianas centered on termite mounds, with one or two larger trees on these mounds or in the centre of the tangle. The larger trees include *Khaya senegalensis* (Mahogany) and *Parkia oliveri*. On the slopes down from the ridges, but (*Daniellia oliveri*) is found, and, on clay soils, *Anogeissus leiocarpus*. In the valley bottoms, there tends to be open grassland or scattered trees of *Terminalia laxiflora* or *T. macroptera*. Many other large trees are found in smaller quantities and there are many species of small trees such as *Combretum* spp., *Grewia mollis* and *Acacia seyal* var. *multijuga*. *Butyrospermum niloticum* becomes dominant with the appearance of parkland, where other species have been removed during shifting cultivation and the latter preserved for the value of its fruit.

### 2.6 Tribes:

Although there are some Dinka inhabiting the north east of Unity state (Pariang), the majority of the population in the area ethnically is from the Nuer tribe, which is one of the biggest and most important tribes in Sudan. The Nuer are divided into eleven sub-tribes or clans; Jikany, Leek, Bul, Jagei, Adok, Nguong, Dor, Ghol, Lak, Thiang and Gawier. Each sub-tribe is originated and based in part of the Greater Upper Nile Area. It is more often to find the Jikany, Leek, Bul, Jagei and Adok in the study area. (Fig. 2.8).

Some of the western Sudan Arab or Baggara nomadic tribes visit the area during the dry season searching for the water and graze. These tribes are primarily from the Misseria Humur predominantly from the sub-tribes Ajaira, Fayareen, Wilad Omran, Mazagna. They reach the area through two major:
Figure 2.8 Map of The Tribes and Traditional Cattle Grazing Tracks
cattle grazing traditional tracks (Murhal as called by the nomads), Eastern Murhal and Middle Murhal. Fortunately the relation between them and the native tribes is good and there were no clashes between them on the water or grass resources.

2.7 Husbandry practices and Animal movement:

The nomadic and semi nomadic (open) are the predominant management systems in the area. Despite of that the Nuer and the Misseria are adopting the same system, there are some slightly differences on the way they practice it in sort of way of living and breeding their cattle.

Both of the Nuer and the Misseria do travel with their cattle during the dry season searching for the graze. The Nuer in general do not travel with their cattle for long distances, basically because water resources and grass are quite available in their areas. Each sub-tribe have their traditional places for camping with their cattle during the dry season; these places usually locate near a river or a big swamp. They commit to stay within the very same places every year and do not change that except for emergencies (e.g. insecurity or outbreaks).

Most of the conflicts between the Nuer sub-tribes on the grazing areas happen during outbreaks times. When an outbreak happens in an area, the closer sub-tribes make a quarantine zone shielding them from the outbreak area, leashing all the herds from there from entering their areas.

The entire Arab nomads’ population visiting the study area are from the Misseria tribe. They originate from Muglad and Babanosa. Typically they leave from there in October – November on an annual long journey to reach Rubkona and Raggad in Unity State in December – January. They stay in the area till June and then leave back reaching their home in July and August.

Traditionally in the Nuer system, the younger family / village members are responsible of the cattle. They travel with the cattle in both genders, young men and boys are for protection and young women and girls are to take care of most
of the household activities. Rarely some older people accompany the crew taking the supervision role.

It is quite different for the Misseria; the whole sub-tribe travels with their cattle and all of the family members take part on this long journey. The role of Misseria men is taking care of their cattle- adjacent to their traditional role of protection- women are to take care of the household activities and children are to assist their parents.

In order to avail milk and meat at the household level in their home villages; the locals leave behind some small numbers of animals.

2.8 The vet – services:

Although there are two vets and two mobile clinic units, still there is no governmental veterinary settled clinic or hospital in Unity state. There are three NGOs working in the field of livestock in the area:

- Benevolence International organization (Vet Serve) and they were acting in Bentiu. Their team was led by a vet doctor. (Their activities have been collapsed due to lack of fund).
- German Agro Action (GAA) and they are acting in the area of Mayom northern Unity State.
- The Community Development and Humanitarian Assistance Program of WHITE NILE PETROLIUM OPERATING COMPANY LTD (Oil Company Exploring in Unity State). And their livestock program is run by two vets working on monthly shifts and assisted by a number of skilled locals. They have three vet services centres in the area (one of them was destroyed on January 2004).

All of the above mentioned organization are adopting the community based animal health systems and have workers networks covering large inaccessible areas in the state.

There was no scheduled vaccination program in the state, only irregular campaign from time to time. Recently (2004 dry season) the local Veterinary
authorities in collaboration with the CDHAP - WNPOC have organised a vaccination campaign in the state and it is planned to be scheduled every dry season covering the area.

2.9 The survey:

The survey was conducted in different places in Unity state: Mirmir, Khor Gamos, Doar Kiech, Mayom, Mankien, Rubkona, Thoan and Abiemnom (Fig. 2.1). The survey took place in the period of June 2003 to January 2004.

2.9.1 Animal Species:

The survey covered only the bovine in the study area. The samples were collected from both of the existing breeds in the area (Nilotic and Baggara).

2.9.2 Sampling:

Purposive sampling was the method adopted for this survey due to the following reasons:

1. The inaccessibility to some of the areas in the state due to either the insecurity or the natural barriers such as swamps and wood lands.
2. The nomadic movement of the herds made it impossible to construct a sample frame for random sampling.
3. The locals were not willing to allow taking samples from healthy animals because they believed this will make their animals weak and may be sick so they accept only to sample the sick ones.

300 thin blood smears were collected from different herds in the study area. 150 of them were collected during the dry season and the rest were collected during the wet season.

2.9.3 Parasitic survey:

Trypanosome detecting on stained thin smear: A drop of blood is placed 20 mm from one end of a clean microscope slide and a thin film is drawn out in the usual way. The film is air-dried briefly, fixed in methyl alcohol for 2 minutes and allowed to dry. The smears were then stained by 5% Giemsa for 45 minutes then checked under microscope(x100 – oil immersion lens).
18 fly samples were hand collected from the study area, preserved in 70% alcohol and sent to be identified.

2.10 Clinical Data:

All the disease cases registration books from the veterinary clinics of the Community Development and Humanitarian Assistance Program (CDHAP) – White Nile Petroleum Operating Company (WNPOC) were entered and analyzed by computer using the SPSS program (Version 10.0). Many statistical tests were applied to the data such as cross tabulation and the proportional morbidity rate.

2.11 Participatory Epidemiological Survey:

The participatory epidemiological survey was conducted in six different places in Unity state Mirmir, Khor Gamos, Doar Kiech, Mayom, Mankien and Abiemnom. (Fig 2.1)

2.11.1 Secondary data and interviews:

Secondary data and interviews with key informants were used as background information to the research. Secondary data included published literature on bovine trypanosomosis, community-based livestock disease control and other topics. Also the registration books and reports of the cases checked at the veterinary clinics and during the mobile clinics of the CDHAP WNPOC. Interviews were conducted with veterinary personnel at the Ministry of Agriculture and Animal Resources at Unity state, villages and cattle camps chiefs. During these interviews questions checking list, diseases lists with local names and veterinary serviced profile were developed in order to ensure proper covering for all subject and to keep the conversations on track.

2.11.2 Participatory mapping

The informants were asked to draw a map on the ground of their areas facilitated with the researcher using every day objects (stones, sticks…etc). Participatory mapping was used to describe features of each location and cattle camp such as:
• The geographical boundaries of the village.
• Natural resources such as water sources.
• Services, facilities and important infrastructure (including roads).
• The grazing areas for the milking herd.

Maps were constructed on the ground by one group of informants in Abiemnom with the Misseria and Dulaek with the Nuer. Other copies were made into the researcher notebook.

2.11.4 Disease ranking (Proportional Piling):

The informants were asked to list all the cattle diseases in their areas. And then standardized list of diseases was developed, checked and revised with three different informant groups before being applied to the survey. The informants groups were asked to rank the list of the diseases according to their importance using 100 stones for proportional piling. The exercise was repeated to rank the diseases prevalence on the year 2003 using the same methods.

2.11.5 Seasonal calendars

Seasonal calendars were used to describe the seasonal incidence of the diseases and cattle movement. Local names for seasons were used and each season was represented using an object placed along the top x-axis of the diagram. These types of seasonal calendar were used with one group of informants from each location.
Chapter 3

Results

3.1 Parasitic Survey:

The parasite had been identified morphologically in all the positive slides as *Trypanosoma vivax*. (Plate 3.1.1 and Plate 3.1.2). The infection rates in the different areas are as detailed in Table 3.1.1. The highest parasitaemia was observed during the dry season. As for breeds the Baggara cattle had higher parasitaemia than the Nilotics.

18 samples of flies were collected by hand catching by the researcher and identified in the Central Veterinary Research Laboratories in Soba to be *Tabanus taeniola* (17 samples) and *Atylotus agrestis* (one Sample).

3.2 Clinical Data Analysis:

All the cases registered in the books of three clinics run by the CDHAP – WNPOC (Thoan, Dandok and Mirmir Villages) in the period from June to December 2003 were entered and analyzed using the SPSS program(Vesion 10.0). 1,780 cases were checked and received treatments in the clinics during the above mentioned period, 1658 cases of them were bovine, 109 caprine, 11 ovine and 2 equine. (Table 3.2.1)

529 cases of bovine trypanosomiasis were diagnosed based on the clinical symptoms only and no laboratory confirmation was available at the time. Fig.3.2.1 and Fig. 3.2.2 demonstrate cases of trypanosomiasis with clear exhibition of the symptoms of poor body condition, rough coat.

All the cases diagnosed as AAT were treated using doses of Diamazine Aceturate and showed good response, the cases that did not show good response were also treated with anthelmentic (Albendazole) and showed complete recovery. The proportional morbidity rate for the AAT cases at the clinics in the period between June to December 2003 was 31.91 %. Cross tabulation analysis for the diseases by month demonstrated in Table 3.2.1 reveals that the AAT is more prevalent in October, November and December(Fig.3.2.3) which
are the months of the dry season as demonstrated in Table 3.2.2. The proportional morbidity rate of AAT compared to other diseases is demonstrated in Fig. 3.2.3. While the rates of AAT by month is demonstrated in Fig. 3.2.4.

3.3 Participatory Epidemiological Survey Results:

3.3.1 Participatory Mapping:

The map prepared by the Misseria informant groups Abiemnom had shown the traditional seasonal movement tracks as they stay in their home villages at Babanosa area only for one month in the August – September when they start moving south to reach Abiemnom in October and stay there till January. The last place they reach south is Dityang where they stay from January to June when they start moving back rapidly to their home villages. They stated that the last vet services they get are in El. Bittikh market in West Kurdufan. (Fig. 3.3.1.)

The Nuer informant group in Dulaek prepared a map showing the grazing areas and the annual cattle movement. The cattle reach Dulaek area and stay there in the period between November to April when they start moving back to their home villages. The only veterinary services available are in Mayom village provided by the network of the Community Animal Health Workers of the German Agro Action Organization. (Fig. 3.3.2)

The maps showed some differences in the husbandry systems between the Nuer and the Misseria communities. The Misseria moves very much longer distances with their cattle than the Nuer, and they get more veterinary services during their movement than the Nuer groups.

3.3.2 Proportional Piling:

The list of the most common five diseases in the Nuer areas is explained in Table 3.3.1 for the Nuer and Table 3.3.2 for the Misseria with its case definition and best bet for the modern veterinary name of each. (Fig. 3.3.2 and Fig. 3.3.3)
The results of the Proportional Piling exercise in ranking of the important disease by prevalence rate and importance in causing high morbidity and mortality in the herd in the different locations are shown in Table 3.3.3 and Figure 3.3.1.

The results from the proportional piling were entered and analyzed by the SPSS program in order to check the level of agreement of the results between the different groups, Kedall’s W coefficient of concordance test was applied to both of the prevalence piling and importance piling data. The Kedall’s W coefficient of concordance (which is measured by a scale from 1.000 to 0.001 the higher and closer it is to 1.000 the higher will be the level of agreement of the results) for the disease prevalence was 0.445 and for the disease importance it was 0.825 which shows a high level of agreement on the importance results and a moderate level of agreements in the prevalence results.

The positive predictive value of herder diagnosis (Number of cattle diagnosed with AAT by owners / number of cattle diagnosed with AAT by Laboratory testing x 100 %) was calculated for both of the Nuer groups and the Misseria groups.

3.3.3 Seasonal Calendar:

All the Nuer Informants agreed on that the AAT is prevalent the whole year but with bigger proportion in the period from October to March (dry season). They also stated that the biting flies are more often to be found at this time and they clearly linked the flies’ bites with Liei.

The Misseria at Abiemnom stated that the AAT is prevalent the whole year too but with more proportion in the period between June to December (which is the period when they usually stay in Unity State during the dry season in their areas. They also stated that this is the time when their animals are vulnerable to flies bites and in contact with wild animals (buffaloes).
Plate 3.1.1 Blood film from Baggara cow infected with high parasitaemia of *Trypanosoma vivax*

Plate 3.1.2 *Trypanosoma vivax* (blood film from Nilotic cow)
### Table 3.1.1 Blood Film Results:

<table>
<thead>
<tr>
<th>Area</th>
<th>Breed</th>
<th>Dry Season</th>
<th>Wet Season</th>
<th>Totals (PMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Samples</td>
<td>Positive</td>
<td>Samples</td>
</tr>
<tr>
<td>Rubkona, Thoan and Dandok</td>
<td>Nilotic</td>
<td>50</td>
<td>2 (4 %)</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abiemnom</td>
<td>Baggara</td>
<td>100</td>
<td>13 (13 %)</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Totals</td>
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<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Disease</td>
<td>Jun</td>
<td>Jul</td>
<td>Aug</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Bovine</td>
<td>Trypanosomiasis</td>
<td>20</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal Parasite</td>
<td>15</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pneumonia</td>
<td>4</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mange</td>
<td>4</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>External Parasite</td>
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<td>42</td>
<td>10</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>FMD</td>
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<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
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<td>Lameness</td>
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<td>22</td>
<td>5</td>
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<td></td>
<td>H.S</td>
<td>2</td>
<td>14</td>
<td>34</td>
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<tr>
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<td></td>
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<tr>
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<td>Brucellosis</td>
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<td>Retained Placenta</td>
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<td>1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye&amp; Ear Infection</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CBPP</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Mastitis</td>
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<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diarrhea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arthritis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>wound</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metritis</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Float</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dystochia</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B.Q</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>9</td>
<td>2</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Totals</td>
<td>88</td>
<td>77</td>
<td>207</td>
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</tbody>
</table>

**Table 3.2.1 Bovine Diseases Cross Tabulation by Month**

*(June – December 2003)*
Table 3.2.2 Bovine Disease Cross Tabulation by Season

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dry Season</th>
<th>Wet Season</th>
<th>Total Number of cases in 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of cases</td>
<td>Proportional Morbidity Rate</td>
<td>Monthly Average</td>
</tr>
<tr>
<td>Trypanosomiasis</td>
<td>232</td>
<td>44.11 %</td>
<td>116</td>
</tr>
<tr>
<td>Internal Parasite</td>
<td>35</td>
<td>6.65 %</td>
<td>17.5</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>58</td>
<td>11.02 %</td>
<td>29</td>
</tr>
<tr>
<td>Mange</td>
<td>33</td>
<td>6.27 %</td>
<td>16.5</td>
</tr>
<tr>
<td>External Parasite</td>
<td>14</td>
<td>2.66 %</td>
<td>7</td>
</tr>
<tr>
<td>FMD</td>
<td>2</td>
<td>0.38 %</td>
<td>1</td>
</tr>
<tr>
<td>Lameness</td>
<td>52</td>
<td>9.89 %</td>
<td>26</td>
</tr>
<tr>
<td>H.S</td>
<td>5</td>
<td>0.95 %</td>
<td>2.5</td>
</tr>
<tr>
<td>Brucellosis</td>
<td>14</td>
<td>2.66 %</td>
<td>7</td>
</tr>
<tr>
<td>Retained Placenta</td>
<td>12</td>
<td>2.28 %</td>
<td>6</td>
</tr>
<tr>
<td>Eye &amp; Ear Infection</td>
<td>13</td>
<td>2.47 %</td>
<td>6.5</td>
</tr>
<tr>
<td>CBPP</td>
<td>1</td>
<td>0.19 %</td>
<td>0.5</td>
</tr>
<tr>
<td>Dystochia</td>
<td>1</td>
<td>0.19 %</td>
<td>0.5</td>
</tr>
<tr>
<td>Metritis</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mastitis</td>
<td>8</td>
<td>1.52 %</td>
<td>4</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>13</td>
<td>2.47 %</td>
<td>6.5</td>
</tr>
<tr>
<td>B.Q</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wound</td>
<td>7</td>
<td>1.33 %</td>
<td>3.5</td>
</tr>
<tr>
<td>Arthritis</td>
<td>10</td>
<td>1.90 %</td>
<td>5</td>
</tr>
<tr>
<td>Bloat</td>
<td>3</td>
<td>0.57 %</td>
<td>1.5</td>
</tr>
<tr>
<td>Others</td>
<td>13</td>
<td>2.47 %</td>
<td>6.5</td>
</tr>
<tr>
<td>Totals</td>
<td>526</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 3.2.1 Cow infected with Liei in Thoan Village, Unity State

Fig. 3.2.2 Cow infected with Liei in Rubkona, Unity State
Figure 3.2.3 Bovine Cases by Month
Figure 3.2.4 Bovine Trypanosomiasis Cases by Month the Year 2003
Figure 3.3.1 Participatory Map of Abiemnom
Figure 3.3.2 Participatory map of Dulaek
Figure 3.3.3. Important Diseases Proportional Piling in Doar Kiech in Mala Area.

Figure 3.3.4 Important Diseases Proportional Piling in Mayom Area.
Table 3.3.1 Lexicon of local terms for diseases in Nuer language:

<table>
<thead>
<tr>
<th>No</th>
<th>Local Term</th>
<th>Probable Veterinary Diagnosis</th>
<th>Meaning</th>
<th>Case Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dat</td>
<td>F.M.D.</td>
<td>Foot Disease</td>
<td>Fever, wounds on the legs, hooves and tongue drop in milk production and death.</td>
</tr>
<tr>
<td>2</td>
<td>Yeithpin</td>
<td>Haemorrhagic Septicaemia</td>
<td>To die quickly</td>
<td>Swelling in the neck and chest, fever, diarrhoea and sudden death.</td>
</tr>
<tr>
<td>3</td>
<td>Liei</td>
<td>Tryps + internal parasites</td>
<td>To steal gradually</td>
<td>It is a cattle disease; the symptom of the disease appears for a long time (chronic). The symptoms are: loss of weight, rough coat, very low productivity of milk, loss of tail hair, abortion, and death. They think the disease can be transmitted via Flies Rum (Tabanids) bite and grazing in the swamps and rivers.</td>
</tr>
<tr>
<td>4</td>
<td>Doap</td>
<td>CBPP</td>
<td>Lung disease</td>
<td>Very hard and painful to breath, nasal discharges and death. The chest full of pus. Transmits between the herds by air.</td>
</tr>
<tr>
<td>5</td>
<td>Mullaeh</td>
<td>Brucellosis</td>
<td>Abortion and joint disease</td>
<td>Abortion, joint swelling.</td>
</tr>
<tr>
<td>No</td>
<td>Local Term</td>
<td>Probable Veterinary Diagnosis</td>
<td>Meaning</td>
<td>Case Definition</td>
</tr>
<tr>
<td>----</td>
<td>------------</td>
<td>-------------------------------</td>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>1</td>
<td>El. Fasokh</td>
<td>Trypanosomiasis</td>
<td>To loose the tail hair</td>
<td>The symptom of the disease appears for a long time (chronic). The symptoms are: loss of weight, rough coat, very low productivity of milk, loss of tail hair and death. They think the disease can be transmitted via Flies <em>El. Dubban or El. Tair</em> (both names are used for Tabanids) bites and also the bites of an other type of flies they called <em>EL. Geem</em></td>
</tr>
<tr>
<td>2</td>
<td>Al Alak</td>
<td>Internal Parasites</td>
<td>Bad or Dirty Food or grass</td>
<td>After the cattle eat from the bad grass with old dunk on it they start loosing weight, rough coat, very low productivity of milk, bottle jaw, big belly, and worms in the faeces and may be cause death.</td>
</tr>
<tr>
<td>3</td>
<td>Tasammum</td>
<td>Haemorrhagic Septicaemia</td>
<td>Poisoning</td>
<td>Swelling in the neck and chest, fever, diarrhoea and sudden death.</td>
</tr>
<tr>
<td>4</td>
<td>Abu Lissan</td>
<td>F.M.D.</td>
<td>Tongue Disease</td>
<td>Fever, wounds on the legs, hooves and tongue drop in milk production and death especially for calves.</td>
</tr>
<tr>
<td>5</td>
<td>Um Zaggala</td>
<td>Black Quarter</td>
<td>Lameness</td>
<td>Cattle disease but also happens buffaloes, lameness, swelling full of gas in the shoulder or hind limp muscles, fever, lose of appetite and drop in milk production, some times cause death.</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.3.3 Prevalence and Importance of diseases as ranked by the different Nuer communities (%)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dat (FMD)</th>
<th>Yeithpin (Haemorrhagic Septicaemia)</th>
<th>Liei (Trypanosomiasis + Internal Parasites)</th>
<th>Doap (CBPP)</th>
<th>Mullach (Brucellosis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doar Kiech, Mala Area</td>
<td>22</td>
<td>44</td>
<td>19</td>
<td>20</td>
<td>33</td>
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<tr>
<td>Mirmir</td>
<td>29</td>
<td>30</td>
<td>20</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>Mayom</td>
<td>29</td>
<td>41</td>
<td>31</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Khor Gamos</td>
<td>26</td>
<td>30</td>
<td>16</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Mankien</td>
<td>32</td>
<td>20</td>
<td>35</td>
<td>55</td>
<td>13</td>
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<tr>
<td>Gwich(Koch)</td>
<td>20</td>
<td>27</td>
<td>29</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>26.3</strong></td>
<td><strong>32</strong></td>
<td><strong>25</strong></td>
<td><strong>27.8</strong></td>
<td><strong>20.5</strong></td>
</tr>
<tr>
<td><strong>Medians</strong></td>
<td><strong>27.5</strong></td>
<td><strong>30</strong></td>
<td><strong>24.5</strong></td>
<td><strong>23.5</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>
Table 3.3.4 Prevalence and Importance of diseases as ranked by the Misseria in Abiemnom (%)

<table>
<thead>
<tr>
<th>Location</th>
<th>Disease</th>
<th>Um Zaggala (Black Quarter)</th>
<th>Tasammum (Haemorrhagic Septicaemia)</th>
<th>Abu Lissan (FMD)</th>
<th>El Fasokh (Tryps)</th>
<th>Al Alak (Internal Parasites)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abiemnom</td>
<td>47</td>
<td>37</td>
<td>46</td>
<td>30</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>


Figure 3.3.3 Proportional Piling for Bovine Diseases Ranking (Medians) for Nuer
Figure 3.3.4 Proportional Piling for Bovine Diseases Ranking for Misseria in Abiemnom:
Chapter Four

Discussion

The overall aim of this study was to avail baseline information about the epidemiology of the African Animal Trypanosomiasis in the area of Block 5A Unity State, Southern Sudan (Fig.2.1) and the role of ethno veterinary practices in the area of study in identification of the disease.

In this study all of the AAT positive thin smears were identified as T. vivax which is the first time to be reported in the study area. This is while T. congolense was identified in Upper Nile, Malakal area (Karib 1961), reported in the Jonglei Canal area (Mefit-Babtie, 1983) and in Nyal deep south of Unity State, Lankien in Jonglei State and Thiet in Bahr El Gazal State. (Catley 2000). Catley also in the same study has identified T. vivax in Nyal and Thiet.

It was also observed in the study that all of the cases with high parasitaemia were from the Baggara breed and no high parasitaemia cases were observed in the Nilotic breed. Also it was observed that only 4% of 50 samples of the samples collected from the Nilotic breeds during the dry season were positive while 13% of 100 samples were identified positive for AAT from the Baggara sample. Consistant with all of that were the results for the samples collected during the wet season to be 3.13% of 54 samples for the Nilotic and 11.11% of 96 samples for the Baggara breed.

Only Tabanids (Tabanus taeniola and Atylotus agrestis) were observed and described by the informants groups, and no Tsetse flies have ever been described or observed. Although in 1972 Yagi and Abdel Razig reported on a survey begun in Southern Darfur 1967 which indicated a northward movement of Glossina morsitans which had engulfed Radom and El Hugeirat on the headwaters of Bahr Elarab between 9°50’ and 10°13’N, there appears not to have been a similar spread of this species into the study area.

The interviews with Nuer informants groups during the Participatory Survey demonstrated much overlap between indigenous knowledge on the
disease Liei with the clinical description and parasitic finding of the AAT. Catley (2000) had described Liei to be a Chronic Wasting Disease, resulting from a mixed infection between Trypanosomiasis and internal parasites. This fit with the fact of that some of the cases that did not respond to Dimanazine Aceturate alone, recovered completely after Albendazole.

Likewise the Interviews with the Misseria informants groups demonstrated much overlap between their indigenous knowledge on a disease they called El. Fasokh with the clinical description and parasitic findings of AAT. They also claimed to treat El. Fasokh successfully with Homidium Bromide (which they called Habba Hamra meaning red pill) and Diamanazine Aceturate (which they called Bowad) which is again considered evidence that the disease is AAT.

Both of the informant groups showed knowledge of the fact that the disease is transmitted by biting flies. The Nuer informant groups described only one type of flies to transfer the infection of Liei and called it Rum, while the Misseria informant group described two kinds of flies to transfer the infection with El. Fasokh, the first one identified to be Tabanids and they called it El. Tair and the other fly they called El. Geem.

Concerning the treatment of the Liei the Nuer informant groups stated they treat it with Homidium Bromide (Ethidium). In addition some of the old informants stated they treat it traditionally with two kinds of treatment. The first one is by using the seeds of a creeping plant they called Yith Lual. They soak the seeds overnight, and then drench it to the sick cow. The other treatment is the Python snake body fat or cattle fat body or the mixture of both, collected then melted on fire then left to be cold a bit then drenched to the sick cow too. The later method is similar to the method used by Orma cattle keeper in Tana River District in Kenya as they use soups prepared from sheep’s head or tail fat or fish waste. (Catley 2000) The informants also stated for both of the treatments some times the sick cow recovers and some times it does not.
The Misseria treat El. Fasokh only with modern treatments as Ethidium and Diamanazine Aceturate.

In the study the results for the proportional morbidity rate of AAT varied between the three different approaches used to assess it. The thin smear technique revealed a PMR of 8%; in the clinical 31.9% of the cases presented were diagnosed as AAT; while proportional piling technique suggested a PMR of 20.5%. These differences however fit well with wider knowledge: thin smear tests are not positive in all clinical cases for a variety of reasons, and local people know which diseases can be treated at the clinic and which cannot. The proportional piling method is therefore likely to be the most accurate real measure of PMR.

Catley, et al (2000). Presented results from a participatory disease search on Liei in Nyal (South Unity State) showing a prevalence of 9.6% of 365 samples using the thin smear technique which is almost matching the prevalence of 8% of 300 samples resulted from the study using the same technique.

The results of the present study demonstrated a seasonal pattern of the prevalence of the AAT in the study area. The thin smear technique showed a Proportional Morbidity Rate for AAT of 6% of 150 samples in the wet season if compared to 15% of 150 samples in the dry season; a result that with a similar trend to the clinical picture for AAT which showed that 26.24% of 297 cases presented in the wet season were AAT, compared to 44.11% of 232 cases presented in the dry season. These both agree with the results from the interviews. Both the Misseria and the Nuer informant groups stated that the morbidity rate of AAT is higher during the dry season due to the larger population of biting flies at this time of the year.

Regarding locally perceived importance of AAT compared to other diseases, the informant groups from the Nuer had ranked Liei according to its importance to be in the third in importance after Yeithpin and Dat respectively.
Their justification for ranking Yeithpin to be the most important disease is because it is the most killing disease and gives no time for response or treatment. The justification for Dat to be second is that it has no treatment and it kills calves. Liei in the third place because it can affect lot of animals from different ages but can be treated and even avoided. Doap is ranked to be the fourth because it is not as prevalent as the other diseases and it is not as killing as the others and also can be treated. Mullaeh is ranked as the least important from the most common disease because it is the less prevalent disease and it is not a killer disease at all.

The informant group from the Misseria had ranked the diseases in a quite different way. They ranked El. Fasokh to come in the fourth place after Abu Zaggala, Tasammum and Abu Lissan respectively, while El. Alak is ranked in the last place. Their justification for ranking Abu Zaggala in the first place because it is a killer disease and it brings Tassamum right after it infects the cattle. Tasammum is ranked in the second place because it is a killer disease too and gives no time for treatment but can be prevented against by vaccination; Abu Lissan is ranked in the third place because it is less killer disease but can not be treated. El. Fasokh is ranked in the fourth place because it is a treatable disease. And the El. Alak is ranked in the last place because it is an avoidable and treatable disease.

The informant groups agreed on the fact of that they use Ethidium or Diamanazine as the general method to control AAT. They also try avoiding the biting flies, but using quite different approaches. The Misseria leave the area during the fly high prevalence time, this is while the Nuer keep their animals inside specially designed big huts called Luak and / or use smoke and fire as repellent for the flies. They also try to release their animals for grazing after the biting fly feeding time (after 9- 10 o’clock in the morning).

The lower infection rate in the Nilotic breed than the Baggara breed could be a result of many factors integrated together. The continuous traditional
movement of the Baggara cattle causes stress to the cattle, which can reduce the immunity of the animals, while the Nilotic cattle breeds only move for relatively short distances. Also it should be considered that the Baggara breeds are more exposed to biting flies and stay in contact with many other susceptible animals and wildlife during their journey. There may also be a higher level of tolerance of AAT in the Nilotic breeds than in the Baggara breeds.

The results from the present study is concluded on that the only Trypanosoma species detected by the techniques used during this study in the area is T. vivax which is backing up the hypotheses of its mechanical transmission and that Tsetse flies are absent from the study area. The study also suggested a seasonal pattern of prevalence of AAT in the area with the disease more prevalent during the dry season than the wet season. The study also suggested that may be the Nilotic breeds are more tolerant of AAT than the Baggara breed. It is also concluded in this study that AAT is very well identified the ethno veterinary knowledge of both of the Nuer (disease name Liei) and Misseria (Disease name is El. Fasokh) and they both use different integrated methods for controlling the AAT in their areas.

This study extends our detailed understanding of the epidemiology of AAT in this part of Sudan. The picture that emerges is consistent with our knowledge of the disease in other areas, its clinical presentation, laboratory diagnosis, and the high level and practical application of local knowledge.

Based on what is concluded above here are in the following the recommendations of this study:

1. The participatory epidemiological methods is very important to be used together with the other epidemiological investigation as it complete the picture of diseases behaviour and also involves the local communities in any future disease control strategies.
2. Our knowledge can be refined by further studies using more sensitive AAT diagnosis methods such as ELIZA and Micro-Haemotocrit centrifugation Methods.

3. More study is to be done on the biting flies’ population as the vector for AAT in the study area.

4. The study can be a base for Community Based Integrated AAT Control Strategy.
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