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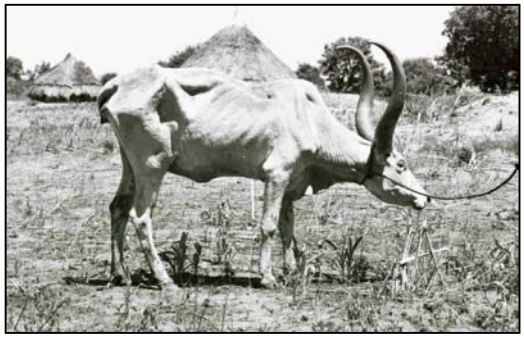

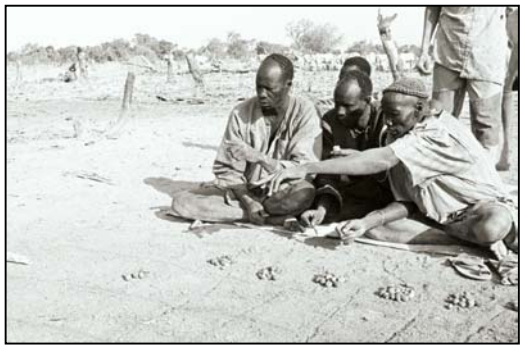

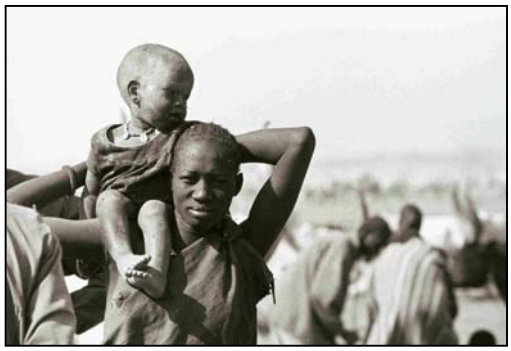

LEARNING ABOUT *LIEI*

Participatory diagnosis of the chronic wasting problem in cattle in southern Sudan

September 2000

PARTICIPATORY APPROACHES TO VETERINARY EPIDEMIOLOGY (PAVE) PROJECT

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Participatory diagnosis of the chronic wasting problem in cattle in southern Sudan

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The following people assisted the PAVE Project in Southern Sudan:

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Ding Kui Rhai
Changath Monyong Deang
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Andy Catley of IIED coordinated the PAVE Project and wrote this report.

SUMMARY

In southern Sudan a disease of cattle called *liei* or *noi* is considered by livestock keepers to be one of the most important health problems affecting their animals. The disease affects adult cattle and is characterised by gradual weight loss, leading to emaciation, poor production and death. The UNICEF Operation Lifeline Sudan (Southern Sector) Livestock Programme operates a community-based animal health programme in southern Sudan that aims to address important animal health problems as jointly identified by livestock keepers and programme staff. However, while some livestock diseases can be diagnosed with reasonable confidence by veterinary workers according to case history and signs of disease, other diseases have rather vague, non-specific clinical signs. This group of diseases includes *liei* and *noi,* and diagnosis according to western concepts of disease is dependent on laboratory tests. These diseases present a special challenge to a community-based programme that covers a large area characterised by very poor infrastructure, minimal laboratory facilities and operational constraints such as severe conflict.

The veterinary literature from southern Sudan describes various diseases that can cause chronic weight loss in adult cattle. These diseases include trypanosomosis, fasciolosis, schistosomosis and parasitic gastro-enteritis. Each of these diseases has a complex epidemiology involving climatic and environmental factors, and in some cases, disease vectors and intermediate hosts. Although much useful information has arisen from previous research, few workers in southern Sudan have considered livestock diseases according to the clinical syndromes that are observed in the field and the notion that chronically sick cattle may be infected with more than one disease agent. Furthermore, researchers have not always related recommendations about disease control to the ability of veterinary agencies to deliver relevant services to livestock keepers, and the capacity of livestock keepers to pay for these services.

In southern Sudan, the combination of an established community-based animal health programme, well-developed indigenous knowledge of livestock keepers and limited field-level laboratory facilities offered an opportunity to use a participatory research approach to characterise the chronic wasting problem. Therefore, a study was designed with three main aims as follows:

- To characterise the chronic wasting problem from the perspectives of both livestock keepers and veterinarians, and identify linkages between these two bodies of knowledge.

- To assess the value of participatory methods in veterinary investigation. In particular, the research focused on the use of standardised tools for comparing the views of informants within and between communities, and to compare 'local' and 'professional' opinions.

- To identify further action needed to develop better control strategies for the chronic wasting problem in southern Sudan.

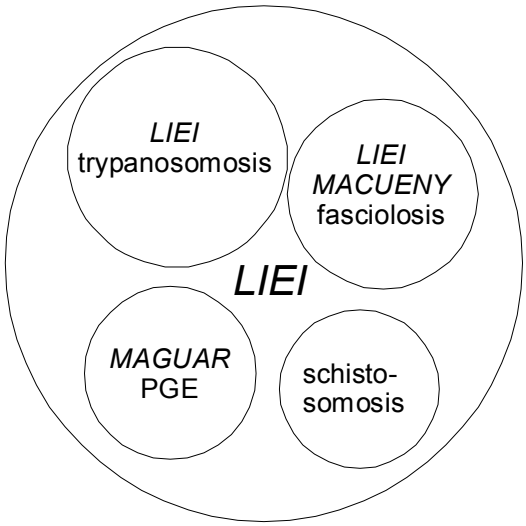
COMPARING LOCAL KNOWLEDGE AND MODERN VETERINARY KNOWLEDGE

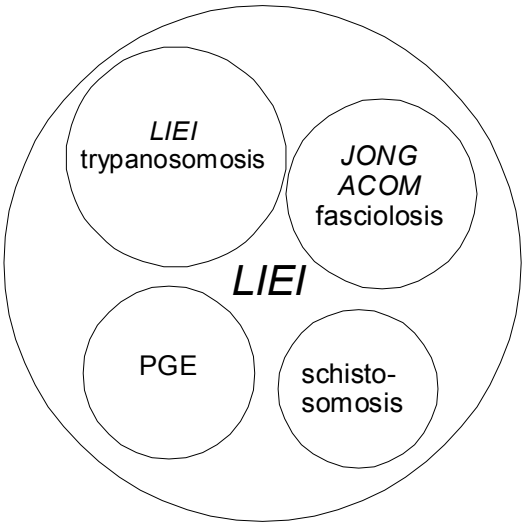
Livestock keepers in southern Sudan characterise chronic wasting disease in cattle using criteria that are very similar to those used by veterinarians. Although the signs of *liei* and *noi* were non-specific, herders used information on seasonal occurrence, exposure to disease vectors and post mortem findings in order to identify different causes of chronic wasting. Considering that cattle keepers could not be expected to recognise microscopic disease agents, the naming of chronic wasting diseases and associations between disease and visible factors were rational and very closely related to modern veterinary thinking.

The local disease names *liei* and *noi* encompass various diseases that are recognised by veterinarians. These 'western' diseases occur as single entities and as mixed infections involving up to four groups of parasites viz. trypanosomes, liver flukes, schistosomes and gastrointestinal nematodes. In cattle suffering from chronic wasting that were examined post mortem, 14/16 cases showed evidence of

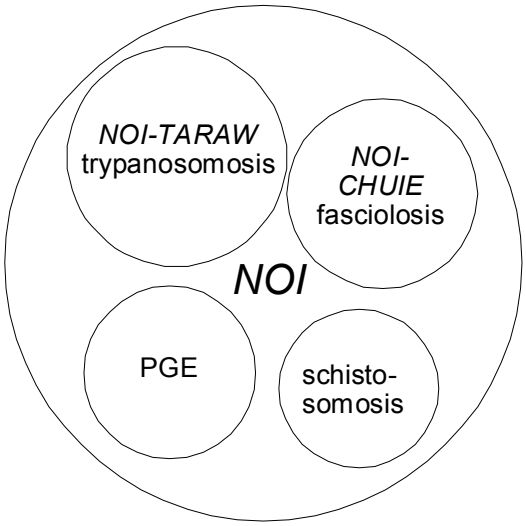
mixed infections involving 2, 3 or 4 different parasites. As a single infection, each of these parasites could cause gradual weight loss in cattle. There was little evidence to indicate that either livestock owners or veterinary workers could distinguish between different infections and combinations of infections on clinical grounds alone.

In Nyal (Nuer), two forms of *liei* were recognised. One form of *liei* was associated with Tabanids (*rom*) and other biting flies, flooding and oedematous, pale carcasses. The other form of *liei* was associated with snails (*chom*), flooding and diseased livers containing liver flukes (*daichom*). This second form of *liei* was also called *macueny,* a name that refered specifically to livers affected by fasciolosis-type lesions. As both snail and fly populations peaked during the wet season, indigenous confirmation of the two forms of *liei* was based on post mortem signs rather than clinical or epidemiological factors. In addition, the disease *maguar* was associated with gastrointestinal worms (causing parasitic gastroenteritis - PGE) and was thought to develop into *liei* if untreated.





In Thiet (Dinka), the diseases *liei* and *jong acom* ('disease of snails') were similar to the diseases *liei* and *macueny* in Nyal. Although loss of hair from the tail was often cited as a clinical sign that distinguished for *liei* from *jong achom*, this sign appeared relatively late in the course of the disease. Also, while *jong achom* was thought to cause abdominal discomfort and more diarrhoea than *liei*, these signs were inconsistent features of the disease. In common with *macueny* in Nyal, the name *jong acom* was used following the observation of livers affected by fasciolosis.



In Lankien (Nuer), there was agreement on the clinical signs of *noi* but varied opinions concerning the cause of the disease. Some people considered *noi* to arise as a result of any long-standing disease or problem such as poor grazing. Other people described two distinct forms of *noi* called *noi-chuie* and *noi-taraw*. These descriptions were virtually identical to the two forms of *liei* described in Nyal related to flukes/snails and biting flies respectively.

While the information above indicates much agreement between indigenous and modern knowledge, the research identified two aspects of the chronic wasting problem for which both local and professional opinions were mixed.

- The role of tsetse flies in the chronic wasting syndrome

The research showed that trypanosomosis is an important cause of chronic wasting in southern Sudanese cattle. Evidence of trypanosomosis was present in 11/16 (73%) of cattle examined post mortem and using diagnostic tests of low sensitivity, trypanosome prevalence in live cattle varied from 1.5% to 9.6% in study sites. *Trypanosoma congolense* was the predominant trypanosome species.

The transmission of trypanosomosis in Sudan is a subject of much debate among trypanosomosis and tsetse control professionals. On one side of the debate, it is argued that the maintenance of *T.congolense* in cattle populations requires tsetse flies. Other workers, including many with experience in southern Sudan, argue that as tsetse flies have not been identified in most areas where trypanosomosis is present, the disease is transmitted by other flies such as Tabanids and Stomoxys.

In terms of indigenous knowledge, the research demonstrated substantial agreement among livestock keepers regarding the identity and behaviour of Tabanids, Hippoboscids and Stomoxys, and the association between these flies and chronic wasting disease. In other words, indigenous knowledge tended to agree with the proponents of mechanical transmission of trypanosomosis. Only in Thiet was there evidence of specific indigenous knowledge about tsetse flies (called *mau*).

- The role of schistosomes in the chronic wasting syndrome

In none of the three study sites were schistosomes readily identified or named by livestock keepers. These parasites are relatively difficult to observe and this may explain the low association between schistosomes and chronic wasting disease. In cattle examined post mortem, macroscopic and microscopic injury due to schistosomes was evident in 14/16 cases.

LESSONS LEARNED ABOUT METHODS

The research demonstrated that standardised participatory methods were useful tools for encouraging the field-level analysis of indigenous animal health knowledge and comparing the opinions of informants within and between communities. Methods such as matrix scoring also provided a means to compare the views of mainly illiterate, but knowledgeable livestock keepers with the views of veterinarians. With this method, it was possible to compare diseases and indicators that were identified by livestock keepers themselves.

Any standardisation procedure runs the risk of reduced flexibility. However, the use of semi-structured interviews after the completion of the matrix scorings ensured that interesting topics could be followed-up. Nonparametric statistical tests were used to summarise data and provide measures of agreement between informants.

Repetition of some of the methods described in this report on a wider scale would enable the livestock programme to develop a more comprehensive understanding of the chronic wasting problem and identify location-specific variations in disease and parasite terminology. The methods require no special resources and can complement conventional research methods used by both social scientists and veterinarians. Furthermore, it should be possible to train community-based animal health workers (CAHWs), Animal Health Auxiliaries (AHAs) and Stockpersons to use the methods for more extensive investigations.

Regarding conventional veterinary investigation work, the vast majority of the samples used in the study were collected by CAHWs and AHAs.

IDEAS FOR FURTHER WORK

Testing different combinations of drugs for the treatment of *liei* and *noi*
A disease syndrome that incorporates both single and mixed parasite infections raises many technical questions concerning parasite interactions, relative importance of the difference parasites and appropriate control methods. In terms of prioritising further work within the existing veterinary programme in southern Sudan, the immediate need is probably to optimise the use of the veterinary medicines that the programme is already supplying. These medicines include homidium and ethidium for the treatment of trypanosomosis, and albendazole for the treatment of fasciolosis and PGE.

In the absence of a specific diagnosis (or diagnoses) in cases of chronic wasting, an animal health worker will probably use a 'best bet' treatment. But what should this best-bet treatment consist of? The options include:

1. ***Simultaneous, combined therapy with trypanocide and albendazole*** (at flukicidal doses) in order to eliminate trypanosomes, liver flukes and parasitic gastrointestinal nematodes. This option will remove 3/4 different parasites but is relatively expensive.

2. ***Sequential use of trypanocide and albendazole.*** This option uses either trypanocide or albendazole initially, followed by the other drug in the event of poor response to the first treatment. This option might be less expensive than option 1. in some cases but when two treatments are required, could be more expensive than option 1. because two visits from the CAHW are needed.

Despite operational difficulties in southern Sudan, it should be possible to conduct participatory assessments of these two treatment options. In short, cases of *liei* and *noi* could be assessed by livestock keepers and vets according to the severity of clinical signs before and after treatment. Results using option 1. would then be compared with results from option 2 in terms of differences in response to treatment, cost of treatment and ease of treatment.

When conducting this type of trial, it should be noted that drug resistance might be a factor in poor treatment response rates. In particular, treatment trials should be accompanied with studies on trypanocidal drug resistance.

Encouraging the wider use of basic veterinary investigation methods
The research highlighted the value of basic veterinary investigation methods such as post mortem examination. The extent to which this method is used in the field by vets is unknown, but there appears to be very few records of post mortem examinations in the OLS Livestock Programme. In view of this, opportunities for more systematic use and documentation of post mortems could be explored. For example, would it be feasible to implement surveys of cattle that are routinely slaughtered in villages? This might involve examination of cattle at selected sites where slaughter slabs were already established and where some kind of incentive for local veterinary workers involved in the survey is feasible. The survey should focus on readily-detected problems such as fasciolosis and schistosomosis, and could relate gross parasitological findings to age and body condition.

Training
Regarding information and training needs in the livestock programme, participatory research on the chronic wasting problem highlighted the limitations of training courses based on specific western diseases rather than the clinical syndromes that are observed in the field. This training approach might encourage CAHWs and AHAs to view *liei* and *noi* cases as either trypanosomosis or fasciolosis, rather than a combination of these or other infections. Although the concept of mixed infections is a challenging training topic, the livestock programme might consider if and how CAHW and AHA training courses could emphasise the importance of mixed infections and the therapeutic implications. At present the livestock programme provides no training in schistosomosis. It would be appropriate to include this disease in training sessions that describe *liei* and *noi* as disease families comprising single and mixed infections. Refresher training for veterinarians in schistosomosis might also be appropriate.

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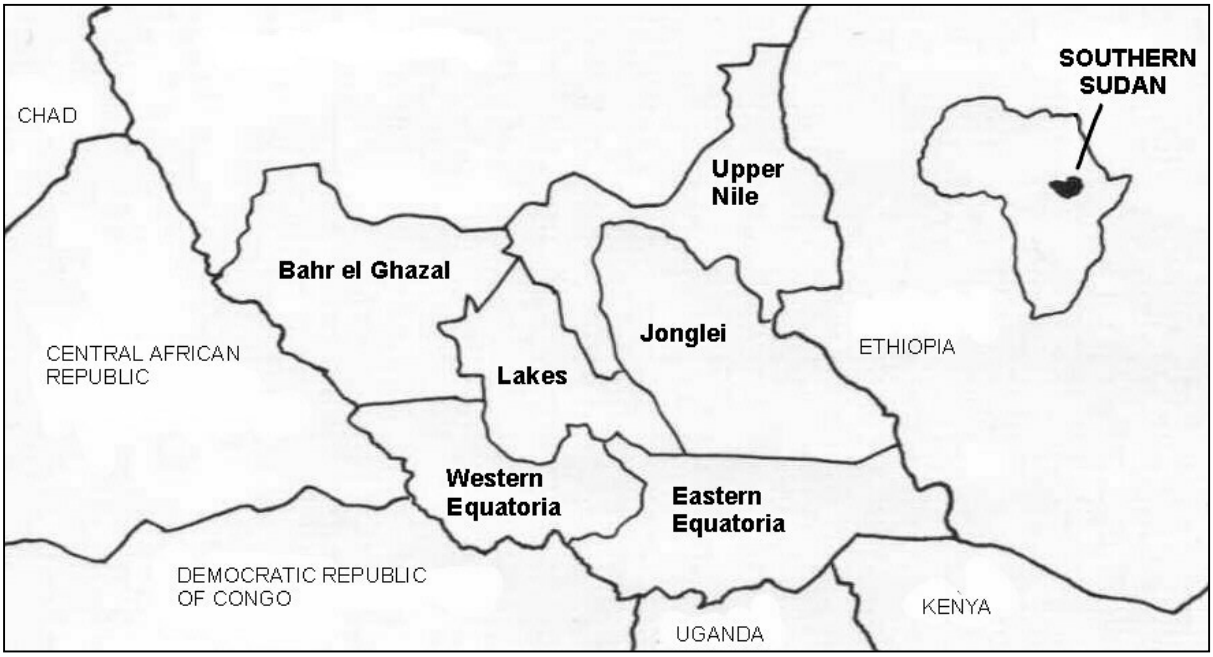
1.0 INTRODUCTION

1.1 Southern Sudan

Southern Sudan is an isolated and vast area covering approximately one third of Sudan and bordered by Chad, Central African Republic, Congo, Uganda, Kenya and Ethiopia. Much of southern Sudan's 800,000km^2 is low-lying, flat grassland and woodland transected by substantial river systems that feed into the White Nile. Seasonal flooding of rivers turns adjacent areas into large swamps that surround and isolate relatively small areas of 'highland'.

The two largest ethnic groups in southern Sudan are the Dinka[1] and Nuer. These people are mainly agropastoralists who rely heavily on cattle and other livestock for their social and economic well-being. They tend to follow seasonal movements between permanent settlements and dry season grazing areas in the flood plains known as the *toic*. The cattle population of southern Sudan is around 4 million animals.

In the jargon of aid agencies, southern Sudan is often described as a 'chronic, complex emergency situation'. The civil war in Sudan is the longest-running civil conflict in Africa, with only 11 years of fragile peace since independence in 1956. While the human population of southern Sudan is estimated at around 6.7 million people, it is also estimated that well over a million people have been killed and 2.5 million displaced due to conflict. At beginning of the new millenium, southern Sudan has virtually no modern infrastructure and its population continues to experience war resulting in needless loss of human life, large-scale displacement of people from their homeland and serious disruptions to rural trade and markets. In most areas, basic health, education and other services are provided by non governmental organisations (NGOs) that depend on the transport of supplies and personnel by air from northern Kenya. Most of these NGOs are coordinated under the UNICEF Operation Lifeline Sudan (Southern Sector) Programme (OLS), based in Lokichokio, northern Kenya.



Map 1. Southern Sudan

[1] Dinka call themselves Muonyjang.

1.2 The Operation Lifeline Sudan (Southern Sector) Livestock Programme

The Operation Lifeline Sudan (Southern Sector) Livestock Programme aims to improve the food security of people in southern Sudan by developing primary-level animal health and vaccination services. The basic justification for the programme arises from the importance of livestock as sources of food and their role in important social events in southern Sudan, including marriages and payment of fines; loans and gifts of cattle and milk form the basis of local social support mechanisms in Dinka and Nuer areas. Some of the functions of livestock and their relative importance in one Dinka area of southern Sudan are shown in Figure 1. According to Iles (1994), '*Cattle play an essential role in Dinka society, providing not only milk and dowry, but performing important social functions ..... a song bull, while not productive in the sense of providing milk and meat, is a source of great pride, prestige and possible influence. 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'* (Iles, 1994).

In 1993 the OLS Livestock Programme began to develop community-based animal health activities in which communities identified priority animal health problems and worked with programme staff to select people for training as community animal health workers (CAHWs). This approach aimed to increase the involvement of communities in the programme and make best use of indigenous animal health knowledge and skills. Although a key aspect of the programme was rinderpest vaccination using a new heat-stable vaccine delivered by CAHWs, the programme also provided a basic diagnostic, preventive and curative service for problems such as blackleg, haemorrhagic septicaemia, trypanosomosis, worms, liver flukes and various bacterial diseases. The initial success of the approach was demonstrated by rinderpest vaccination figures of 1.5 million cattle in 1994, an increase of 10.6 times relative to 1992 and before the onset of the CAHW system (Leyland, 1996).

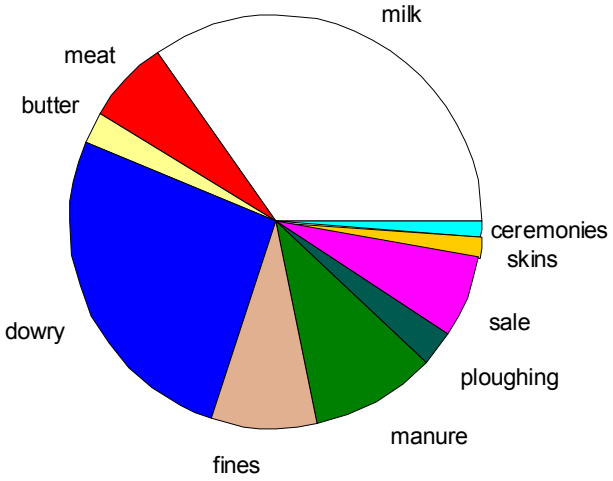


Figure 1. The ten main benefits of keeping livestock in Akop Payam, Tonj County (source: Catley, 1999)

'Everyone depends on milk like a drug. It makes people fat and healthy' (men, Toic Lou).

'Milk brings health and if healthy, one can marry' (women, Panhial).

Method: proportional piling with 5 groups of women and men.

By 1998 the OLS Livestock Programme had grown to a network of more than 700 CAHWs who were estimated to cover approximately 70% of southern Sudan (Jones et al., 1998). Common guidelines and practices had been formulated for partner NGOs and a cost recovery system for veterinary medicines and vaccines was in place.

1.3 The chronic wasting problem in cattle

As the OLS Livestock Programme began to impact on livestock diseases in southern Sudan, some diseases became less important and other diseases became 'new' priorities. This changing disease pattern was reflected in reports from field workers and participatory impact assessments. For example, an impact assessment in Ganyiel, Western Upper Nile in 1999 clearly showed how people recognised the reduced incidence of rinderpest (called *gieng*), and considered the disease called *liei* to have increased relative to other problems (Figure 2).

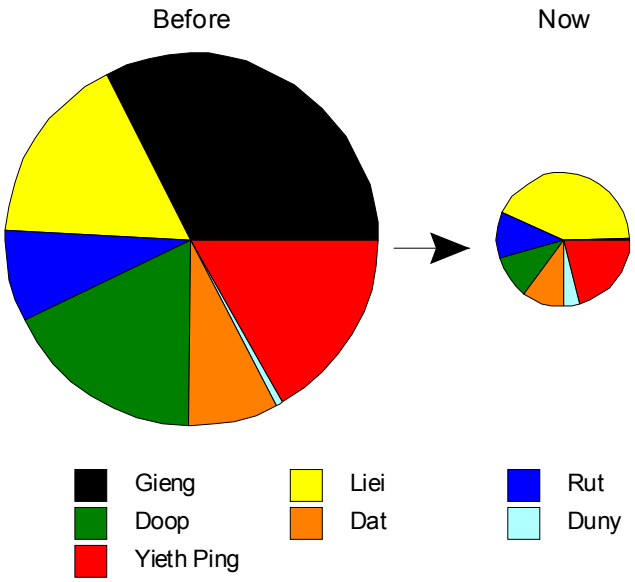


Figure 2. Local perceptions of changes in cattle diseases 'before' and 'after' the onset of the community-based animal health system in Ganyiel, Western Upper Nile (source: Catley, 1999).

Method: 'Before' and 'after' proportional piling with 6 informant groups. The areas of the two pie charts are proportional according to the numbers of seeds used.

The disease name *liei* means *'to steal slowly'*. It refers to a chronic disease of adult cattle that causes gradual loss of weight and body condition until eventually, the animal is emaciated and non-productive. Although the disease has been known in southern Sudan for many years, there were mixed views regarding the 'western' or modern diagnosis of the disease. While many veterinarians tended to use *liei* as a synonym for trypanosomosis, the clinical signs of the disease were non-specific and could be evident in other diseases such as fasciolosis, parasitic gastroenteritis (PGE), chronic malnutrition or a combination of these problems. In some Nuer areas of southern Sudan, the disease name *noi* was used instead of *liei*.

Table 1 overleaf lists clinical signs and post mortem signs for four diseases of adult cattle in their chronic forms. All these four diseases are known to occur in southern Sudan and the clinical descriptions indicate that diagnosis on clinical grounds alone is unreliable. However, for fasciolosis, PGE and schistosomosis, diagnosis is reasonably straightforward at post mortem examination.

In terms of confirming a diagnosis in cases of *liei* in the live animal, laboratory tests are required to confirm diagnoses of trypanosomosis, fasciolosis, PGE and schistosomosis. However, in most locations in southern Sudan basic laboratory facilities are absent and although UNICEF and Save the Children (UK) support a veterinary laboratory in Lokichokio, the number of samples submitted to this laboratory up to the end of 1999 was low. Even when samples were submitted, the poor sensitivity of standard diagnostic tests probably meant that many cases of trypanosomosis or fasciolosis were overlooked.

In addition to the problem of diagnosing *liei* and *noi*, the treatment of diseases such as trypanosomosis and PGE can be compromised by the development of drug resistance. Therefore, it was important for the UNICEF-OLS programme to demonstrate that as far as possible, disease control

strategies delivered via CAHWs were based on good information and monitoring. Operational conditions and resource constraints in southern Sudan tend to hinder the use of conventional epidemiological methods and for many animal health problems there was a lack of technical data

Despite these problems, it was evident that Dinka and Nuer livestock keepers knew a great deal about their animals. The high levels of indigenous livestock knowledge in southern Sudan are discussed in published literature (e.g. Schwabe and Kuojok, 1981) and UNICEF's own ethnoveterinary surveys in Dinka and Nuer areas (Blakeway et al., 1996; Lindquist et al., 1996). Considering the community-based philosophy behind the OLS Livestock Programme and the presence of a CAHW network at field-level, there were opportunities to conduct participatory studies on *liei* and *noi*, and build on previous experiences.

Table 1. Textbook descriptions of some chronic forms of diseases affecting adult cattle

Trypanosomosis	Fasciolosis	Parasitic gastroenteritis	Schistosomosis
Clinical signs: ▪ intermittent fever ▪ dullness ▪ poor appetite ▪ eye discharge ▪ loss of body condition ▪ emaciation/wasting ▪ enlarged lymph nodes ▪ pale mucus membranes ▪ some diarrhoea ▪ lacklustre coat	*Clinical signs:* ▪ weight loss ▪ reduced milk yield ▪ pale mucus membranes ▪ chronic diarrhoea ▪ wasting	*Clinical signs:* ▪ intermittent diarrhoea ▪ wasting ▪ pale mucus membranes	*Clinical signs:* ▪ most infections are asymptomatic ▪ poor growth or weight loss
Post mortem signs: ▪ non-specific ▪ pale carcase ▪ emaciation ▪ serous atrophy of fat ▪ enlarged lymph nodes ▪ enlarged liver ▪ enlarged spleen ▪ corneal opacity	*Post mortem signs:* ▪ flukes in liver ▪ bile duct thickening ▪ hepatic fibrosis ▪ hepatic calcification ▪ pale carcase ▪ oedematous carcase ▪ emaciation	*Post mortem signs:* ▪ worms in gastrointestinal tract ▪ pale carcase ▪ oedematous carcase ▪ gelatinous fat	*Post mortem signs:* ▪ worms in mesenteric blood vessels ▪ thickening/fibrosis of mesenteric blood vessels

(source: Radostits et al., 1994; Sewell and Brocklesby, 1990)

1.4 The PAVE Project

The Participatory Approaches to Veterinary Epidemiology (PAVE) project aims to investigate uses of participatory appraisal[2] (PA) in epidemiology and in particular, looks at issues of reliability and validity of PA methods. The project works with local partners and conducts field research according to local demand. The research methodology involves the use of both participatory and conventional forms of veterinary investigation, and a comparison of information arising from these two approaches.

[2] In this report, the term 'participatory appraisal' is used to encompass approaches and methods drawn from Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA).

Following discussions with UNICEF-OLS, a study was designed to investigate the problems of *liei* and *noi* in southern Sudan. The aims of the study were as follows:

- To characterise local perceptions of chronic wasting in cattle in southern Sudan and confirm the diagnosis of the disease from a western, 'scientific' viewpoint.
- To assess the value of PA in veterinary investigation in southern Sudan.
- To identify options for further action that was required to develop better control strategies for *liei* and *noi* within the existing community-based animal health programme.

Regarding the third aim, the provision of veterinary medicines via CAHWs in the UNICEF-OLS(SS) programme was designed on a cost-recovery basis. This meant that solutions to animal health problems had to be affordable to livestock owners and deliverable through the community-based system. Therefore, an important aspect of the study was to use a disease investigation approach which enabled livestock keepers to analyse the chronic wasting problem in partnership with technical staff.

2.0 METHODS

2.1 Study locations

The study was conducted in three locations in southern Sudan called Nyal, Lankien and Thiet (Table 2 and Map 2). When selecting these sites, the following factors were considered:

- Evidence that livestock keepers perceived chronic wasting to be an important health problem in cattle.
- The presence of a well-established animal health project where field-level partners had developed good relationships with communities and local administrations.
- Willingness and capacity of partner agencies to allocate resources and time to the research.
- The research sites should be representative of typical livestock husbandry and environment, and be located in the main cattle-rearing areas.

Table 2. Study locations and timing of fieldwork

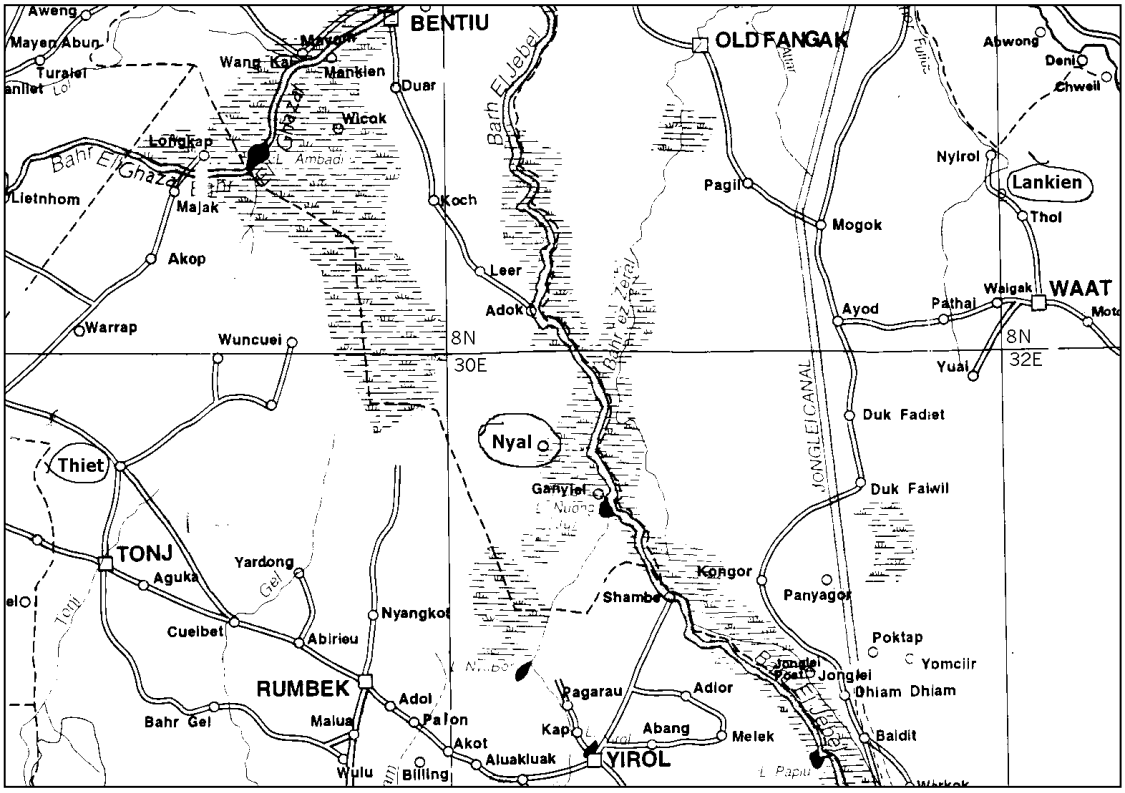
Study location	Ethnic group	Research partner	Timing of fieldwork
Nyal (Western Upper Nile)	Nuer	VSF Switzerland	29th May-28th June 1999 (early wet season)
Lankien (Central Upper Nile)	Nuer	SCF-UK	14th-20th September 1999 (late wet season)
Thiet (Bahr el Ghazal)	Dinka Rek	UNICEF-OLS(SS)	21st January to 11th February 2000 (dry season)

2.2 Literature search

In participatory inquiry, secondary data is used to help the research team develop checklists for use with participatory tools, inform interviews conducted after the completion of diagrams, and to triangulate information. The review of secondary data focussed on livestock diseases that were selected by the veterinarian conducting the review and a judgement was made concerning those diseases which were most likely to be associated with chronic wasting in cattle in the southern Sudan. Therefore, literature searches were based on references concerning trypanosomosis, fasciolosis, parasitic gastroenteritis and schistosomosis[3].

[3] It could be argued that other diseases might also cause gradual weight loss in adult cattle e.g. CBPP. However, this and other diseases were already well-characterised and were considered to present a distinctive clinical appearance relative to 'chronic wasting'.

Map 2. Study locations



2.3 Interviews

Informal semi-structured interviews were used throughout the investigation. Specifically, these interviews were used to collect general background information on local perceptions of the most important diseases, including those causing weight loss in cattle, and parasites and disease vectors. Commonly, proportional piling was used during interviews in order to apply scores to items under discussion. Interviews were also used extensively in connection with other participatory methods, particularly seasonal calendars, matrix scoring and during post mortem examinations. These interviews were based on probing, open questions designed to cross-check information presented in a seasonal calendar or matrix, or open up discussion on lesions or parasites observed in carcasses.

2.4 Participatory mapping

Participatory mapping was used to describe seasonal movements of cattle and relate cattle movements to areas harbouring disease vectors such as snails and biting flies. Maps were usually constructed on the ground and often followed interviews related to matrix scoring of disease 'causes' (see below). For example, if a discussion developed about snails as a cause of disease, informants might be requested to construct a map showing snail-infested areas. This map would then be expanded to include other disease vectors and seasonal movements of livestock.

2.5 Matrix scoring

Matrix scoring was used to understand local perceptions of the main clinical signs of chronic wasting diseases and the causes or other factors associated with these diseases. The development of the matrix scoring method involved two main stages:

- identification of diseases and indicators to be scored;

- development of the matrix and scoring procedure.

Identification of diseases and indicators

In participatory ranking and scoring methods, indicators are factors which informants use to describe or distinguish between different items or issues. When investigating livestock diseases, indicators can include clinical signs, disease vectors, seasonal occurrence of disease or post mortem findings. In order to identify local indicators of chronic wasting in cattle, two methods were used viz. pair-wise comparison of diseases and semi-structured interviews conducted during post mortem examination of cattle.

The pair-wise comparison of diseases was based on the method described by Catley and Mohammed (1996). In summary, this method uses a short list of livestock diseases which are then compared in pairs in order to produce the indicators. For example, according to the secondary literature and interviews conducted in Nyal, three diseases called *liei*[4]*, maguar* and *maceuny* were selected due to their apparent association with weight loss in cattle and infection with parasites. As these three diseases were likely to produce similar indicators, two more diseases were added to the list. These diseases had already been characterised by OLS and were foot and mouth disease (FMD, *dat*) and contagious bovine pleuropneumonia (CBPP, *doop*). The inclusion of these two diseases was also intended to prevent informants exaggerating their responses to *liei, maguar* and *maceuny*, and informants were not told that the researchers were particularly interested in these three diseases alone. Therefore, the five diseases in the list were *liei, maguar, macueny, doop* and *dat.*

The pair-wise comparison of the five diseases was conducted with a group of 12 chiefs and cattle camp leaders in Nyal village. Common, everyday objects were used to represent each of the five diseases and the method produced 20 indicators that were grouped into 11 disease-signs and 9 disease-cause/sources. Therefore, two matrices were used - one showing disease signs and the other showing causes or sources of disease.

In addition to adding *dat* and *doop* to the matrix as controls, another type of control was used by adding a potentially irrelevant indicator to the causes or sources of disease. This control indicator was 'disease caused or transmitted by ticks' as this indicator was not mentioned during interviews or pair-wise comparisons, and from a technical viewpoint, was not associated with any of the five diseases in the matrix.

Some of the disease-causes/signs produced by the pair-wise comparison included descriptions of parasites. In order to relate local descriptions and names to western scientific names, information was cross-checked during post mortem examination of cattle suffering from chronic wasting (see below). Informants were asked to name specific parasites during the post mortem and the researchers were able relate local names to actual specimens. Preserved specimens of flies were also on hand to show to informants.

Development of the matrix scoring

A standardised matrix scoring method was developed in the field in order to understand local perceptions of associations between wasting-type diseases of cattle, signs of disease and causes or sources of disease. The matrix scoring method was based on the methodology for a livestock disease scoring method described by Catley and Mohammed (1996).

In order to form the disease-signs matrix, the researchers referred to a traditional Nuer game called *yied*. This game used two parallel rows of shallow holes in ground and involved the movement of seeds or stones between holes by the players. Local familiarity with this arrangement was adapted to form the disease-signs matrix by making 5 columns and 11 rows of shallow holes in the earth. The 5 columns were labeled using common objects to represent the 5 diseases *liei, dat, maguar, doop* and *maceuny*, and the 11 rows were labeled using simple illustrations drawn on to pieces of card to

[4] The disease name *liei* was used in preference to *noi* in Nyal District.

represent the disease-signs. For example, a diagram of a thin cow was used to represent the indicator 'chronic weight loss'. Each illustration was explained to the informants.

For each disease-sign, informants were asked to score each disease by dividing piles of 20 seeds against the 5 diseases. The more important a particular disease-sign, the greater the pile of seeds assigned to it. After the scoring of each disease-sign, the researchers prompted the informants to check their scoring and confirm that as a group, they agreed that the scores were correct. When all the disease-signs had been scored, the results were recorded and the researchers asked additional questions to cross-check and probe the responses. The questions asked were open questions designed to elicit additional information and follow-up interesting scores. For example, if the disease *liei* was scored with 20 seeds for the disease-sign 'loss of tail hair' and the other diseases were scored 0, the informants were asked 'So you've given *liei* all 20 seeds, so why is it only when the animal has *liei* that you see this sign?' The physical presence of the matrix and piles of seeds on the ground facilitated this type of questioning because the researchers could actively point to the piles of seeds, and usually the informants would do likewise when responding.

When the additional questioning about disease-signs was completed, the card illustrations of disease-signs were removed and replaced by illustrations of disease-causes/sources. These illustrations were supported by samples of parasites that had been collected during post mortem examinations of typical cases of *liei* and *maguar*. The parasites were passed around the informants to check the identity and local name of the parasite. A similar scoring and questioning procedure was used as for the disease-signs matrix. A completed matrix is shown in Figure 3.

Figure 3. Example of a completed scoring matrix for causes or sources of disease in Nyal

The five cattle diseases being scored are represented by the five objects at the bottom of the photograph. At right angles to these objects is a row of diagrams representing different causes or sources of disease. Shallow holes in the ground have been used to form the matrix and provide a place for the placing of seeds during the scoring.

The use of controls in the matrix assumed that for the diseases *doop* and *dat*, informants would apportion high numbers of seeds to the indicator 'coughing' for *doop* and 'salivation' for *dat*. Also, it was expected that the indicator 'caused/transmitted by ticks' would be allocated a score of 0 for all five diseases. If this type of scoring of control diseases and indicator appeared in the matrix, it was a good indication that the informants understood the methodology and scoring procedure.

In Thiet, a very similar matrix scoring method was used. However, herders in Thiet identified and provided indicators for the diseases *liei*, *dop*, *jul*, *jong acom* and *cual*. Of these diseases, *liei, jul* and *jong acom* were associated with thin cattle whereas *abuot pou* (CBPP) and *cual* (brucellosis/ hygromas) had already been characterised by the OLS Livestock Programme (Blakeway et al., 1996; Lindquist et al., 1996) and so were used as control diseases in the matrices.

The scoring matrices were used with 12 informant groups in Nyal and 7 informant groups in Thiet, as detailed in Table 3. Group sizes ranged from 3 to 11 individuals. Informants were selected in two main ways. Some informants were contacted in Nyal and Thiet by field partners and requested to visit the agency's compound to discuss livestock problems. Other informants were present in cattle camps and were contacted by walking around the cattle camps and simply asking people if they had time to sit and discuss livestock problems.

Table 3 Location and number of informant groups completing the matrix scoring in Nyal and Thiet

Location of informant group	Number of informant groups
Nyal	
Nyal village	3
Kan Gat's cattle camp	1
Lwali cattle camp	1
Garang fishing camp	1
Geaf tach	2
Nyamet cattle camp	3
Pasil cattle camps	1
total	12
Thiet	
Cuie-cek cattle camp	3
Diang cattle camp	2
Madhol cattle camp	2
total	7

Assessing levels of agreement between informants groups

One reason for attempting to standardise the matrix scoring method was to assess whether different groups of people had similar views on the signs and causes of chronic wasting in cattle. In order to assess the level of agreement between informant groups, Kendall's Coefficient of Concordance (W) was used. Calculations were performed manually using the formula provided by Seigel and Castellan (1994) and results were cross-checked using the statistical software package SPSS Version 9.0. Confidence interval software (Gardner *et al.*, 1992) was used to calculate 95% confidence limits.

2.6 Seasonal calendars

Seasonal calendars were used to describe the seasonal incidence of the diseases used in the matrix scoring, and seasonal populations of ticks, biting flies and snails. Rainfall was also depicted. The methodology for constructing the seasonal calendars was similar to the matrix scoring. Local names for seasons were used and each season was represented using an object placed along the top x-axis of the diagram. Diagrams depicting diseases and parasites, and specimens of parasites, flies and ticks were placed along the y-axis of the diagram. This type of seasonal calendar was used with 10 groups of informants in Thiet. Levels of agreement were assessed using Kendall's Coefficient of Concordance (W) (SPSS version 9.0) and 95% confidence intervals were calculated using Confidence Interval Analysis software (Gardner et al., 1992).

2.7 Participatory pathology

Cases of chronic wasting in adult cattle were selected for post mortem examination. The selection of cases was based on the opinion of the researchers and their assessment of the case history provided by the cattle owner, the name given to the disease by the cattle owner and a clinical examination of the animal. Animals were often rejected for post mortem examination because the history or clinical appearance was judged by the researchers not to be typical of chronic wasting[5]. During the post mortem examination, the cattle owner was usually present and other livestock herders were assisting with handling the carcass (and distributing the meat). This situation provided an opportunity to ask

[5] Rejection of cases occurred most frequently in Nyal. This was probably because the study in Nyal took place at the end of the dry season/beginning of the wet season and people were relatively keen to sell cattle in order to buy food.

questions about post mortem lesions, parasites observed in carcasses and associations between these findings and disease names.

A total of 16 cattle were examined. Of these, 10 cases were from Nyal, 3 cases were from Thiet and 3 cases were from Lankien. Tissue samples were preserved in 10% buffered formol saline and parasites were preserved in 70% alcohol. Fresh faeces was collected and placed in cold storage, and duplicate samples were fixed in 10% formalin. Blood samples were collected for parasitological and serological diagnosis of trypanosomosis. Blood smears and lymph node smears were prepared, air-dried and stained with Geimsa.

2.8 Survey to estimate prevalence of parasites

Sampling

Blood and faeces samples were collected from cattle in order to estimate the prevalence of trypanosomosis, fasciolosis and gastrointestinal nematodes. In all three locations a convenience sampling method was used. Information on herd locations and sample sizes is provided in Table 4.

Table 4 Numbers and locations of cattle sampled for estimates of parasitic infections

Location	Number of herds sampled	Mean sample size	Range	Total number cattle sampled
Nyal				
Nyal village	9	14.7	6-45	132
Kan Gat's cattle camp	3	14.0	12-18	42
Lwali cattle camp	6	21.7	9-37	130
Pasil cattle camp	4	51.8	39-66	207
total	22	23.2	6-66	511
Thiet				
Cuie-cek cattle camp	26	4.27	1-10	111
Diang cattle camp	31	4.84	2-16	150
Madhol cattle camp	20	8.70	2-28	174
Maker cattle camp	33	6.0	1-16	198
total	110	5.75	1-28	633
Lankien total	30	7.0	1-28	210
Totals for all 3 locations	162	8.4	1-66	1354

During discussions with local veterinary personnel, herds and cattle camps were identified that were accessible and representative of typical management practices in the areas concerned. Selection of cattle camps was also influenced by the need to sample animals during a 2 to 3 hour period between daybreak and the release of cattle for grazing. A number of logistical constraints also affected the sampling method, as exemplified by the situation in Nyal.

In Nyal, sampling was influenced by the lack of data on the human and cattle population and distribution in the district, the need to travel to all locations on foot and the difficulty of staying overnight in locations outside of Nyal village. Access to cattle camps in Nyal District was hindered by the absence of roads and no vehicular transport, the need to remain in regular radio contact with base camp for security reasons and the rapid relocation of the cattle camps by herders in order to avoid the attention of soldiers[6]. Consequently, having made arrangements to visit a particular cattle camp it was possible that the cattle camp would move rapidly and unexpectedly. The research team

[6] Cattle owners sometimes avoided locations where soldiers were present because the soldiers might demand milk or other food.

traveled on foot and all supplies, equipment and samples were carried by the team assisted by porters. A further constraint to sampling was that cattle owners kept their animals tethered until around 9-10am and then released the animals for grazing. Therefore, cattle could only be sampled between sunrise and 9-10am. Further considerations included a need to collect samples rapidly before the onset of the rains and worsening of conditions for travelling on foot as the rains began.

The cattle selected for sampling in Nyal comprised two main groups according to their location. Cattle in luaks[7] were located in or near to Nyal village, and the cattle camps[8] were all within 4 hours walk of Nyal village. A total of 511 cattle were sampled and based on field experience and rinderpest vaccination activities, VSF-CH estimated the cattle population of Nyal District to be approximately 40,000 animals.

In Lankien the research team also travelled on foot. In this location, the main sampling constraint was lack of time (6 days) and so herds within easy reach of Lankien village were sampled. Sampling was planned so that herds on all sides of Lankien and within approximately 40 minutes walk of the village were sampled. A total of 210 cattle were sampled in Lankien. In Thiet, access to cattle camps was relatively straightforward as dry season movements towards the *toic* were in progress near to Thiet and these cattle camps were easily accessible by vehicle. A total of 633 cattle were sampled in cattle camps south of Thiet.

In each cattle camp, the sampling team moved from one herd to the next in order to sample all herds in the cattle camp. Occasionally, livestock owners were absent and the people left responsible for the cattle were unwilling to allow the animals to be sampled. For other herds, livestock keepers were present but did not wish their animals to be sampled. Individual cattle were identified for sampling based on discussion with livestock keepers. In each herd, adult cattle were sampled that included animals that were considered by the livestock keeper to be healthy and sick. The age, sex and health status of the animal was recorded for each case.

Blood samples

All blood samples were collected by teams of animal health auxiliaries and CAHWs, under the supervision of a vet. Samples were collected from the jugular vein into plain vacutainers. Immediately following sample collection, thin smears were prepared and air-dried, and heparinised capillary tubes were filled. These samples were handled as follows:

- The microhaematocrit centrifugation technique (MHCT) was used to diagnose trypanosomosis in Lankien and Thiet. In Lankien, a portable, battery-operated microhaematocrit centrifuge with size 17 microlitre capillary tubes was used, whereas in Thiet, a standard microhaematocrit centrifuge was used with size 80 microlitre capillary tubes. As the sensitivity of the MHCT is partly dependent on blood volume, the Lankien method was considered to be approximately 4 times less sensitive than the Thiet method. Dark field microscopy was used to examine wet buffy coats in both locations.

- Thin smears were labelled and stored for transport to Lokichokio. In Lokichokio and Nairobi, the smears were fixed in methanol, stained with Giemsa and examined.

- Vacutainers were left to stand and serum was harvested and frozen. Trypanosome antibody and *Schistosoma bovis* circulating anodic antigen were detected by enzyme-linked immunosorbent assay (ELISA) at KETRI and the University of Leiden respectively.

[7] Luaks are large, circular buildings that are used to house cattle at night and are usually located in permanent settlements. Fires are lit inside the luak to keep flies away from the cattle.
[8] Cattle camps are dry season congregations of cattle comprising a few hundred to several thousand animals. The cattle camps have a well-organised structure and leadership.

Faeces samples

All blood samples were collected by teams of animal health auxiliaries and CAHWs. Fresh faeces was collected into polythene bags, labelled and placed in cold storage. Samples were transported to Lokichokio where the following tests were performed:

- Gastrointestinal nematode eggs were detected using a standard salt flotation technique and McMaster counting chamber.
- Fluke eggs were detected using a standard sedimentation technique.

Figure 4
Sampling cattle in Diang cattle camp, near Thiet.

3.0 RESULTS

3.1 Literature search

The literature search revealed papers published in scientific journals, project reports and other grey literature that was categorised as follows:

- Disease-specific scientific papers on trypanosomosis and tsetse flies, fasciolosis, schistosomosis and parasitic gastroenteritis (PGE). Most of these papers described cross-sectional surveys.
- Project reports and grey literature from southern Sudan, including the Jonglei Canal study, ethnoveterinary surveys and two accounts of causes of debilitated or thin cattle.

3.1.1 Trypanosomosis

Early reports of bovine trypanosomosis in southern Sudan include cases in 87 cattle moved from Upper Nile to Khartoum in 1904 (Karib, 1961). In the following years there were diagnoses in all types of livestock *'south and east of Khartoum'*. For example, there were reports of trypanosomosis in cattle in Yei (Balfour, 1913), the Koalib Hills of the Nuba Mountains (Archibald, 1927) and in 1943, Malakal (Karib, 1961). In 1946, a major epidemic of trypanosomosis in Upper Nile due to *T.congolense* was associated with heavy flooding and caused the death of 50% of Shilluk cattle. This epidemic prompted a mass treatment campaign and similar campaigns were a common activity of the Sudan veterinary services during the colonial period and later (Karib, 1961).

The distribution of tsetse flies in southern Sudan approximates to the area of ironstone hills stretching from a point 10 latitude on the western border to a point 34 longitude on the southern border, as

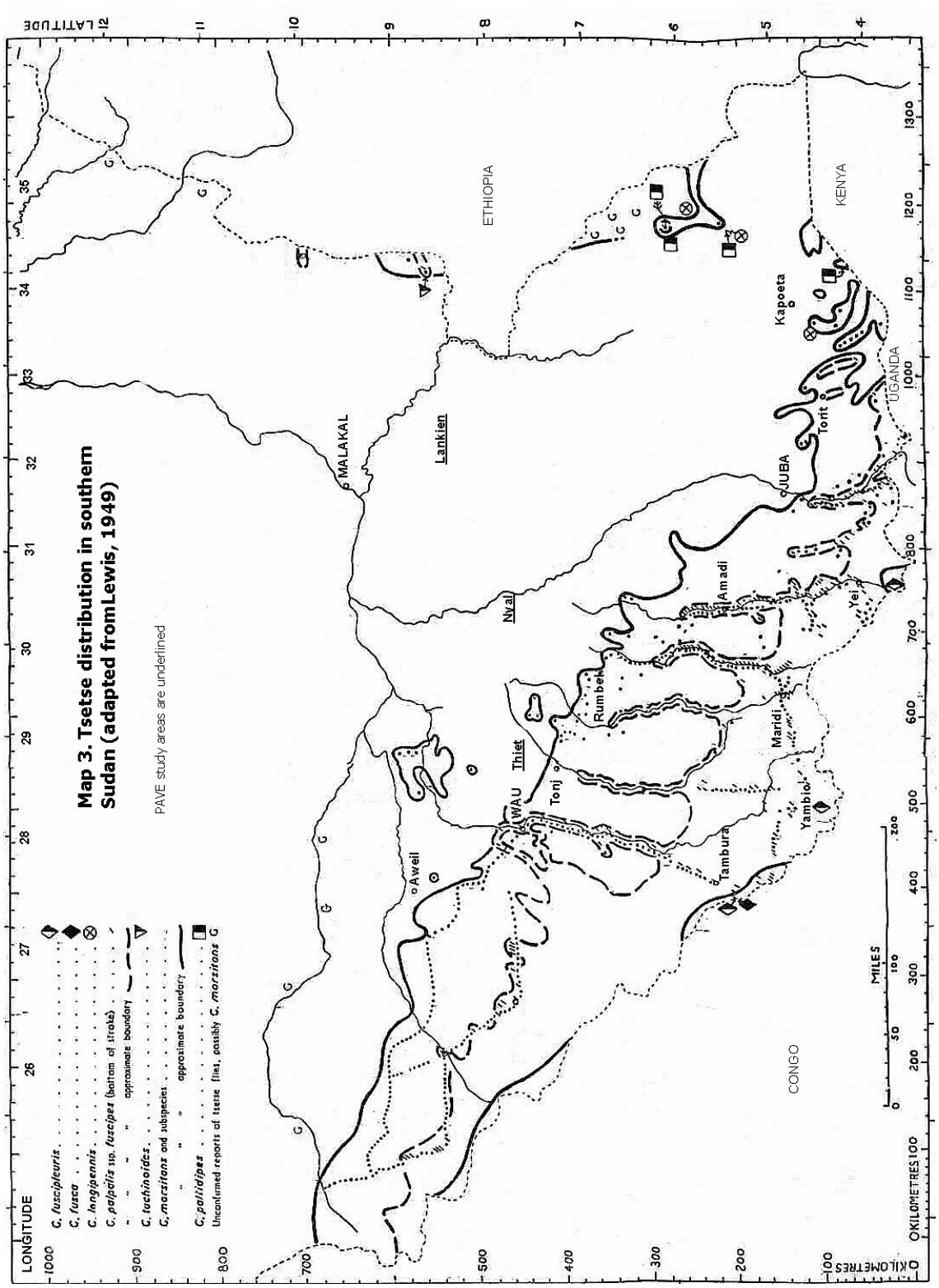
shown in Map 3[9]. These hills rise to an altitude of 500-800m and form a shallow horseshoe around the southern edge of the low-lying grass plains and swamps that are home to Dinka and Nuer cattle-keeping communities. According to Lewis (1949), *'The annual reports of the Sudan Veterinary Service contain numerous references to bovine trypanosomiasis, particularly that due to* Trypanosoma congolense*. The Dinka name for it, jong alel, means the sickness of the ironstone country and implies that these swamp-dwellers believe it to originate in the tsetse country south of them'*. Lewis' account also cites reports from travellers in the mid-1800s who described how the presence of tsetse flies in some areas was the main determinant of farming and animal husbandry systems. Seasonal movements of livestock were also described along the border of the tsetse belt, with herders to the north moving nearer to tsetse areas during the dry season. Similarly, people residing in the tsetse areas would sometimes move away when fly populations increased. The name *mau* was reported in the literature as a local name for the tsetse fly as early as 1869.

The two main tsetse species in southern Sudan responsible for bovine trypanosomosis are *Glossina morsitans* and *G.fuscipes*. For example, these flies were detected in high numbers around Yei in 1961 and associated with disease in cattle (Abdel Razig and Yagi, 1972). However, many reports note and discuss the presence of serious disease in cattle due to *T.congolense* in areas far north of the officially-recognised tsetse belt. For example in Sudan, *T.congolense* was diagnosed in cattle in Gedaref (latitude 14) and Abe 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 trypanosomosis prevalence of up to 8.6% (Rahman et al., 1991a) whereas fly surveys detected large Tabanid populations, but no tsetse[10] (Rahman et al., 1991b).

More recently, bovine trypanosomosis was reported in the Jonglei Canal area (Mefit-Babtie, 1983). 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, Phou State, Central Upper Nile, Western Upper Nile, Bor County, Akobo and northern Bahr el Ghazal.

[9] Although other tsetse distribution maps have been produced for Sudan (e.g. Abdel Razig and Yagi, 1973), they are very similar to this early map produced by Lewis.

[10] Tsetse flies (*Glossina* species) are biting flies that transmit trypanosomosis. Trypanosome species such as *Trypanosoma vivax* and *T.congolense* undergo a stage of development within tsetse flies, and therefore this kind of transmission is called 'cyclical transmission'. The distribution of cyclically-transmitted (also called 'tsetse-transmitted') trypanosmosis in Africa is determined by the distribution of tsetse flies, sometimes called the 'tsetse belt'. However, trypanosomosis can also be transmitted 'mechanically' by biting flies. This mode of transmission involves the simple transfer of trypanosomes between animals, without the trypanosomes developing within the flies. Biting flies such as Tabanids ('horse flies') are often implicated in the mechanical transmission of trypanosomosis both inside and outside the tsetse belt. Whereas it is known that *T.vivax* can be transmitted mechanically by Tabanids, this type of transmission has not been proven for *T.congolense*. Herein lies the reason for prolonged debate among scientists about the transmission of bovine trypanosomosis in southern Sudan, because *T.congolense* is the most prevalent trypanosome species in cattle in areas up to 400km north of the tsetse belt. In short, some workers argue that in the absence of tsetse flies *T.congolense* is transmitted mechanically by Tabanids and other biting flies. Other workers argue that *T.congolense* cannot be maintained in cattle populations in the absence of tsetse, and that tsetse flies must be present in so-called 'non-tsetse areas'.


Map 3. Tsetse distribution in southern Sudan (adapted fromLewis, 1949)
PAVE study areas are underlined
LONGITUDE
LATITUDE
G. fusciplevris
G. fusca
G. longipennis
G. palpalis ssp. fuscipes (bottom of strata)
" " " approximate boundary
G. tachinoides
G. morsitans and subspecies
" " " approximate boundary
G. pallidipes
Unconfirmed reports of tsetse flies, possibly G. morsitans
ETHIOPIA
KENYA
UGANDA
CONGO
MALAKAL
Lankien
Nyal
Thiet
WAU
Tonj
Rumbek
Aweil
Tambura
Yambio
Maridi
Amadi
Yei
JUBA
Tonit
Kapoeta
MILES
KILOMETRES

Regarding the use of trypanocidal drugs in Sudan, ethidium bromide seems to have been one of the most commonly used drugs since it was introduced in 1953. Cattle owners reported relapses after single treatment with ethidium bromide in 1968 and using strains of *T.congolense* from Malakal in the treatment and relapse method, Abdel Razig et al. (1968) induced resistance to ethidium bromide at dose rates of up to 4 mg/kg[11]. During a mass treatment campaign in southern Darfur in 1971, Abdel Gadir et al. (1972) isolated a strain of *T.congolense* that was resistant to ethidium bromide. This strain proved to be fully susceptible to isometidium chloride and diminazene (Berenil) at normal dose rates. Also from southern Darfur, Abdel Gadir et al. (1981) used seven strains of *T.congolense*, three strains of *T.brucei* and two strains of *T.vivax* in studies on ethidium bromide resistance and detected resistance to normal dose rates in five, two and one strain respectively. All cases responded to ethidium bromide at the higher dose of 3.5 mg/kg. Since the early 1990s, the OLS Livestock Programme has distributed large quantities of homidium (Novidium) in southern Sudan. To date, there have been no studies on resistance to homidium in the programme area.

3.1.2 Fasciolosis

Humid, warm and wet conditions in the main cattle-rearing areas of southern Sudan are well-suited for the survival of the aquatic snails that act as the intermediate hosts[12] for Fasciola species (liver flukes), schistosomes and paramphistomes. The presence of permanent, extensive swamps in some areas and seasonal flooding of grazing land adjacent to swamps and rivers provides ample habitat for the snails. Relative to the literature on trypanosomosis, reports of fasciolosis in southern Sudanese cattle are few. However, the available literature does report a high prevalence of infection, particularly in cattle occupying the wetter, more swampy areas around the Nile and its tributaries.

A review conducted by Karib (1962) examined records from provincial abattoirs in Sudan for the year 1961 and noted the highest prevalence of bovine fasciolosis in Blue Nile (7.7%, n=38,514), Upper Nile (26.1%, n=7,258), Equatoria (9.8%, n= 12,586) and Bahr el Ghazal (13.7%, n=18,646) provinces. The high prevalence of disease in these areas was attributed to the extensive river systems and flood plains: *'During flood time very large areas on both sides* (of the rivers) *are flooded and when the river recedes to its natural course, numerous pools are left which harbour the snails of several genera, including* Limnaea, Bulinus *etc. Usually, good grazing grasses grow in and around these pools which are enriched annually by river silt, and these grasses constitute the main dry season grazing'*.

Other records from abattoirs include data from Malakal for the period 1962-63, during which 19.5% of bovine livers were infected with flukes. In the same area, Eisa (1963) found liver flukes in 74/200 (37.0%) cattle examined post mortem. He also examined faeces from 365 cattle and detected fluke eggs in 15.4% of cases. Abdel Malek (1959) diagnosed fasciolosis due to *Fasciola gigantica* in Wau and Rumbek, and in Malakal 17% (5981/35000) of cattle livers were condemned due to fasciolosis between May 1976 and December 1981 (Mefit-Babtie, 1983). In Bor slaughterhouse, 21% (980/4580) of cattle livers were condemned for the same reason. Fluke eggs were in found in the faeces of 66% (109/166) adult cattle in the Jonglei Canal area and *F.gigantica* were present in 51% of 114 cattle of all age groups examined post mortem (Mefit-Babtie, 1983). The prevalence of *F.gigantica* was 80% in adult cattle (n=52) in the same sample.

Dinka and Fellata cattle in Bahr el Ghazal were surveyed for parasites in 1979-81 and results from 390 herds indicated a prevalence of *Fasciola* at 31% (Majok et al., 1993). It was proposed that fasciolosis could be controlled by treating cattle in November and December, before they were moved to dry season grazing in the *toic.* A second treatment should be given in April to May when cattle returned to home areas, in order to reduce infection of pastures. A third treatment in September to October was suggested if acute fasciolosis was observed.

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[11] The normal dose rate for ethidium bromide is 1 mg/kg.

[12] In the life cycle of parasites such as liver flukes, immature forms of the parasite infect and develop in snails - the 'intermediate host' - before infecting livestock. Therefore, the distribution of liver fluke disease (also called fasciolosis) is determined by the distribution and numbers of snails, which in turn, is determined by climate and environment.

3.1.3 Schistosomosis

According to Hussein et al. (1975), *Schistosoma bovis* was first detected in Sudanese cattle in White Nile Province (Kosti District) in 1915. Major outbreaks of schistosomosis in Kosti in the 1960s, including losses of over 8000 cattle, seem to have prompted extensive research on the problem. Papers describing the pathology (Hussein et al., 1975), pathogenesis (Dargie, 1980), and epidemiology (Majid et al., 1908) of bovine schistosomosis in Sudan are available. The latter describes a two-year longitudinal study near Kosti and demonstrated 90% schistosome infection in 18-month old cattle. Also around Kosti, McCauley et al. (1983) estimated annual mortality in 6-30 month old cattle due to schistosomosis at 7.1%. Although these studies focussed on young cattle, a key finding from Dargie (1980) was that a chronic form of schistosomosis affected adult Sudanese cattle. This form of the disease was associated with reduced liveweight gain, anaemia, hypoproteinaemia and worm burdens as low as 500 worms or less.

In southern Sudan, Abdel Malek (1959) detected *S.bovis* in cattle in Wau and Rumbek, and Eisa (1963) found *S.bovis* in 49/200 cattle examined post mortem in Malakal. Some years later, post mortem examination of cattle in the Jonglei Canal area revealed *S.bovis* in 131/148 (88%) cattle comprising all age groups (Mefit-Batie, 1983). This figure reached 100% in the 38 adult cattle in the sample. Although numbers of parasites were reported to be low in these animals, by reference to Dargie (1980) it was also noted that low worm burdens could cause a chronic, debilitating disease. Studies on the snail intermediate host in Jonglei indicated that the snail was widely distributed (Mefit-Babtie, 1983).

Regarding the prevention or treatment of bovine schistosomosis in Sudan, a live, irradiation-attenuated vaccine was tested in the field in the late 1970s and afforded good protection (Hussein, 1980). However, this vaccine was not appropriate for large-scale field use because it was difficult to mass-produce and required liquid nitrogen storage facilities (Taylor, personal communication, 1999). More recently, a recombinant *S.bovis* antigen vaccine was tested in the field in Zambia and produced significant immunity against natural *S.mattheei* infections in cattle (De Bont, 1995). Further research on recombinant vaccines is ongoing in China but as yet, no vaccine is commercially available.

In the absence of a vaccine, the control of schistosomosis requires the separation of cattle from water sources that harbour the snail intermediate hosts and the use of anthelmintics such as praziquantel. Neither of these options seems to be applicable to southern Sudan. Fencing of water sources is not practical and the high cost of praziquantel would prevent its use, particularly as repeated treatments would be required (De Bont, 1995).

3.1.4 Parasitic gastroenteritis

Eisa (1963) reported faecal egg count results for 365 cattle from Arab and Shilluk herds around Malakal, Upper Nile. Strongyle eggs were found in only 5.7% of samples and counts never exceeded 85 eggs per gram. In the same study, 200 cattle were examined post mortem and the most commonly detected nematodes were *Haemonchus contortus* (32.0% of cases), *Onchocerca atmillata* (14.5% of cases), *Oesophagostamum radiatum* (9.5% of cases) and *Bunostomum phlebotomum* (8.0% of cases). No information was provided on the ages of the cattle in the study or their clinical condition (although the title of the paper implied that the cattle were normal). Further south in Jonglei, these parasites were detected in 71% (n=84), 67% (n=9), 50% (n=81) and 19% (n=57) of cattle examined post mortem (Mefit-Batie, 1983). In the Jonglei report it was suggested that *H.contortus* was the most important nematode in the area as other parasites were detected in low numbers. In cattle, abomasal worm counts in mature animals revealed mean counts of 250 worms (n=5) in the dry season and 8000 worms (n=3) in the wet season. The clinical condition of these animals was not described.

In their survey of 390 cattle herds in Bahr el Ghazal, Majok et al. (1983) detected worm eggs in 51% of samples. Due to high dry season temperatures in excess of 90°F and the Dinka practice of burning old pastures at the onset of the dry season, it was proposed that nematode larvae would not survive

on pastures during the dry season. Therefore, it was proposed that treatments should be concentrated in the wet season at either monthly or six-week intervals.

3.1.5 Literature on 'thin cows'

The problem of 'thin cows' is not new to southern Sudan. More than fifty years ago the anthropologist Evans-Pritchard (1940) reported a *'mysterious wasting disease of cattle'* called *noi* in Nuer areas that occurred despite the presence of *'plenty of green grass and clean water'* and was associated with biting flies such as Tabanids, Stomoxys and *tharkwac*[13]*.* Karib (1961) suggested that the Nuer and Dinka name *noi* was a synonym for trypanosomosis although in another paper, noted the similarity of the clinical signs of fasciolosis and trypanosomosis, and that *'cattle may be suffering from two diseases at the same time'* (Karib, 1962).

In the Jonglei Canal area, Mefit-Babtie (1983) conducted post examinations on debilitated Dinka cattle and showed various mixed infections with *F.gigantica* (11/11 cases), schistosoma (11/11 cases), paramphistoma (11/11 cases), *H.contortus* (6/11 cases), trypanosomes (1/11 cases) and other parasites. It was suggested that *'This loss of condition is probably caused by a combination of factors'*.

Ten years later, Fison (1993) examined 385 sick cattle in Bahr el Ghazal and Upper Nile and of these 166 (43%) were *'thin cows, variously accompanied by staring coat, hair loss from the tail, diarrhoea, general weakness'*. In Eastern and Western Upper Nile, thin and thick blood smears revealed trypanosomosis prevalence between 3.7% (n=27) and 22.2% (n=45) respectively. In Ler and Nasir, post mortem examination demonstrated *F.gigantica* in 66% (n=18) and 100% (n=5) of cases, *S.bovis* in 93% (n=14) and 80% (n=5) of cases and *H.contortus* in 50% (n=16) and 100% (n=5) of cases respectively. Local names for thin cows included *liei* (Bhar el Ghazal and Western Upper Nile) and *anoi* (Eastern Upper Nile). A typical case of *liei* was described as a combined infection of trypanosomosis and fasciolosis.

3.1.6 Indigenous knowledge

A small number of reports and papers describe animal diseases in southern Sudan from the perspective of livestock keepers. For example, Schwabe and Kuojok (1981) reported how Dinka traditional healers described fasciolosis - *'The hair coat of the thorax is rough, the mucosae and sclerae are pale. The animal coughs. (Fasciolosis is difficult to recognise clinically, but an 'unthrifty coat is usual and anaemia is evident in heavy infections). Worms are found in the 'vessels' of the liver. It is believed that fasciolosis is associated with rain and dirty water, and that worms 'crawl up on the grass'. These latter associations are scientifically acceptable as far as they go'.*

In 1996, the OLS Livestock Programme conducted extensive surveys of animal health knowledge among the Nuer and Dinka. The survey methodology included semi-structured interviews based on an 'ethnoveterinary question list' of disease names, signs, causal factors and treatments, workshops with traditional healers and observation of healers preparing and using local medicines. In Nuer areas, at least four locally-recognised diseases were associated with chronically thin cattle. These diseases were *liei, noi, maguar* and *maceuny* as detailed in Box 1.

[13] The flies called *tharkwac* were identified as Hippoboscid species in Nyal by the present study - see section 3.2.2.

Box 1 Indigenous knowledge on chronic wasting in Nuer cattle (source: Blakeway et al., 1996)

Disease name: *chuie*
This condition requires elucidation. *Chuie* are *'very small snakes without bones found in stomach'*; *chuie* lives in cows' second stomach and intestines, and is the parasite that causes *guaw'*. *Chuie* affects cattle and sheep of all ages, in any season, anywhere. It affects many animals at one time, but does not spread from animal to animal, or between animals and people.
'It is caused by snails which live in the grass while cattle are grazing. The cow mixes the grasses with snails, and the snails turn to worms in the cows stomach'.
'A worm in the second stomach burrows through into gall bladder, and into big red organ (?liver) which becomes very big'.
'It is caused by floods so that there should be more worms'.
'Comes from any water or green grass, not necessarily only from rivers, swamps and floods'.
Signs:
'In the evening when cows come back from grazing and are resting, the affected one, its intestines use to make noise (guak guak), has frequent, severe diarrhoea (ciith) and produces many white worms; the cow is thin'.
'There is shivering, weakness and when the cow is dead, more water in it'.
'May see chuie animal without sickness on slaughter, or may see in sick animal at post mortem. An animal affected with chuie may recover.

Disease name: *liei*
Liei means 'steal slowly'. *Liei* affects cattle and shoats of all ages. It starts with one cow and spreads to other cows one by one. Water is the cause; caused by grazing in water and so seen from September. Before, didn't have so much *liei* because we were better able to move to dry areas where the disease was less prevalent.
Signs:
The disease steals the body of the cow. The bones show and there is watery diarrhoea (but not bloody). The hair stands up and there is gradual loss of condition and fever on and off. The eyes are sunken and may show lacrimation; the cow is photophobic and seeks shade. There is no hair on the tail; the cow doesn't graze. Sheep have pot belly, unkempt coat, diarrhoea, and may have bottle jaw. NB the cow with *liei* is photophobic, cow with liver fluke (*jok cuey*) basks in sunshine. At post mortem the meat is watery, sometimes jelly like with poor taste. When roasted, the bone marrow is watery. May get flukes in the liver and worms in stomach and intestine; generally lots of yellow water around organs and *'worms in all organs'.*

Disease name: *machueny*
Swelling of the liver due to a type of snail and grazing in water. The cow loses weight slowly; animal swollen at front, thin at back. After death the liver is very big.

Disease name: *magwar*
Magwar means too much grazing or weak cow. *Magwar* affects all animals, mainly older animals, particularly from November to January; also in rainy season when cattle kept in *luaks*. It affects all animals at the same time, goes from one and goes to another. It is caused by water (all diseases come from water), or bad weather especially floods; from *luang*, a big fly. It steals the body condition of cows until they have no body left and die; loses condition despite eating a lot; lots of diarrhoea but still milks, tears, and liquid from mouth; weakens body of cow, no grazing, no milk, lasts three months; eye pain, weakened body of cow, rough skin body look change and weak and unable to walk, stop the milk, also when it is near to death it causes stop grazing.
PM all organs normal

Disease name: *noi*
A disease of cattle (and goats), of all ages, in any (or just rainy) seasons, in all places. Just affects one cow, not from affected to unaffected. Sometimes caused by lack of grass.
Signs:
Gradual loss of weight and condition, fever, weakness, polydypsia, hair stands up, shivering, especially in morning, milk reduced; salivation, lacrimation (though eyes dry when death near), avoids sun, urine and faeces passed in small amounts, diarrhoea, lack of blood, bones weak;
2 types: rapid death, 12hrs, fever, shivering, hair standing, no blood except in heart; or slow course, tail hair lost, tail not swished about as normal, urine smells and passed in small amounts, meat pale;
PM marrow and meat watery, smells bad when cooked (only eat if starving), makes plain, green soup without fat. Without treatment, should die.

In Dinka areas, the diseases associated with chronic weight loss in cattle included *liei, jong acom* and *guao* (Box 2). More recently, Agol Malak Kwai (1999) used the names *liei, maau, maliei* and *manhiai* as synonyms for trypanosomosis, *acoom* or *macueny* as synonyms for fasciolosis, and *ngany* as a synonym for paramphistomosis.

Box 2 Indigenous knowledge on chronic wasting in Dinka cattle (source: Lindquist et al., 1996)

Disease name: *liei*
Liei (or *maliei*) is a chronic problem that mainly affects cattle, although a few informants also mentioned goats, chickens and buffaloes. Some informants considered *liei* to be a problem of cows that had just delivered, and the disease does not affect young stock or castrated, fat males.
This disease is characterised by weight loss, weakness and lethargy, and hair loss from the tail. There are also changes to the skin and hair, loss of appetite and 'tearing' from the eyes. Eventually, the cow becomes too weak to stand. When the cow dies, the meat and blood are pale, and the body is full of water. The meat is tasteless.
Liei is caused by heavy rains and flooding, keeping animals in dirty places, and insects such as *dhier, mau* and *rung*. Therefore, the disease is prevented by moving cattle to higher (drier) places and lighting dung fires to repel insects.

Disease name: *jong acom*
Jong acom literally means 'disease of the snails'. Affected cattle show gradual weight loss, pain in the stomach and 'the causative agent is found in the dung'. When the animal dies there are 'cysts' and 'worms' in the liver and the meat is tasteless. The liver is full of hard bits, like sand.
A group of traditional healers in Kakuma concurred that *jong acom* occurred only in swampy or flooded places between May and October. The disease is caused by 'small things that live inside snails' which are swallowed by the cow and affect the liver. The disease can be prevented by keeping the cows in high, dry places.

Disease name: *guao*
Guao is a chronic condition of weight loss and unthriftyness. The disease affects individual animals and is contagious. The disease is characterised by swollen knees and other joints, called *cual*, and poor condition of the animal. Some people said that *guao* occurred when a cow gave birth and the placenta was not expelled. The disease was also thought to cause constipation, loss of appetite, reduced milk production and abortion.

3.1.7 Summary

The literature provides much evidence to show that trypanosomosis and fasciolosis are major diseases of cattle in southern Sudan. There were also indications that schistosomosis and haemonchosis could be implicated in chronic wasting-type syndromes. In terms of scientific publications, the most recent account of diseases related to chronic wasting in cattle in southern Sudan was the parasite survey conducted in Bahr el Ghazal (Majok et al., 1993). This paper describes research conducted in 1979-81, and so there appears to have been a twenty-year period during which very little information was published. This situation reflects the long-term conflict in southern Sudan and the difficulties of conducting conventional epidemological studies.

The grey literature produced by the Jonglei Canel studies (Mefit-Babtie, 1983) and disease investigation work conducted by vets in the OLS Livestock Programme, most notably by Fison (1993), are among the few available reports. These include the results of post mortem examination of debilitated cattle and provided evidence that mixed infections were an important consideration in the diagnosis of chronic wasting. Surveys of indigenous animal health knowledge conducted by the OLS Livestock Programme provided much information on Nuer and Dinka perceptions.

3.2 Participatory diagnosis of chronic wasting in cattle: indigenous knowledge on *liei, noi* and other diseases

3.2.1 Disease signs

Nyal

A matrix scoring tool was also used to collect information on disease signs (see section 2.4 Matrix scoring). Despite the apparent complexity of the matrices (5 columns for disease and 11 rows for disease signs), groups of livestock keepers in Nyal were able to complete the matrices using seeds without difficulty. Typically, a matrix was completed in 45 minutes to 1 hour.

Analysis of the disease-signs matrix scores demonstrated good agreement between the 12 informant groups for 9 out of 11 disease-signs (Figure 5). The two disease signs for which there was disagreement among informants were 'disease causes death' and 'disease causes shivering'.

The disease *liei* was strongly associated with chronic weight loss, loss of tail hair and to a lesser extent, diarrhoea, tearing, reduced milk production and salivation. The term 'tearing' was used to describe serous eye discharge from one or both eyes that resulted in staining of the animal's face. In discussions following the completion of the matrices, some informants mentioned 'shivering' in relation to *liei* but stated that this was an inconsistent sign of the disease and only occurred for a short period of approximately 24 hours at the beginning of the disease. Other comments were 'With *liei* the cow becomes weak over a long period' and 'In the dead cow with *liei*, the meat is watery and the liver can be large, white and hard. Worms are also seen in the dead animal.'

The other disease most clearly linked to chronic weight loss was *maguar* and this disease was also associated with diarrhoea, reduced milk yield, tearing and salivation. Informants explained that *maguar* had a shorter duration than *liei* and cattle that did not recover from *maguar* became *liei* cases.

The disease *macueny* did not receive high scores for any disease sign relative to the other diseases, but was assigned scores for diarrhoea, tearing and weight loss. Specific comments about macueny were *'This disease is only known when a big, hard and white liver is seen in a dead cow'* and 'maceuny *is in the same family as* liei'.

The two control diseases in the matrix scoring method were *dat* (FMD) and *doop* (CBPP). For *dat,* high scores were assigned to the disease signs *'animal seeks shade'* (indicative of fever), reduced milk yield, loss of appetite and excessive salivation. Lower scores were given to tearing and weight loss. Cattle with *dat* were lame, had mouth lesions and their hair *'stood up'*. Comments about *dat* included *'The cow fears the sun and it's milk production is reduced. The milk never returns to normal'* and *'The cow breathes heavily'.* For *doop*, a high score was assigned to coughing and lower scores to weight loss, reduced milk yield, reduced appetite and excess salivation.

Thiet

Matrix scoring was also used to collect information on disease signs in Thiet and results are presented in Figure 6. The five diseases used in the matrix were *liei, abuot pou, jul, jong acom* and *cual.*

Figure 6 shows how *liei* and *jong achom* were both strongly associated with chronic weight loss and diarrhoea, whereas only *liei* was associated with loss of tail hair. The scoring patterns for *liei* among Nuer informants in Nyal (Figure 5) and Dinka informants in Thiet (Figure 6) were similar.

Figure 5. Matrix scoring of disease signs in Nyal

Signs	*liei*	*dat*	*maguar*	*doop*	*macueny*
			Diseases		
Chronic weight loss (W=0.507***)	10 (6.0-15.5)	1 (0-2.5)	3 (0-3.0)	1 (0-2.5)	1 (0-2.0)
Animal seeks shade (W=0.878***)	0 (0)	20 (17.0-20.0)	0 (0)	0 (0-3.0)	0 (0)
Diarrhoea (W=0.523***)	4 (0-8.5)	0 (0)	11 (6.0-16.0)	0(0)	4 (0-7.5)
Reduced milk yield (W=0.507***)	2 (0-4.0)	13 (7.0-20.0)	3 (0-9.0)	1 (0-2.5)	0 (0-1.0)
Coughing (W=0.763***)	0 (0-0.5)	0 (0-0.5)	0 (0-2.0)	19 (16.5-20.0)	0 (0-0.5)
Reduced appetite (W=0.543***)	0 (0)	13 (7.0-20.0)	0 (0)	5 (0-10.0)	0 (0)
Loss of tail hair (W=0.886***)	20 (16.5-20.0)	0 (0)	0 (0-3.5)	0 (0)	0 (0)
Tearing (W=0.279*)	6 (3.0-13.0)	2 (0-6.5)	4 (0-8.5)	0 (0-1.5)	3 (0-8.0)
Salivation (W=0.500***)	2 (0-3.0)	14 (7.0-20.0)	3 (0-6.5)	1 (0-2.0)	0 (0-0.5)

Number of informant groups = 12; W = Kendall's Coefficient of Concordance (*p<0.05; **p<0.01; ***p<0.001). W values vary from 0 to 1.0; the higher the value, the higher the level of agreement between informants.

The black dots represent the scores (number of seeds) that were used during the matrix scoring. Median values are presented and 95% confidence limits are shown in parentheses. A high number of dots indicates a relatively strong association between a sign and a disease whereas a low number of dots indicates a weak association.

Figure 6. Matrix scoring of disease signs in Thiet

Signs	Diseases: *liei*	*abuot pou*	*jul*	*jong achom*	*cual*
Chronic weight loss (W=0.673**)	12 (4.0-20.0)	0(0)	0 (0)	8 (0-16.0)	0 (0)
Seeks shade (W=0.880***)	0 (0-1.0)	9 (6.0-11.0)	20 (15.0-20.0)	0 (0)	0 (0)
Diarrhoea (W=0.671**)	5 (0-14.0)	0 (0)	0 (0)	15 (6.0-20.0)	0 (0)
Seeks sun (W=0.120)	3 (0-10.0)	0 (0-10.0)	0 (0)	0 (0-7.0)	0 (0-20.0)
Coughing (W=0.939***)	0 (0)	10 (16.5-20.0)	0 (0	0 (0-3.5)	0 (0-0.5)
Reduced appetite (W=0.384*)	3 (0-12.0)	13 (3.0-20.0)	0 (0-2.0)	0 (0-4.0)	0 (0-2.0)
Loss of tail hair (W=1.000****)	20 (20.0-20.0)	0 (0)	0 (0)	0 (0)	0 (0)
Tearing (W=0.347*)	8 (0-20.0)	0 (0)	0 (0)	0 (0-5.0)	0 (0)
Swollen joints (W=1.000****)	0 (0)	0 (0)	0 (0)	0 (0)	20 (20.0-20.0)
Reduced milk (W=0.733***)	0 (0-8.0)	0 (0-1.5)	20 (12.0-20.0)	0 (0-3.0)	0 (0-0.5)
Rough coat (W=0.902***)	0 (0-1.5)	0 (0-2.0)	20 (16.5-20.0)	0 (0)	0 (0)
Abortion (W=0.419**)	3 (0-10.0)	0 (0-3.0)	0 (0-10.0)	0 (0-3.0)	12 (3.5-20.0)

Number of informant groups = 7; W = Kendall's Coefficient of Concordance (*p<0.05; **p<0.01; ***p<0.001; ****p=1.0).

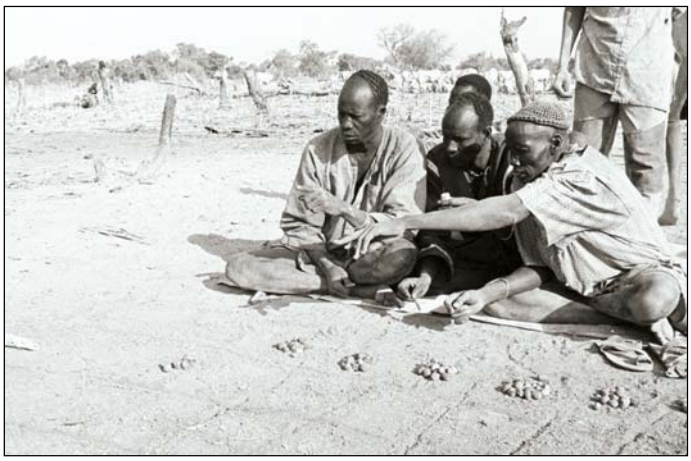
The disease called *jul* was included in the matrix scoring because during initial interviews in Thiet, it was commonly cited as one cause of 'thin cows'. Previous reports for southern Sudan had noted that *jul* was characterised by poor body condition and productivity in adult cattle (Linquist *et al.,* 1996) and therefore, there was some connection with the 'chronic wasting' syndrome. These reports also suggested that *jul* was a result of a previous illness called *dat,* a problem that was usually interpreted as FMD by vets (also see Figure 5). Dinka informants in Thiet considered the main signs of *jul* to be shade seeking behaviour, reduced milk yield and a rough coat. Discussions about *jul* after the completion of the matrices also indicated that:

- The disease always followed the illness called *dat.* It affected adult cattle and these animals never returned to normal after the signs of *dat* had subsided.
- The course of *jul* was prolonged. Affected cows became less fertile and produced less milk than normal cows. Affected animals never recovered.
- A further sign of *jul* was 'difficult breathing', especially when the animal was grazing.

The disease called *cual* was strongly associated with abortion, swollen joints and sun-seeking behaviour. Informants explained that in the morning, these animals remained recumbent until the sun rose and was hot. This behaviour was attributed to stiffness in the joints and the cattle preferring not to stand or move in cold weather. In common with the matrix scoring in Nyal, CBPP was used as a control in the matrix. The Dinka name for this disease was *abuot pou* and the disease received high scores for coughing, reduced appetite and shade-seeking behaviour. This scoring pattern was similar to the scores for *doop* (Figure 5), the Nuer name for CBPP in Nyal.

Figure 7. Completing disease-signs scoring matrices

a. Madhol cattle camp, near Thiet



b. Lwali, Nyal District

Figure 8

Figure 9

Figure 8. A typical case of *liei* in Nyal
The cow is emaciated and there is
loss of hair on the tail tip.

Figure 9. Chronic, mild diarrhoea in a case
of *liei* in Nyal

Figure 10. A typical case of *jul* in Thiet
The coat has a characteristic overgrown,
slightly woolly appearance.

Figure 11. A typical case of *cual* in Thiet
Fluid-filled swellings are just visible on the
fore-limbs, particularly the right knee.

Figure 10

Figure 11

3.2.2 Causes and sources of disease

Interviews with people in Nyal indicated that some diseases of cattle were associated with biting flies, ticks or snails whereas other diseases occurred when sick cattle came into contact with healthy animals. Using samples of flies, ticks and snails, and by reference to parasites collected during post mortem examinations it was possible to confirm the Nuer names for these specimens. The names listed in Table 5 were provided by informants without hesitation when viewing the various specimens.

Table 5. Nuer names used for parasites and vectors associated with chronic wasting in cattle in Nyal

Nuer name	Notes on identification and interpretation
chuie 	Paramphistomes in the rumen and abomasum, and liver flukes (*F.gigantica*) were all called *chuie.* The use of the word *chuie* partly explained the disease name *macueny* (pronouced *machuien*) for fasciolosis. Some people called liver flukes *daichom* (see below).
daichom 	*Daichom* was another name for liver flukes. The name meant *'calf of the snail'* and this name was used because the parasites were thought to originate from snails.
chom 	*Chom* was the Nuer name for snails. In cases of fasciolosis, the hard, dark greenish bile concretions in the liver were called *chom* by some informants.
loak 	*Loak* was used to describe nematodes such as Haemochus and Trichuris. When schistosomes were named, these parasites were also called *loak*.
nyiith 	*Nyiith* were mosquitoes. These flies occurred in large numbers during the wet season and were a nuisance to cattle and people.
tharkuach 	*Tharkuach* were flat-bodied biting flies with a distinctive, patterned thorax and stocky legs. The flies rested on the flanks, belly and limbs of livestock. These flies were identified as Hippoboscid species (louse flies).
rom 	*Rom* were large biting flies that occurred in great numbers at certain times of years and caused severe distress to cattle and people. These flies were identified as Tabanid species (horse flies).
chak 	*Chak* was the name used for all types of ticks. Regarding cases of *liei*, ticks were thought to seek out thin cattle and worsen the condition of the animal. In other words, *chak* were not the primary cause of *liei*.

While some flies and parasites were easily identified by informants, there were other parasites that caused much discussion and various names were suggested. Among the flies, preserved specimens of tsetse flies were never identified using a name that was specific for that type of fly alone. Hence, tsetse flies were called *rom, mau* or *wath*. Informants did sometimes state that tsetse were biting flies and in some cases, tsetse were thought to be young *rom* (Tabanids). In addition, some but not all people associated tsetse flies with *liei*. Overall however, there were mixed views regarding the local name for tsetse and the significance of this fly. When asked to collect *rom* (tabanids) and show them to the team, people usually caught these flies within a few minutes. In comparision, people were never able to collect tsetse flies.

For internal parasites, paramphistomes (*chuie*) and liver flukes (*daichom*) were readily identified and named by herders. However, there was some overlap of names and paramphistomes, liver flukes and haemonchus were all called *chuie* by some people. During post mortem examinations conducted in Nyal (see later) herders never identified schistosomes in mesenteric blood vessels and when shown these parasites, either did not name them or called them *loak*. The name *loak* was also used to describe Haemonchus in the abomasum and seemed to be a general name for nematodes. Ticks were invariably called *chak* and these parasites were thought to *'go to sick cows'*.

A similar approach to collecting information of the names of flies and disease vectors was used in Thiet and results are summarised in Table 6. Overall, the flies and other specimens identified were similar to those in Nyal. In addition to the flies mentioned in Table 6, a fly called *mau* was also discussed. This fly was usually described as a largish biting fly with a dark body and white and other coloured markings. However, there were also other, more vague descriptions of *mau* and opinions about the distribution of the fly were mixed. Some people said that the fly was present in the *toic* along Tonj River, whereas others suggested that *'The bite of mau makes the animal become very thin. Mau feeds mainly on buffalo and giraffe so it is not found around here. In bad years some people migrate as far as the Zande tribe areas* (approximately 10 days walk into Western Equatoria*). These areas are forested and hilly, and have more wild animals. It is here that cattle become bitten by mau, when cattle come close to buffalo in the toic in those places. These people bring cattle suffering from mau to this area'*. These movements and locations were clarified using mapping, and seasonal calendars were used to show seasonal variations in rainfall and fly populations (see later). In both Nuer and Dinka locations, the importance of flies as causes of ill health in cattle was reflected in the everyday practice of using smoke fires in the cattle camps and luaks to repel flies. Ash was also rubbed into the coat of cattle to deter flies.

Matrix scoring of causes or sources of disease

Matrix scoring was also used to understand local perceptions of relationships between diseases and causes or sources of disease. Results from Nyal are summarised in Figure 12 and show high levels of agreement between the 12 informant groups for each of the 8 listed causes/sources.

The disease *liei* was strongly associated with biting flies and specifically, the large flies called *rom* that were identified by the researchers as Tabanids. *Liei* was also related to flooding, liver flukes, paramphistomes, stomach worms and snails. Similar causes and sources of disease were linked to the disease *macueny* with the exception of biting flies and with a different scoring pattern. In particular, *macueny* was thought to be caused by liver flukes, as seen in the liver of affected animals. As mentioned in Table 5, informants related liver flukes to snails, and in the matrix scoring snails were scored highly under *macueny*. The disease *maguar* was related to similar factors as *macueny*, but with more emphasis on stomach worms and less emphasis on liver flukes.

The two control diseases in the matrix, *dat* (FMD) and *doop* (CBPP), received high scores for *'sick cow entering the herd'* as a cause of disease. These two diseases were not thought to be caused by other factors.

In Thiet, 7 groups of livestock keepers completed matrices showing the relationship between diseases and causes or sources of disease, and results are shown in Figure 13. In common with the Nyal

results, there were moderate to high levels of agreement between informant groups for each of the 8 indicators. *Liei* was linked to the biting flies called *rum,* flooding and snails but was not associated with liver flukes. The disease *jong acom* (literally 'disease of the snails') was scored highly for liver flukes, snails, flooding and wet grass. Some informants remarked that small snails were present on wet grass; when these snails were consumed by cattle, they caused the disease *jong acom*.

Table 6. Dinka names for parasites and vectors associated with chronic wasting in cattle in Thiet

Dinka name	Notes on identification and interpretation
chom 	*Chom* was the Dinka name for snails. Interviews indicated that the snails in question were small snails attached to wet grass, rather than the large snails found scattered over flood plains. These small snails were said to be various colours. No specimens of snails were used during the interviews.
guak chom 	*Guak chom* meant '*young snail'* and this name was used when informants were shown specimens of *F.gigantica*. In common with Nuer areas, the name derives from the belief that liver flukes are young forms of those snails that are found on wet grass.
ngany 	*Ngany* was the name given to paramphistomes in the rumen and abomasum.
thio 	*Thio* was the name given to worms such as Haemonchus and Trichuris species that were readily visible with the naked eye. When shown schistosomes in mesenteric blood vessels, these parasites were also called *thio*.
atek 	*Atek* was the name given to specimens of Hippoboscid flies. These were said to be biting flies with a patterned thorax and they rested on the flanks, belly and limbs of livestock. The name *atek* derives from the behaviour of the flies and indicated that they were difficult to kill by swatting them.
luang 	*Luang* was a general name for flies derived from the concept of *'passing on something bad'.* The name *luang* was also used to describe specimens of Stomoxys flies.
dhier 	Mosquitoes were called *dhier*.
rum 	*Rum* was the name given to specimens of Tabanid flies. The name *rum* derives from the behaviour of the fly and its ability to alight on an animal or person without the host being aware of the fly. A small number of informants called these flies *rong*.
achak 	*Achak* was used to name ticks of all types.

Figure 12. Matrix scoring of causes or sources of disease in Nyal

Causes or sources	Diseases: *liei*	*dat*	*maguar*	*doop*	*macueny*
Liver fluke *daichom* (W=0.676***)	2 (0-4.5)	0 (0-2.5)	3 (0-7)	0 (0)	15 (10.0-20.0)
Sick cow entering herd (W=0.735***)	0 (0-1)	8 (5.0-10.0)	1 (0-3)	9 (5.0-12.0)	0 (0-0.5)
Paramphistomes *chuie* (W=0.329*)	5 (0-12)	0 (0)	5 (0-12.5)	0 (0)	5 (0-13.5)
Stomach worms *luok* (W=0.454**)	3 (0-5.5)	0 (0)	8 (3.5-14.0)	0 (0)	5 (5.0-10.0)
Flooding (W=0.493***)	8 (2.5-13.0)	0 (0)	6 (2.5-12.5)	0 (0)	4 (3.75-10.0)
Biting flies *rom* (W=0.817***)	19 (15.5-20.0)	0 (0)	0 (0-6)	0 (0)	0 (0-1.5)
Ticks *chak* (W=1.000****)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Snails *chom* (W=0.600***)	2 (0-4.5)	0 (0)	5 (2.5-9.0)	0 (0)	10 (5.0-15.0)

Number of informant groups = 12; W = Kendall's Coefficient of Concordance (*p<0.05; **p<0.01; ***p<0.001; ****p=1.0).

The black dots represent the scores (number of seeds) that were used during the matrix scoring. Median values are presented and 95% confidence limits are shown in parentheses Actual samples of flies, ticks, liver flukes, paramphistomes, worms and snails were used. A high number of dots indicates a relatively strong association between a cause or source of disease and a disease whereas a low number of dots indicates a weak association.

Figure 13. Matrix scoring of causes or sources of disease in Thiet

Causes or sources	Diseases: *liei*	*abuot pou*	*jul*	*jong acom*	*cual*
Liver fluke *daichom* (W=0.679**)	0 (0-10.0)	0(0)	0 (0)	20 (10.0-20.0)	0 (0)
Sick cow entering herd (W=0.653**)	0 (0-3.0)	9 (6.0-11.0)	0 (0-6.0)	0 (0)	7 (3.5-10.0)
Worms (W=0.429*)	0 (0)	0 (0)	0 (0)	10 (0-20.0)	0 (0)
Wet grass (W=0.566**)	10 (0-20.0)	0 (0)	0 (0)	10 (0-20.0)	0 (0)
Flooding (W=0.353*)	10 (0-20.0)	0 (0-1.5)	3 (0-12.0)	4 (0-13.5)	0 (0-0.5)
Biting flies *rom* (W=1.000****)	20 (20.0-20.0)	0 (0)	0 (0)	0 (0)	0 (0)
Ticks *chak* (W=1.000****)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Snails *chom* (W=0.627**)	5 (0-14.0)	0 (0)	0 (0)	15 (6.0-20.0)	0 (0)

Number of informant groups = 7; W = Kendall's Coefficient of Concordance (*p<0.05; **p<0.01; ***p<0.001; ****p=1.0).

The black dots represent the scores (number of seeds) that were used during the matrix scoring. Actual samples of flies, ticks, liver flukes, paramphistomes, worms and snails were used. Median values are presented and figures in parentheses are 95% confidence limits. A high number of dots indicates a relatively strong association between a cause or source of disease and a disease whereas a low number of dots indicates a weak association.

Both *abuot pou* and *cual* were strongly related to a sick cow entering the herd whereas the disease *jul* was not strongly attributed to any cause but was given a low score for flooding. Informants explained that when cattle stood or grazed in flooded areas for long periods they became stressed and lost condition. This observation also explained the link between flooding and *liei* and *jong acom*.

Results from interviews and scoring methods in Lankien

In Lankien a mix of interviewing and scoring methods were used to collect information on the disease called *noi*. Secondary data, interviews and advice from veterinarians working in southern Sudan indicated that in Lankien, *noi* was a Nuer word that was used in a similar way to *liei* in Dinka and other Nuer areas.

Summary of interview with 3 men in Lankien

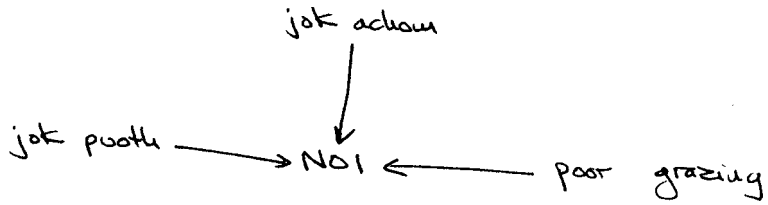
Question: What are the different problems that make a cow become thin?

Four problems were named. Objects were placed on the ground to represent these problems and they were ranked in order of importance as follows:

noi	1st
jok acom	2nd
jok puoth	3rd
poor grazing	4th

However, the informants also advised that *'all these problems go to noi if the animal doesn't recover'*. Therefore, the four objects were rearranged on the ground as follows:

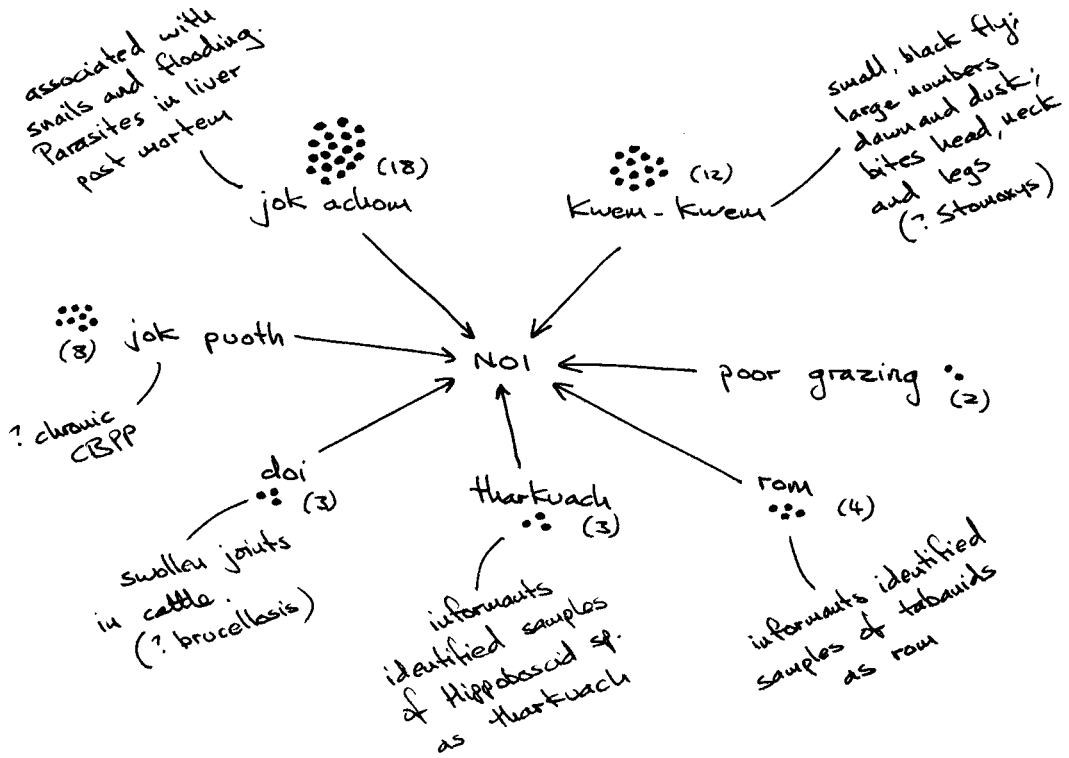
This rearrangement was approved by the informants.



Question: Are there any other causes of *noi* other than those already mentioned?

The informants named three different types of flies, called *rom, kwem-kwem* and *tharkuach*, and a disease called *doi*. These causes of *noi* were added to the diagram, represented by more objects, and scored together with the other causes of *noi.* Further information was added about some of these causes as summarised in the sketch overleaf. Therefore, for these informants the main causes of *noi* were *jok acom* (scored 18), *kwem-kwem* (scored 12)*, jok puoth* (score 8) and rom (score 4).

The final point in the discussion focussed on ways to identify the cause of *noi* while the sick animal was still alive. It was concluded that in the case of *jok acom*, this disease could only be known after the animal was dead and parasites were seen in the liver (cf *macueny* in Nyal). In the case of *noi* caused by biting flies, the history of the animal would help, although it was recognised that all cattle are exposed to biting flies.



The idea that *noi* was a condition that could arise from a number of diseases or causes and that led to a chronically thin animal was supported by one owner whose cow was purchased for post mortem examination. This man said that *'Any cow that doesn't recover from disease and remains sick for a long time, we call noi*[14].

<u>Summary of interview with 3 men, Lankien</u>

Question: What are the main causes of thin cows?

1st = *noi* *'With this disease the animal is thin, has tears running down the face and passes dry, hard faeces. If one cow is sick with noi in the luak, the disease spreads in the smoke in the luak to other cows'.*

2nd=*jok puoth* Chronic respiratory disease/CBPP.

3rd=*chuie* *'With this disease there is diarrhoea with mucus. The disease is due to flooding and in the dead animal, parasites called chuie are seen in the liver'.*

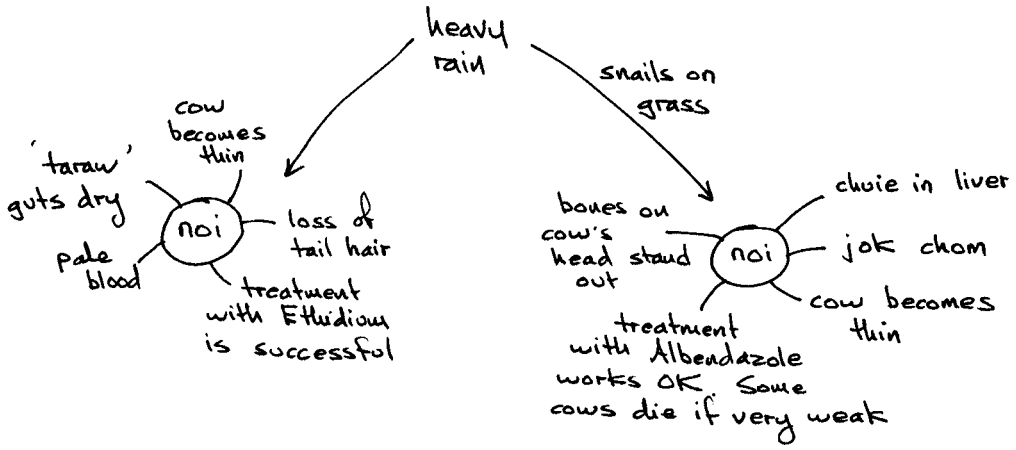
This ranking and brief description of three diseases led to a discussion as to whether the diseases were distinct, separate diseases or whether they all *'led to noi'*. For these informants, *noi* and *chuie* were quite separate diseases although only one person claimed to be able to distinguish between them in the live animal. In addition, it was agreed that an animal could be suffering from both *noi* and *chuie*, but the latter would only be confirmed by looking at the carcase. The scientific name of the parasite *chuie* was checked by asking informants to name samples of paramphistomes, haemonchus, liver flukes and schistosomes. The liver flukes were called *chuie.*

[14] This animal was found to be suffering from schistosomosis and haemonchosis - see case L3, Table 11.

The disease and parasite called *chuie* was particularly associated with flooding, rather than just swampy areas. However, it was suggested that for most of the year, cattle in the areas had access to wet areas and therefore were at risk of *chuie*.

<u>Summary of interview with 2 men, Lankien</u>

This interview began by asking the informants to describe the disease called *noi*. In the discussion, two distinct types of *noi* were described as summarised below. The two types of *noi* were *noi taraw* and *noi chuie*.



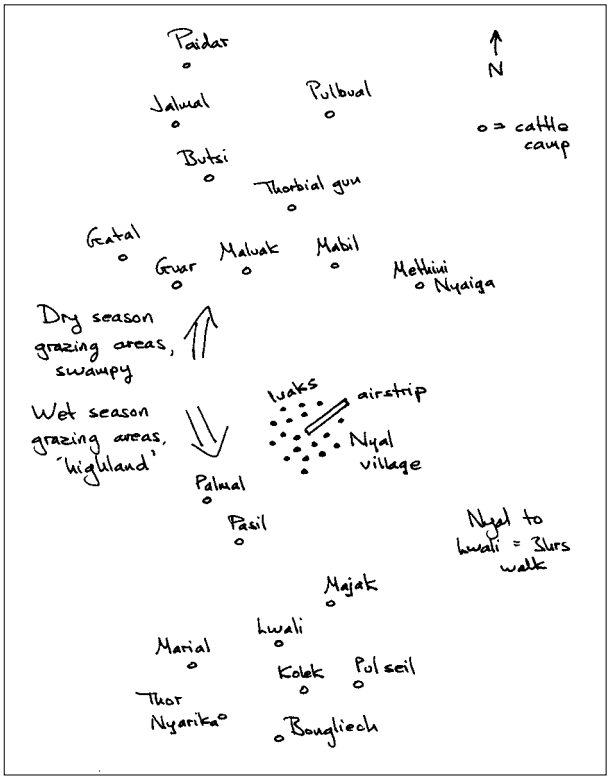
After describing these two types of *noi* it was noted how these diseases could easily be confused because they were so similar. It was also suggested that if an animal with *'noi-chuie'* didn't recover after treatment with albendazole, then the animal would recover if treated with Ethidium.

3.2.3 Seasonal and geographical factors

Local perceptions of seasonal and geographical factors associated with *liei* or *noi* were investigated using mapping and seasonal calendars. The maps showed cattle movements and wet and dry season grazing areas.

<u>Information about *liei* in Nyal</u>

Discussions about *liei* were based on a map of the Nyal area produced by cattle owners (Map 3). This map shows the main wet and dry season grazing areas. The swampy areas to the north of Nyal were used in the wet season whereas the relatively high areas to the south of Nyal being used in the dry season.



Map 3. Seasonal movement of cattle in Nyal

(Map constructed by 6 cattle owners in Nyal village)

After completing the map, the cattle owners provided the following information:

- In the wet season, cattle become infected with *liei* but do not show signs of disease. The infection is caused by eating grass that is growing in water. Later in the year this grass is burnt and the new grass is 'clean'. When cattle go to the dry season grazing areas, they also drink water from pools which is cleaner than water in the swamps.

- In the dry season cattle shows signs of *liei*. The disease is particularly bad in years when there is flooding because cattle continue to eat grass that is growing in water during the dry season.

- Therefore, cattle can be eating grass in wet or swampy areas at any time of year. There are many things in the grass like small snails that stick to the grass. These cause the liver disease *macueny* in which there are things moving in the liver. The meat becomes full of water and tasteless.

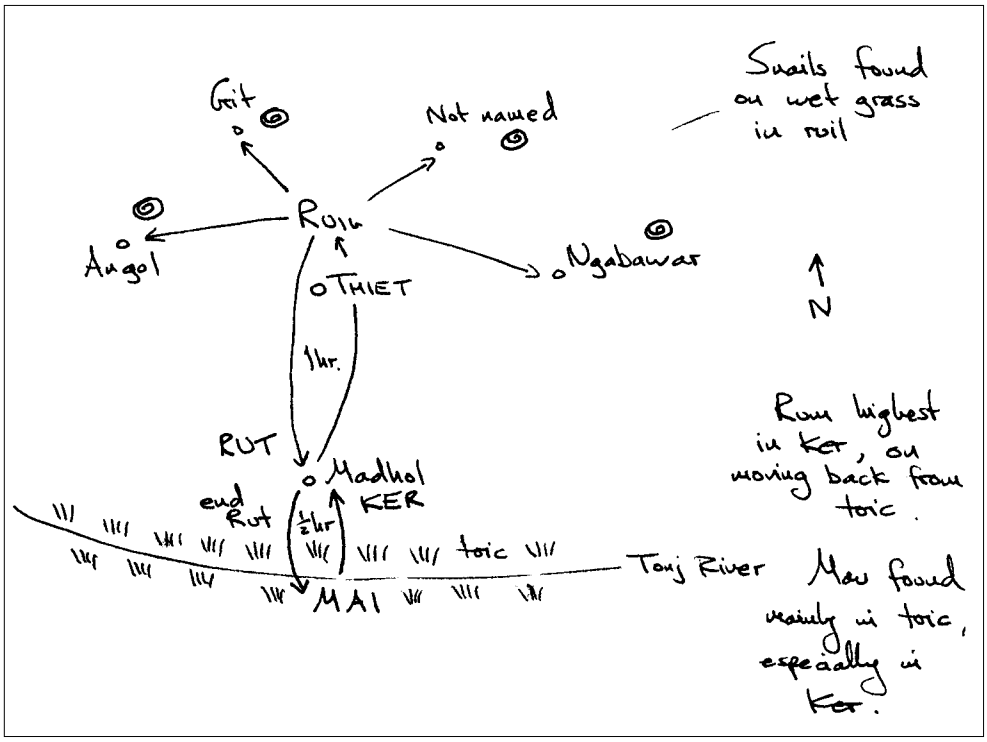
- Before death, the animal that is later found to have liver disease is thin, shivering and weak. There can also be diarrhoea. This disease is called *liei*.

- Regarding flies, there is not much difference in fly numbers between wet and dry season but as cattle congregate, fly numbers increase. There are more biting flies in the wet season grazing areas and these flies are bad because they transmit disease by sucking blood. The flies called *rom* transmit *liei*.

<u>Seasonal cattle movements in and around Thiet</u>

The maps below show some of the seasonal movements of cattle in and around Thiet. The *toic* are flood plains alongside main rivers that are used as dry season grazing areas.

Map 4. Seasonal movements of cattle in Madhol cattle camp



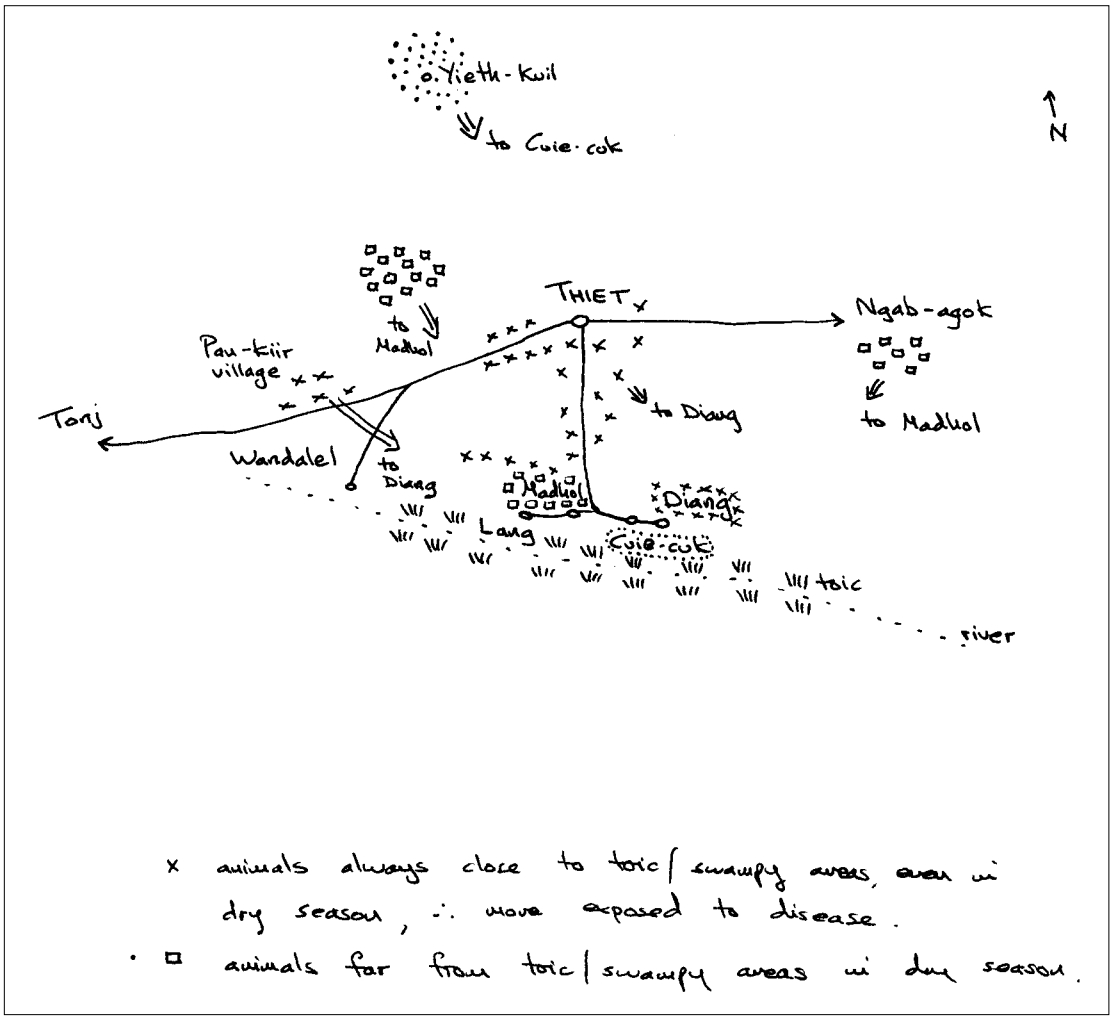
Dinka seasons:
Mai - Feb.to April
Ker - May to July
Ruil - Aug. to Oct.
Rut - Nov. to Jan.

(Map constructed by 7 men in Madhol cattle camp)

Map 4 shows the informants' permanent home locations called Ngabawar, Git and Angol. Informants were present in these places during the wet season and although some distance from the river, snails were found on the grass and in pools at this time. As the dry season began and pasture availability decreased, cattle were slowly moved towards the *toic*. Behind the moving herds, the old pasture was burnt. Cattle were most bothered by flies such as *rum* and *mau* during *ker* (May to July). The movement pattern described by these informants involved transhumance over quite small distances, as the distance from the main settlements to the *toic* was only 1.5 to 2 hours walk.

Map 5 was drawn from a series of smaller maps produced by people in Cuie-cek, Diang and Madhol cattle camps near the *toic*, south of Thiet. The map shows the location of home (wet season) grazing areas relative to the *toic* (dry season) grazing areas. Again, seasonal movements were modest and some herds were close to the *toic* in both wet and dry seasons e.g. herds occupying Diang cattle camp. Herders noted that these cattle were constantly exposed to wet, snail-infested areas.

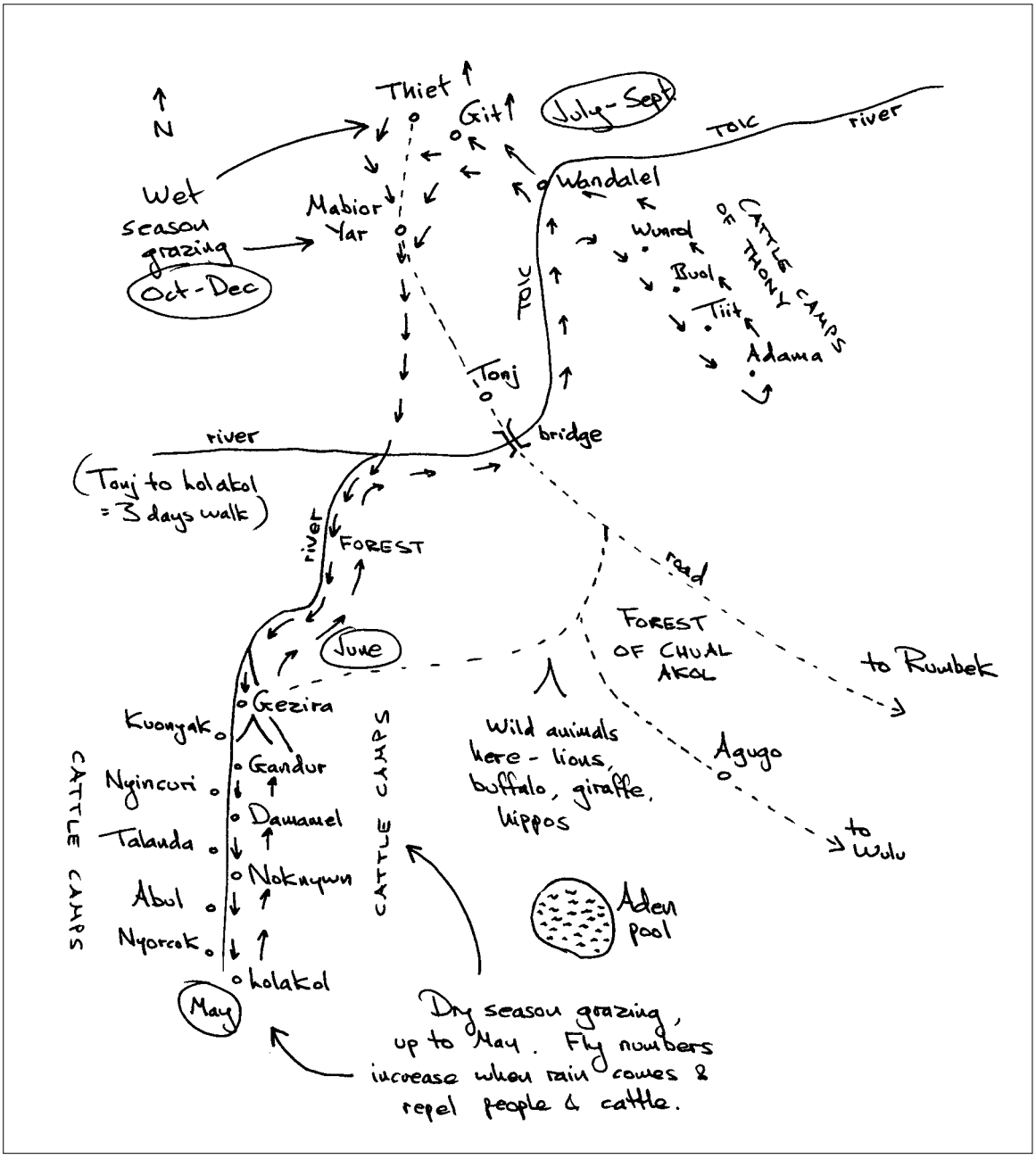
Map 5. Seasonal movements to cattle camps in the *toic*, south of Thiet



Map 6 was produced by trainees on a tsetse control course run by UNICEF in Thiet. The map shows movement of cattle over long distances, following the river from areas around Thiet to dry season cattle camps between Gezira and Lolakol. In different years, people opted to move in different ways. The decision-making process was complex and the presence of biting flies in some areas was an important factor in causing people to move from certain areas as fly populations increased. This

situation was most commonly mentioned in relation to cattle camps north of Lolakol along the river. The fly in question was called *mau*.

Map 6. Seasonal movements of cattle along the river system south of Thiet



The fly called *mau* was also said to be present in large numbers around Agugo and in the forest areas occupied by wild game. People in Agugo tended to keep their cattle in areas where there were no *mau* to bother them, such as around Thiet. This explains why there are no cattle movements to Agugo marked on the map.

Seasonal variations in diseases, flies, snails and ticks in Thiet

Seasonal calendars were used to show seasonal variations in livestock diseases (the same 5 diseases as described in the matrix scoring), rainfall, flies, ticks and snails, as summarised in Figure 14 overleaf. Moderate to good agreement was evident between the 10 informant groups concerning seasonal patterns of rainfall and the diseases, *liei, abuot pou, jul*, and *jong acom*. Informants also demonstrated agreement over their scores for seasonal populations of ticks, snails and the flies called *rum, luang* and *dhier*. In general, disease incidence, fly populations and tick and snail populations peaked during the wet season. Agreement between informant groups regarding seasonal populations of the fly called *mau* was low (W=0.076).

Rainfall patterns: comparing the results of PA with the objective rainfall data

The seasonal calendars used in Thiet included a 'rainfall' indicator. The 10 informant groups who constructed seasonal calendars gave similar scores for rainfall (W=0.955) for the Dinka seasons of *mai, ker, ruil* and *rut*. In areas where temperature and photoperiod do not vary widely throughout the year, rainfall is likely to be a major factor affecting seasonal variations in the populations of some species of flies, ticks, snails and nematodes. Therefore, an attempt was made to assess the validity of the rainfall scores in the seasonal calendars. The data was compared with objective measures of rainfall provided by the USAID Famine Early Warning System (FEWS) in Nairobi. The FEWS rainfall data was derived from a combination of satellite data, rain-gauge reports, model analyses of wind and relative humidity, and orography to estimate accumulated rainfall (Herman *et al.*, 1997). Measurements were made at 10-day intervals throughout the year and the data used in the comparison was data collected for Tonj County for the period 1995-1998.

In order to compare the two sets of data, each data set was converted into seasonal proportions of total annual rainfall (Table 7). The two sets of proportions were not statistically different and the data is shown graphically in Figure 15.

Table 7. Comparison of rainfall seasonal patterns as determined by seasonal calendars and objective rainfall data

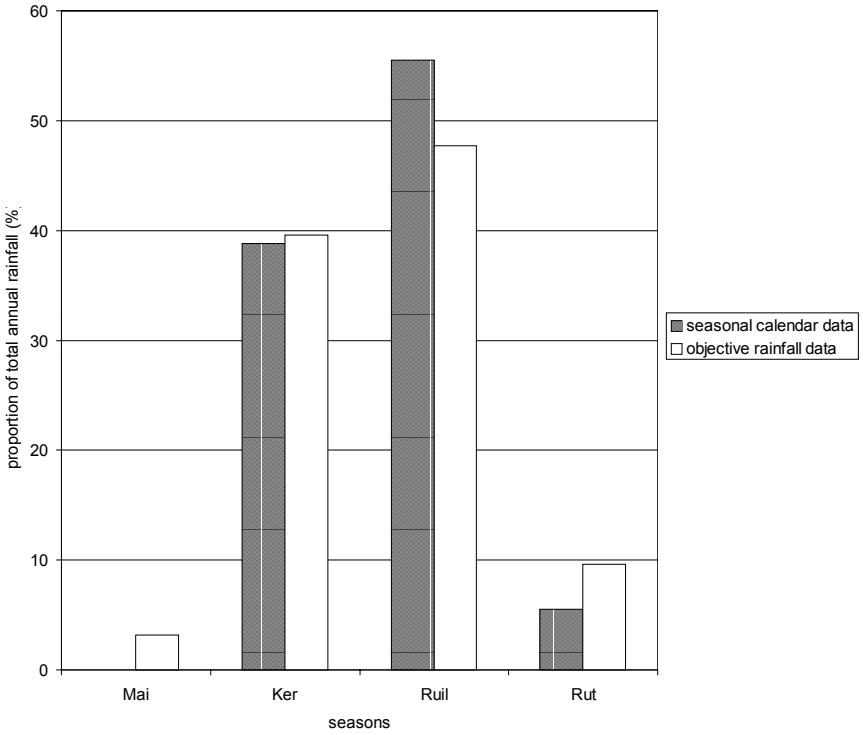
Seasons	Data from 10 seasonal calendars			Data from FEWS 1995-1998	
	median rainfall score	95% confidence limits	score as a proportion of total annual score (%)	mean rainfall (mm)	rainfall as a proportion of total annual rainfall (%)
mai (Jan-Mar)	0	0	0	40.0	3.2
ker (Apr-Jun)	7.0	5.0-9.0	38.8	499.0	39.6
ruil (Jul-Sep)	11.0	10.0-13.5	55.5	601.0	47.7
rut (Oct-Dec)	1.0	0-2.5	5.5	121.0	9.6

Figure 14. Summarised seasonal calendar for livestock diseases, biting flies, ticks and snails in Thiet

		Seasons			
		MAI (Feb-Apr)	*KER* (May-Jul)	*RUIL* (Aug-Oct)	*RUT* (Nov-Jan)
	rainfall (W=0.955***)	0 (0)	7 (5.0-9.0)	11 (10.0-13.5)	1 (0-2.5)
diseases	*liei* (W=0.317*)	4 (1.0-7.0)	1 (1.0-2.0)	7 (3.0-11.5)	7 (3.5-10.5)
diseases	*abuot pou* (W=0.408**)	3 (1.5-4.5)	4 (2.5-5.0)	8 (6.5-10.0)	5 (3.0-7.0)
diseases	*jul* (W=0.378*)	3 (0-10.0)	3 (0-5.5)	11 (5.5-15.5)	3 (0-5.5)
diseases	*jong acom* (W=0.502**)	0 (0-0.5)	7 (0-11.5)	9 (4.5-11.0)	4 (0-6.5)
diseases	*cual* (W=0.212)	3 (0-5.0)	5 (2.0-9.0)	6 (2.5-9.0)	6 (2.5-9.5)
flies, ticks and snails	*rum* Tabanid sp. (W=0.418**)	1 (0-2.5)	9 (5.0-11.0)	4 (2.0-8.0)	6 (2.0-9.5)
flies, ticks and snails	*luang* Stomoxys sp. (W=0.377*)	5 (3.0-7.0)	7 (4.0-9.0)	7 (4.5-9.0)	2 (0-3.5)
flies, ticks and snails	*dhier* mosquitoes (W=0.854***)	0 (0-0.5)	5 (2.0-6.5)	12 (11.0-15.0)	4 (1.0-5.5)
flies, ticks and snails	*chom* snails (W=0.831***)	0 (0)	9 (5.0-12.0)	9 (7.0-14.5)	0 (0-2.0)
flies, ticks and snails	*achak* ticks (W=0.787***)	0 (0-2.5)	11 (6.0-14.0)	6 (3.5-9.0)	1 (0-2.5)

Number of informant groups = 10; W = Kendall's Coefficient of Concordance (*p<0.05; **p<0.01; ***p<0.001).
The black dots represent the number of seeds that were used during the construction of the seasonal calendars. Median values are presented and 95% confidence limits are shown in parentheses. A high number of dots indicated a relatively strong association between a disease or parasite and season, whereas a low number of dots indicated a weak association.

Figure 15. Comparison of rainfall seasonal patterns as determined by seasonal calendars and objective rainfall data



Seasonal variations in diseases in Lankien

In Lankien, a seasonal calendar was used on a single occasion to look at changes in the presence of *noi* and parasites at different times of year. Results are presented in Figure 16 below.

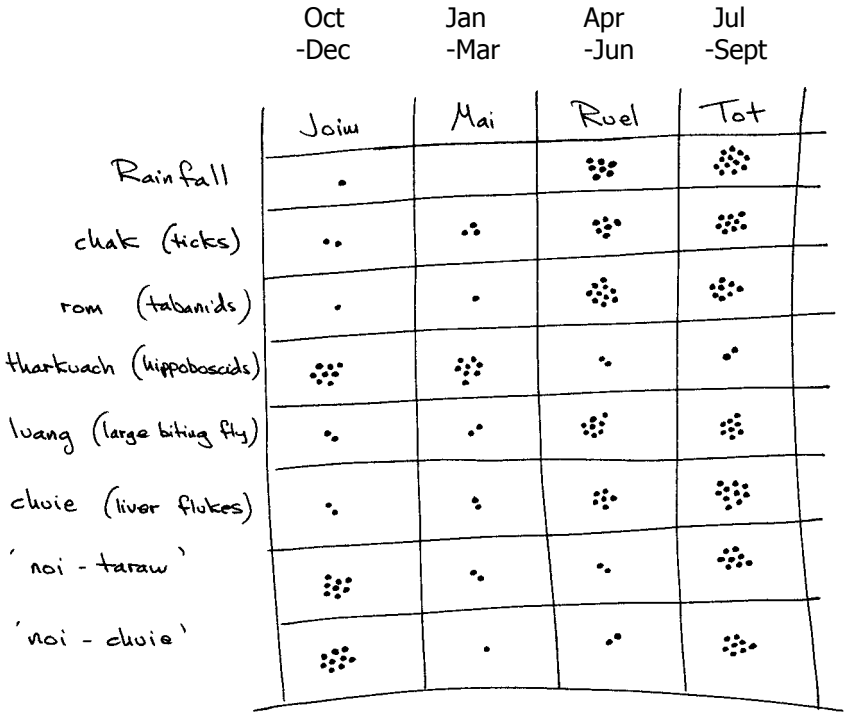


Figure 16. Seasonal variations of disease vectors and types of *noi* in Lankien

(Informants - 2 men in Lankien)

This seasonal calendar indicated that *noi taraw* and *noi chuie* occurred at similar times of year and therefore the timing of cases would not be a helpful factor in distinguishing between the two diseases.

3.2.4 Distinguishing between different forms of chronic wasting

In Nyal and Thiet the completed disease-signs and disease causes/sources-matrices, and maps were used as a basis for further discussions on those diseases that resulted in cattle becoming chronically thin, and ways that people distinguished between these diseases. In particular, further questioning in Nyal focused on *liei* and *macueny* while in Thiet, the diseases *liei* and *jong acom* were discussed.

<u>Nyal</u>

Matrices completed in Nyal indicated that *liei* was characterised by weight loss in adult cattle, loss of tail hair and sometimes, diarrhoea and tearing. *Liei* was also strongly associated with biting flies, particularly *rom* (Tabanids) and flooding. The disease *macueny* was characterised by the presence of liver flukes, as observed in the livers of dead cattle, snails and flooding. The main sign of *macueny* was diarrhoea, but the disease also caused some weight loss, tearing and salivation.

In further discussions, some informants stated that two forms of *liei* existed and that these two forms of the disease were caused by either biting flies or flooding.

Question: In sick cattle, does the liei caused by flies look different to the liei that comes from water?

- *There is no difference in the appearance of the animal. Rom (Tabanids) increase when there is flooding and liei from water can be transmitted during the dry season by rom.*
- *Rom are most numerous from juom (October-December) and are present until ruel (March to May), including mai (January to March).*

Question: Do the post mortem signs of liei caused by rom differ from those of liei caused by water?

- *There are some differences. With liei caused by rom there is shivering, diarrhoea, weakness and death. There is nothing to see in the liver but still the animal is very thin. There is not much blood in the cow. In wet times, there are many things in the grass like small snails which stick to the grass. These cause the liver disease macueny in which there are things moving in the liver. The meat becomes full of water and tasteless. There is no sign that differentiates the two types of liei when the animal is alive.*
- *Liei caused by water can be compounded later in the year by liei caused by rom.*

Overall, this information suggested that the name *macueny* applied specifically to diseased livers that were observed in dead animals. In other words, *macueny* was essentially a post mortem diagnosis. Before death, most cattle showing signs such as chronic weight loss, diarrhoea and tearing would be called *liei* and it was only after death that *liei* caused by biting flies would be distinguished from *liei* caused by liver flukes i.e. *macueny*.

Regarding treatments for *liei*:

- *'We use the red tablets (*Ethidium*). If there is no other medicine we dissolve ampicillin capsules in water and inject them'.*
- *'The red tablet is the best of these medicines. The latter is only used in emergencies'.*
- *'We also use drench for liei'.*

Question: Which is best medicine for *liei*, the red tablet or drench?

- *'It is best when both medicines are used. The disease clears when you use both. If only one medicine is used, the disease does not clear completely'.*

These ideas were developed further by asking people to think about mixed infections and the possibility that thin cattle could be suffering from more than one disease. This concept seemed to readily understood and informants explained that many different types of worms and other parasites could be found in a single animal.

Thiet

Figure 13 shows that in Thiet, both *liei* and *jong acom* were linked to wet grass and flooding, but *liei* alone was strongly associated with biting flies and only *jong acom* was associated with liver flukes (as seen in a dead animal) and snails. When the matrix scorings had been completed, informants were asked to think about the scores they had given to *liei* and *jong acom*, and in particular, explain how they distinguished between these two diseases in the live animal. This line of questioning revealed that:

- Although loss of tail hair was an important sign for separating *liei* from *jong acom*, this sign only appeared towards the end of the sickness when the animal was already in very poor condition. As a distinguishing feature of *liei* this sign was not very useful until the disease was advanced.

- The diagnosis of *jong acom* was dependent on the detection of *guak chom* (liver flukes) in the liver i.e. *jong acom* was often a diagnosis that was only reached after the animal was dead. Hard, bile deposits in the liver were also called *chom* and the local aetiology for this disease involved consumption of small snails on wet grass by cattle followed by the appearance of snail shell-like *chom* in the liver and 'young snails' called *guak chom*.

- Cattle were exposed to biting flies, snails and swampy areas for large parts of the year (see seasonal calendars later). These factors were strongly associated with chronic weight loss but could not be used to distinguish an animal suffering from *liei* as opposed to an animal suffering from *jong acom*.

- Some people stated that *jong acom* caused more diarrhoea than *liei* and also caused abdominal pain. However, these differences were not thought to be obvious in all cases.

- Informants generally agreed that it was possible to find *guak acom* in the carcase of an animal that also had loss of tail hair. This point led into discussion on mixed infections and the notion that an animal could harbour many different types of parasite at the same time. This idea was understood and supported by statements such as *'If you open any of these cattle you will find the parasites that you have shown us. There are many kinds of parasites in these cows'*.

Overall, the matrix scoring and interviews indicated that cases of *liei* could be either trypanosomosis alone, fasciolosis alone or mixed infections. Also, cases of *jong acom* could be infected with liver flukes alone, or liver fluke and trypanosomes. When presented with this complex picture, one cattle camp leader in Diang agreed that diagnosis was not easy: *'Its like we're fishing* (for the answer)*. Different people say different things; each has his own idea'.*

Lankien

Much less information was collected in Lankien than in Nyal or Thiet, and ideas on ways to distinguish different types of *noi* are described in section 3.2.2. These ideas could be summarised into two main groups. One line of thinking was based on the concept of *noi* as an end-stage condition that developed in cattle that failed to recover from any long-standing disease i.e. *'all diseases go to* noi'. Other people felt that *noi*, and different types of *noi*, were diseases in their own right and quite distinct from other chronic diseases such as *jok puoth* (CBPP) or *juol* (chronic manifestations of FMD).

For the two types of *noi*, one form *noi taraw* was associated with pale, thin cows that recovered following treatment with Ethidium whereas the other form *noi chiue* was linked to liver flukes and treatment with albendazole. These informants agreed that it was possible for both types of *noi* to exist in the same animal and that separation of *noi-chuie* from *noi-taraw* was problematic.

3.3 Post mortem examination of chronic wasting cases

Sixteen cattle suffering from chronic wasting were purchased and slaughtered for post mortem examination. The mean age of these cattle was 7.8 years and the age range was 3 to 12 years. Fourteen of the cattle were female and 2 were male. Details of case history, clinical signs and post mortem findings for each case are summarised below.

3.3.1 Case histories

The key feature of the case histories was gradual loss of body condition over periods ranging from 6 months to 3 years. In 3 cases, loss of tail hair was reported and diarrhoea was reported in 2 cases. In cows, a history of abortion followed by a failure to conceive was noted and in other cases, calves had not survived. Information on case histories is summarised in Table 8.

Table 8. Summary of case histories for cases of chronic wasting

History	Number of cases
Chronic weight loss	16
No response to treatment[1]	9
Loss of tail hair	3
Poor appetite	3
Diarrhoea	2
Tearing	2
Abortion	2
Failure to conceive	1
Reduced milk yield	1
Death of calves	1
Poor coat	1

1 - 9/16 cases were treated; see Table 9

Table 9. Use of veterinary drugs in cases of chronic wasting

Drugs used	Case numbers
Albendazole and oxytetracycline	N1, T1
Albendazole and Ethidium	T3
Ethidium alone	N6, L3
oxytetracycline alone	N4, N5, N7, N10

Treatments had been tried without success in 9 cases and the use of veterinary drugs is summarised in Table 9. Information is presented according to case numbers so that Table 9 can be compared with information in Table 11 on pathological and parasitological findings. Oxytetracycline was obtained in injectable form from CAHWs or as tablets from human pharmacies. The latter were crushed, mixed with water and injected by livestock keepers.

3.3.2 Clinical findings

Clinical findings are summarised in Table 10. The clinical finding common to all cases was emaciation. In 8 cattle the coat was in poor condition with irregular alopecia and in 5 cattle there was loss of hair from the tail. Loss of tail hair occurred at the tip of the tail and in 2 cases the entire tail tip was absent.

In cattle showing tear staining, this sign seemed to result from 'sunken eyes' and overflow of tears down the face. Three animals showed more marked ocular lesions and evidence of corneal damage.

Eight animals were infested with ticks. Amblyomma species predominated followed by Hyalomma species. Infestations usually involved approximately 20-50 ticks. Three cattle showed evidence of mild but chronic diarrhoea.

Table 10. Summary of clinical findings in cases of chronic wasting

Clinical sign	Number of cases
Emaciation	16
Poor coat condition	8
Tick infestation	8
Enlarged superficial lymph nodes	5
Loss of tail hair	5
Tear staining	5
Diarrhoea	3
Pale mucus membranes	3
Corneal ulceration/scarring	3
Laboured respiration	3
Elevated pulse rate	2
Muffled heart sounds	1
Dehydration	1
Bottle jaw	1

3.3.3 Gross pathology

Gross pathological findings are summarised in Table 11 overleaf. Infection with parasites *and associated lesions* were a common finding. Results presented are restricted to those parasites that were considered to be potentially important pathogens and include Haemonchus (9/16 cases), schistosomes (14/16 cases), liver flukes (11/16 cases) and trypanosomes (2/16 cases). Serological tests for trypanosomes indicated that 11/15 cases had experienced trypanosome infection either previously, or at the time of the post mortem examination. In 14/16 cases there was evidence of mixed infections involving 2, 3 or 4 different parasites.

Packed cell volume (PCV) - the mean PCV for the 16 cases of chronic wasting was 19.6%. The range of PCV values was 10.0% to 28.0%.

3.3.4 Histopathology

Histopathology highlighted the nature and widespread occurrence of lesions related to schistosome infection. Fourteen animals showed changes that were interpreted as having been caused by these parasites. Schistosoma-related damage affected the portal vessels of the liver and the walls of the small and large intestine. The mucosa of the small intestines of 14 animals was infiltrated by excess numbers of eosinophils and lymphocytes and the appearance of this inflammatory cell response strongly suggested parasitic enteritis. In those areas where schistosome infection does not occur, if any, the inflammatory response in the mucosa would indicate a diagnosis of parasitic enteritis.

Liver fluke has caused extensive injury in some animals and lesser insults to others. Twelve or thirteen livers (out of 16) showed lesions that suggest infection by adults and/or larvae. Again there is some overlap between the lesions caused to portal areas by liver flukes and those resulting from schistosomal vasculitis.

Sarcocyst infection was almost universal in these cattle. The level of infection varied from slight to heavy but the accompanying myocarditis was not obviously related to the weight of infection in the myocardium or Purkinje fibres. Four cases of epicarditis or endocarditis were found. These were predominately lymphocytic in nature but the cause could not be determined with any certainty.

Renal lesions were extremely common. Mild multifocal lymphocytic aggregates, occasionally accompanied by local tubular or glomerular damage, have formed in the cortex and less commonly in the outer medulla. The multifocal distribution and the interstitial/perivascular location of the lesions indicates haematogenous spread of the aetiological agent. Trypanosomes and Gram-negative bacteria should be included in the list of differential diagnoses. Generally the damage was mild and in no case was renal function likely to have been significantly impaired.

Other lesions included sporadic cases of pneumonia with differing causes e.g. aberrant parasite migration, diffuse proliferative interstitial pneumonia (which might be trypanosome-related) and exudative bacterial pneumonia. Two cases of purulent lymphadenitis and one with excess eosinophils were seen. Single cases of focal splenitis and of diffuse non-suppurative hepatitis were found.

In summary, histopathology confirmed the presence of injury caused by liver fluke and schistosomes, and suggested there may be a significant parasitic enteritis problem. Histopathology was unable to elucidate the role of trypanosomes in these cattle.

There were no other lesions in these tissues to suggest that the debility of these cattle was caused by some unrecognised infectious or degenerative disease.

Table 11. Pathological findings in cases of chronic wasting in adult cattle in Nyal, Thiet and Lankien

Owner's diagnosis	Case number		Parasites and associated gross lesions					Other gross lesions
			Haemonchus with abomasitis	Schistosomes with mesenteric vasculitis	Liver flukes with hepatic fibrosis, bile duct thickening, calcification	Trypanosomes		
						parasitological diagnosis	serological diagnosis	
liei	Nyal	N1	-	++	-	-ve	ms	Cachexia, dehydration, diarrhoea
liei		N2	++++	+++	+++	-ve	+ve	Very thin carcass
liei		N3	+++	++	-	-ve	+ve	Cachexia, oedema
liei		N4	++++	+++	+++	-ve	+ve	Cachexia, oedema, LV hypertrophy
liei/maguar		N5	-	+++	++	-ve	-ve	Cachexia, oedema
liei		N6	-	+++	+	-ve	-ve	Thin carcass
liei/maguar		N7	-	+	-	-ve	+ve	Thin carcass, splenomegaly
liei		N8	+++	++	+++	+ve *Tc*	+ve	Thin carcass, splenomegaly
no diagnosis		N9	+++++	+++	+	+ve *Tc*	+ve	Cachexia, oedema, pleural & pericardial effusion, 'flabby' heart.
maguar		N10	+++	++	++	-ve	+ve	Thin carcass
liei	Thiet	T1	-	-	+++	-ve	+ve	Cachexia
no diagnosis		T2	+	+++	+	-ve	+ve	Cachexia, oedema
liei		T3	-	-	+	-ve	+ve	Thin carcass, focal pleural adhesions
noi	Lankien	L1	++	+++	+++	-ve	+ve	Cachexia, 'flabby' heart
noi		L2	-	++	-	-ve	-ve	Thin carcass
noi		L3	++	++	-	-ve	-ve	Thin carcass, focal pericardial adhesion
no. cases in which parasitic lesions were detected			9/16 (56%)	14/16 (88%)	11/16 (69%)	2/16 (13%)	11/15 (73%)	

(see overleaf for explanatory notes)

Notes for Table 11

Haemonchus	- = no parasites seen; + = 0-500 parasites; ++ = 500-1000 parasites; +++ = 1000-5000 parasites; ++++ = 5000-10000 parasites; +++++ = > 10000 parasites
Schistosomes	- = no parasites seen; + = parasites difficult to detect, low numbers; ++ parasites readily detected and obvious blood vessel lesions; +++ = more parasites than ++ and lesions more severe and widespread. Schistosomes were identified as *Schistosoma bovis*.
Liver flukes	- = no parasites seen; + = small numbers of flukes and mild bile duct thickening; ++ = moderate numbers of flukes, marked bile duct thickening, hepatic fibrosis and calcified foci; +++ = large numbers of flukes, severe bile duct thickening and impaction with bile concretions, marked hepatic fibrosis. Flukes were identified as *Fasciola gigantica*.
Trypanosomes	Parastological diagnosis for Nyal cases was based on thin smears and for Thiet and Lankien cases, the microhaematocrit centrifugation technique. ELISA was used to detect trypanosome antibody. Tc=*Trypanosoma congolense*.

ms = missing sample

3.4 Prevalence estimates for parasite infections

Prevalence estimates for parasite infections are summarised in Table 12.

Table 12. Summary of prevalence estimates for gastrointestinal nematodes, liver flukes and trypanosomes in the PAVE study areas

Location	Gastrointestinal nematodes	Fasciolosis	Trypanosomosis	
			serological diagnosis	parasitological diagnosis
Nyal	46.0% (n=446)	21.1% (n=437)	45.0% (n=365)	9.6% (n=365) thin smears
Thiet	50.2% (n=598)	15.3% (n=575)	45.5% (n=633)	6.0% (n=633) MHCT
Lankien	61.0% (n=202)	14.0% (n=186)	54.5% (n=198)	1.5% (n=191) MHCT

MHCT=microhaematocrit centrifugation technique

Prevalence of fluke was estimated by detection of fluke eggs in faeces. Prevalence estimates from Nyal were 21.1% (n=437), Thiet 15.3% (n=575) and Lankien 14.0% (n=186). There was no correlation between the prevalence of fluke eggs and age or sex factors.

Prevalence of gastrointestinal nematodes was estimated by detection of worm eggs in faeces. Prevalence estimates for Nyal were 46.0% (n=446), Thiet 50.2% (n=598) and Lankien 61.0% (n=202). There was a negative correlation between age and presence of worm eggs ($p<0.05$) in Nyal and Thiet.

In Nyal, prevalence of pathogenic trypanosomes was determined by examination of thin smears and indicated a 9.6% prevalence (n=365). In Thiet, the microhaematocrit centrifugation technique (MHCT) was used and indicated a 6.0% prevalence (n=633). Parasitaemias were considered to be low with only a single trypanosome detected in most buffy coats. In Lankien, a MHCT method was

also used but the method was considered to be less sensitive than the MHCT method in Thiet[15]. A prevalence of 1.5% was obtained.

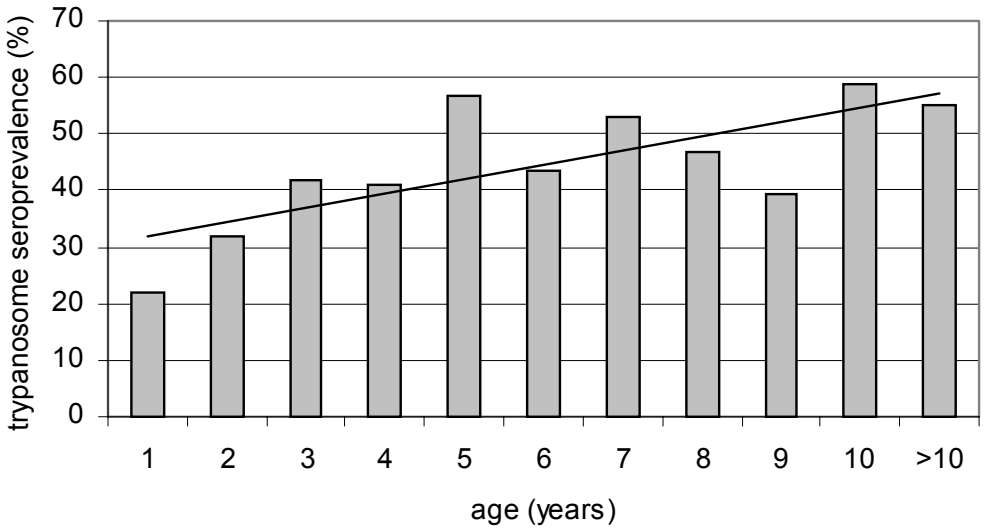
Trypanosoma congolense was the predominant trypanosome species, representing 74.2% (26/36) of cases in Nyal, 94.7 % (36/38) of cases in Thiet and 100% (3/3) of cases in Lankien. The only other trypanosome species identified in Nyal and Thiet was *T.vivax*.

Trypanosome antibody was detected by ELISA and prevalence estimates for Nyal were 45.0% (n=365), Thiet 45.5% (n=633) and Lankien 54.5% (n=198).

For parasitological diagnosis of trypanosomosis in Nyal and Thiet, and for serological diagnosis in all three sites there was a significant correlation between positive cases and age ($p<0.01$). Overall trypanosome seroprevalence by age group for all three study sites is shown in Figure 17. Annual trypanosomosis incidence rate was calculated at 5.9%.

The mean PCV of cattle sampled in Nyal, Thiet and Lankien was 24.6% (SD 4.51), 27.9% (SD 3.82) and 28.5% SD 4.27) respectively.

Figure 17. Estimated trypanosome seroprevalence by age group



Note: the trend line in this graph was applied automatically by the software package.

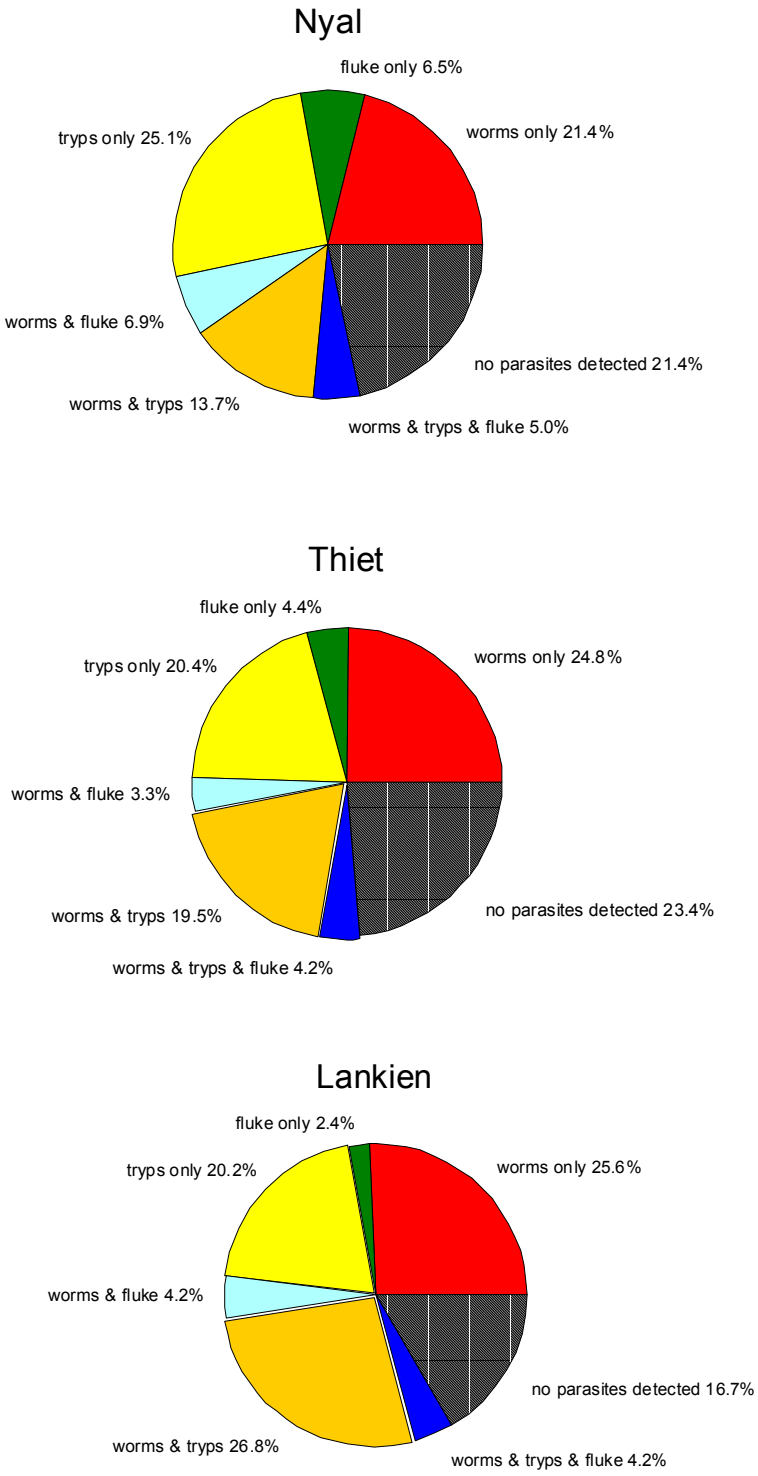
Examination of thin blood smears provided limited evidence of Babesia, Anaplasma or other tick-borne haemoparasites.

Prevalence estimates for mixed infections

In order to estimate the prevalence of mixed parasite infections, data was compiled for all individual cases for which complete sets of results were available for gastrointestinal nematodes, liver flukes and trypanosome (antibody). Results are summarised in Figure 18 and show similar patterns of no infection, single infection and mixed infections in the three study sites.

[15] Refer to section 2.8 for details of the variation in MHCT used in Lankien and Thiet.

Figure 18. Proportions of cattle with evidence of no infection, single infections and mixed infections



<u>Notes</u>
Tests for detecting liver fluke eggs and worm eggs in faeces had low sensitivity. The timing of sample collection was as follows: Nyal - early wet season; Thiet - dry season; Lankien - late wet season. Results from the 16 post mortem examinations are not included. *S.bovis* circulating antigen results not available at time of writing.

4.0 DISCUSSION

4.1 Comparing indigenous and western knowledge

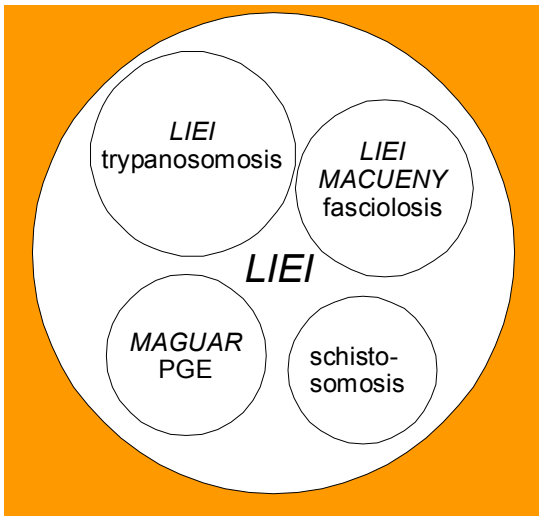
This research demonstrated much overlap between indigenous knowledge on diseases such as *liei, noi, macueny* and *jong acom*, and western diseases such as trypanosomosis and fasciolosis. When looking at the linkages between these two bodies of knowledge, the study focussed on those aspects of health problems that were visible macroscopically rather than microscopic lesions or pathogens. This approach assumed that livestock keepers could not be expected to see those things that veterinarians see with microscopes and biochemical devices, and, that livestock agencies and CAHWs in southern Sudan are almost totally dependant on the use of case history, clinical signs and post mortem signs to diagnose disease.

Livestock keepers in southern Sudan characterise chronic wasting disease in cattle using criteria that are very similar to those used by veterinarians. Although the signs of *liei* and *noi* were non-specific, herders used information on seasonal occurrence, exposure to disease vectors and intermediate hosts, and post mortem findings in order to identify different causes of chronic wasting. As mentioned above, cattle keepers could not be expected to recognise microscopic disease agents and with this in mind, the naming of chronic wasting diseases and associations between disease and visible factors were rational and very closely related to modern veterinary thinking.

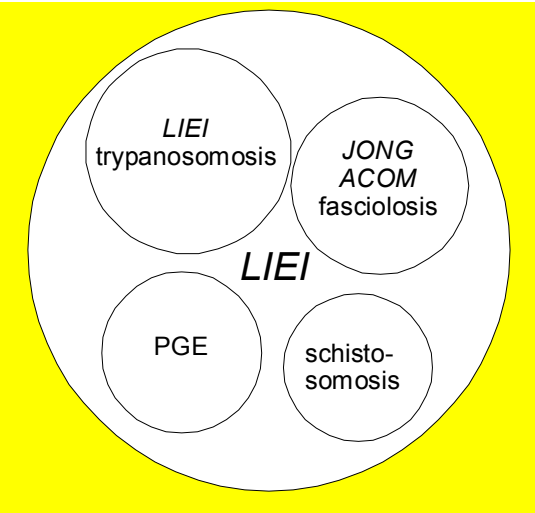
The local disease names *liei* and *noi* encompass various diseases that are recognised by veterinarians. These 'western' diseases occur as single entities and as mixed infections involving up to four groups of parasites viz. trypanosomes, liver flukes, schistosomes and gastrointestinal nematodes. In cattle suffering from chronic wasting that were examined post mortem, 14/16 cases showed evidence of mixed infections involving 2, 3 or 4 different parasites. This pattern of infection in debilitated cattle is similar to that reported by Mefit-Babtie (1983) and Fison (1993). In chronic wasting cases from Nyal, Thiet and Lankien, gross pathology revealed lesions due to liver flukes, schistosomes and gastrointestinal nematodes, and these findings were supported by histopathology. Microscopic examination also showed lesions suggestive of trypanosomosis. Post mortem findings were supported by estimates of parasite prevalences, although the low sensitivity of diagnostic tests probably led to under-estimations of prevalence.

Figure 19 illustrates the relationships between Nuer and Dinka disease names, and diseases recognised by veterinarians. Regardless of whether a case involved single infections or combined infections, the animal in question would have a similar clinical appearance.

Figure 19. Relationships between Nuer and Dinka names for chronic wasting in cattle, and western disease names

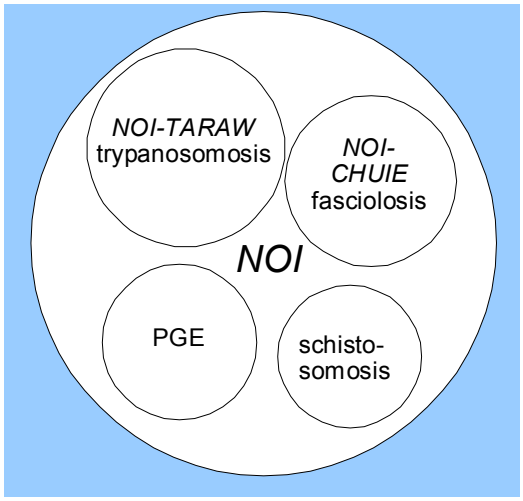


Nyal (Nuer)
Two forms of *liei* were recognised. One form of *liei* was associated with Tabanids (*rom*) and other biting flies, flooding and oedematous, pale carcasses. The other form of *liei* was associated with snails (*chom*), flooding and diseased livers containing liver flukes (*daichom*). This second form of *liei* was also called *macueny,* a name that refered specifically to livers affected by fasciolosis-type lesions. The two forms of *liei* were not readily distinguished on clinical grounds. The disease *maguar* was associated with gastrointestinal worms and was thought to develop into *liei* if untreated. **The disease name *liei* encompassed all of these problems.**



Thiet (Dinka)
The diseases *liei* and *jong acom* ('disease of snails') were similar to the diseases *liei* and *macueny* in Nyal. Although loss of hair from the tail was often cited as a clinical sign that distinguished *liei* from *jong acom*, this sign appeared relatively late in the course of the disease. Also, while *jong acom* was thought to cause abdominal discomfort and more diarrhoea than *liei*, these signs were inconsistent features of the disease. In common with *macueny* in Nyal, the name *jong acom* was linked to the observation of livers affected by fasciolosis. **The disease name *liei* encompassed all of these problems.**

Lankien (Nuer)
In Lankien, there was agreement regarding the clinical signs of *noi* but varied opinions concerning the cause of the disease. Some people considered *noi* to arise as a result of any long-standing disease or problem such as poor gazing. Other people described two distinct forms of *noi* called *noi-chuie* and *noi-taraw*. These descriptions were virtually identical to the two forms of *liei* described in Nyal that related to flukes/snails and biting flies respectively.



Regarding the likely pathogenesis of chronic wasting in cattle, the four groups of parasites identified during the research share a common and important feature viz. they all cause a clinical syndrome of gradual weight loss through an underlying pathology of anaemia. In terms of indigenous knowledge, the presence of anaemia tends to fit herders' post mortem descriptions and the researchers' observations of *liei, noi* and *jong acom* cases during this research, and previous reports (Blakeway et al., 1996; Lindquist et al., 1996). For example, cattle owners consistently described thin, 'watery' and pale carcasss in relation to *liei, noi* and *jong acom.* It was also interesting to note the opinions of some informants in Lankien who suggested that all unresolved and long-standing diseases *'go to noi'*. In other words, for these herders *noi* was an end-stage condition with various initial causes.

<u>The role of biting flies</u>

In the minds of cattle keepers in Nyal, Lankien and Thiet, the fly that was most consistently associated with chronic wasting in cattle was called *rom* (Nuer) or *rum* (Dinka). These flies were repeatedly and confidently identified by informants either when observing specimens in isolation, or when comparing different types of flies. Both *rom* and *rum* were identified as Tabanids by the researchers, and the presence of these flies in southern Sudan has been noted on numerous occasions by other workers (e.g. Evans-Pritchard, 1940; Rahman et al., 1991b).

Informants in both Dinka and Nuer areas also used specific names for Hippoboscid flies, calling them *atek* and *tharkwach,* and associated these flies with *liei* and *noi*. Evans-Pritchard (1940) noted the link between *tharkwach* and *noi* more than fifty years ago. In western veterinary medicine, Tabanids and Hippoboscids are known to be mechanical vectors of *T.vivax* and therefore, there is some overlap

between herders' views on the role of *rom/rum* and *tharkuach/atek* in *liei/noi*, and the identification of *T.vivax* in cattle. However, the most common trypanosome species identified in the study sites was *T.congolense,* a finding that agrees with previous surveys in southern Sudan. According to many tsetse and trypanosomosis workers, *T.congolense* is not transmitted mechanically, but cyclically.

Of the three study sites, only informants in Thiet were able to name tsetse flies and offer confident opinions regarding their significance. In general, such informants were few and used the name *mau* when shown samples of tsetse. The name *mau* seems to have been in use in southern Sudan for at least 140 years and was noted by workers in the 1860s (Lewis, 1949). In terms of proximity to known tsetse areas, Thiet was closer to the tsetse belt than Nyal and Lankien (Map 3). Also, there was some seasonal movement of Dinka cattle towards tsetse areas, as described in Map 7. These factors indicate that indigenous knowledge about tsetse was due to people's actual experience of the fly. In general, the estimated prevalence of *T.congolense* in Thiet could be explained by tsetse transmission of the parasite.

The situation in Lankien and Nyal regarding the transmission of trypanosomosis was less clear. Although low to moderate prevalence of *T.congolense* was detected, there was no evidence from the literature or indigenous knowledge to indicate presence of tsetse. These findings agree with numerous reports form southern Sudan of disease due to *T.congolense* in areas far outside the known tsetse belt. Although it might be argued that small populations of tsetse remain undetected in Upper Nile, it was surprising that informants did not recognise tsetse flies although they were knowledgeable about a range of disease causes, signs, vectors and epidemiological factors.

The role of snails

Livestock keepers in all three study sites made strong associations between snails, liver flukes and some of the chronic lesions of fasciolosis. Typically, liver flukes were regarded as 'young snails' and the hard, rounded and coloured concretions of bile seen in chronically diseased livers had a similar appearance to snails. Small snails adhering to wet grass, particularly in flooded areas, were thought to be consumed by cattle and the young snails passed into the liver. Considering that herders could not be expected to know about the microscopic larval stages of liver flukes, the similarity between their understanding of liver fluke development and the complex life-cycle that is known by veterinarians, was striking. The research did not attempt to discover whether herders recognised (and named) different species of snails. However, interviews and participatory mapping showed that the snails that were associated with sick cattle were located in swampy areas and pools.

Schistosomes and the chronic wasting problem

It was notable that during the 16 post mortem examinations conducted during the research, livestock keepers did not appear to recognise schistosomes in mesenteric blood vessels. There were no specific local names for these parasites and they were not associated with particular health problems. This apparent deficit in indigenous knowledge might relate to the difficulty in observing schistosomes which although quite large parasites (up to about 1.5 cm in length), can only be seen if the mesentery is stretched so that the worms become visible in the flattened blood vessels. Also, the worms cannot be seen once the blood has clotted. While herders seemed to lack knowledge about schistosomes, there was little evidence to show that veterinarians working in southern Sudan were better informed. Although the veterinary literature from Sudan notes the importance of schistosomosis as a cause of chronic weight loss in cattle, the disease did not feature in the livestock programme in southern Sudan. This issue is discussed more fully in section 4.2 and 4.3.

Jul and 'chronic' foot and mouth disease

Matrix scoring of the disease *jul* in Thiet showed strong associations between *jul* and 'rough coat', 'animal seeks shade' and 'reduced milk yield' (Figure 6). Also, the problem caused difficult breathing, followed a prolonged course measured in months and years, and was evident in cattle previously affected by *dat* (FMD). Although chronic manifestations of FMD are not well described in recently

published veterinary textbooks, one account noted that *'A sequel to foot and mouth disease in cattle, due probably to endocrine damage, is a chronic syndrome of dyspnoea, anemia, overgrowth of hair, and lack of heat tolerance described colloquially as panting'* (Radostits et al., 1994). Consequently, there was much similarity between herders' descriptions of *jul* and vets' descriptions of chronic FMD.

Ticks

Regarding the role of ticks (*chak* or *achak*) as causes of disease, these parasites were not thought to be a cause of chronic wasting disease (Figures 9 and 10). Occasionally, informants gave moderate scores for ticks against *liei* or other chronic diseases but invariably, explained that ticks tended to seek out sick cattle and exacerbated existing illnesses. Blood smears examined during the research provided limited evidence of Babesia, Anaplasma or other tick-borne diseases. Amblyomma ticks, as observed frequently on thin cattle, cause substantial blood loss.

4.2 Lessons learned about approaches and methods

4.2.1 Participatory appraisal methods

One aim of the research was to assess the value of participatory appraisal (PA) in veterinary investigation in southern Sudan. Part of this process involved the repetition of standardised methods in order to determine their repeatability[16]. In addition, data produced by PA methods was compared with conventional data in order to assess the validity of the PA data.

Repeatability

Both the standardised matrix scoring method and standardised seasonal calendar produced similar results from different groups of informants, as determined by Kendall's Coefficient of Concordance. For the disease-signs matrices, 9/11 and 11/12 disease signs were scored with moderate to high levels of agreement in Nyal (Figure 5) and Thiet (Figure 6) respectively. For the disease-causes/sources matrices, all 8 indicators were scored with moderate to high levels of agreement in both Nyal (Figure 13) and Thiet (Figure 14). The 10 seasonal calendars produced in Thiet showed agreement over seasonal variations in 4/5 of the diseases and 5/6 of the flies, ticks and snails (Figure 14). These results indicate that PA methods can produce repeatable results with quite small sample sizes e.g. only 7 informant groups scored the disease signs and causes in Thiet. Furthermore, key informants were not specifically sought out by the researchers and therefore the results reflect the views of typical livestock keepers in the study sites. The results were achieved despite the somewhat vague, non-specific clinical signs of *liei, noi* and similar diseases.

Validity

The study did not attempt to judge the validity of PA results using quantitative comparisons with conventional data. To a large degree, it was felt that the low sensitivity of the diagnostic tests used for prevalence estimates, as discussed in section 4.2.2 below, would limit the value of such comparisons.

Consequently, the study attempted to judge the validity of herders' opinions by making a qualitative comparison of the results obtained by PA with descriptions of diseases and parasites in veterinary textbooks, clinical and post mortem examination of sick cattle, and to a lesser extent, prevalence estimates for parasitic diseases. As described in section 4.1, this comparison revealed considerable overlap between indigenous knowledge and modern veterinary knowledge. For example, during matrix scoring the scores allocated to the control diseases *dat* and *doop* in Nyal, and *abuot pou* and *cual* in Thiet were as expected. Furthermore, although some vets in the OLS Livestock Programme tended to use the disease name *liei* as a synonym for trypanosomosis, matrix scoring of disease

[16] Repeatability can be defined in terms of agreement between sets of observations made on the same animals by different observers.

causes in Nyal and Thiet showed that *liei* was not only associated with biting flies. Other 'causes' of *liei* were snails and flooding (Nyal and Thiet), liver flukes and worms (Nyal), and wet grass (Thiet). These results indicated that *liei* was a mixed infection and this finding was confirmed by post mortem examination of chronic wasting cases.

The comparison of rainfall data obtained from seasonal calendars in Thiet and objective measures of rainfall from FEWS indicated good validity of local assessments of seasonal rainfall patterns.

Issues concerning the standardisation of participatory methods

Many of the methods used in participatory inquiry evolved from the qualitative research methods of social scientists. Qualitative research includes the use of inductive methods that are open-ended and allow scope for following up interesting and unexpected topics. Participatory inquiry usually aims to understand issues and problems within a local, specific context, leading to action that is locally-appropriate. In comparison with quantitative research methods, participatory methods are more flexible and are not constrained by questions that are all predetermined by the researchers. Although there is now growing interest in ways to quantify participatory methods and analyse the results using statistical tools, this way of working was deliberately avoided during the early development of PRA.

The standardised matrix scoring tools used in this research were designed in an attempt to retain some of the core features of participatory approaches and methods whilst also allowing direct comparisons between different informants groups, and quantifying levels of agreement. In the event that different people provided similar information, results from numerous informants might then be summarised in a succinct form. Regarding the participatory aspects of the standardised matrix scoring, the main subject under investigation i.e. chronic wasting in cattle, had already been identified as a local priority. During the development of the matrix scoring method, local disease names and local indicators of disease (signs and causes) were used in the matrix. The researchers added two 'control diseases' to each matrix and one 'control indicator' to check that informants understood the scoring procedure. The use of open and probing questions after the completion of the scoring introduced flexibility and potential to discuss issues not represented in the matrix.

The summarised scoring matrices (Figures 5,6,12 and 13) show results both pictorially and numerically, provide measures of agreement between informants groups (W statistic) and describe the spread of the scores for each indicator against each disease (95% confidence limits). However, the results of statistical tests need to be interpreted carefully. For example, although groups of informants might agree about a particular issue (as demonstrated by a high W value and significance), this does not necessarily mean that the information is correct in a technical sense. In this research, most of the associations described in the matrices agreed with modern veterinary thinking and therefore, the researchers considered many of the findings to be valid. However, this might not be the case for other diseases in other parts of southern Sudan.

Another important point is that although these diagrams provide a useful summary of some of the main associations between disease signs and causes, the results of follow-up questioning were equally important. This aspect of the method has implications with regards to the wider application of this or similar methods within the OLS Livestock Programme. In particular, although it should be straightforward to train people how to facilitate the formation of the matrices and the scoring, it will probably be far more difficult to teach people how to 'interview the matrix', cross-check the data and explore inconsistencies and interesting results. Furthermore, while a matrix tends to produce a fairly neat set of numbers that can be recorded easily, documenting the additional questions and answers is usually more time-consuming and requires more thought on the part of the researchers. These methodological features indicate that attempts to 'scale-up' the method should pay particular attention to developing the interviewing skills of the researchers. The consistent use of a standard method would allow indigenous knowledge from different areas to be compared and summarised.

4.2.2 Conventional veterinary investigation methods

Diagnostic tests

When a disease is characterised by vague clinical signs, vets often use laboratory tests in order to identify a specific disease agent or agents. For example, the examination of blood might reveal the presence of trypanosomes, thereby confirming a diagnosis of trypanosomosis. In part, the value of a laboratory test is determined by it's sensitivity[17]. Using the example of trypanosomosis, a test with 'good' sensitivity might detect trypanosomes in 90 or more animals in a group of 100 cattle that were actually infected with trypanosomes. In other words, the test would have a sensitivity of 90% and 10 positive animals in the group would be missed by the test.

As the ability to diagnose disease is of fundamental importance in modern veterinary medicine, much effort and resources have been invested in developing sensitive and specific diagnostic tests. However, although trypanosomosis, fasciolosis and PGE are widely recognised as major livestock diseases in the tropics, veterinary researchers have not yet developed sensitive diagnostic tests that are suitable for field use. For example, the sedimentation method for the detection of fluke eggs is reported to be the most sensitive diagnostic method but detects only 30% of eggs in a sample (Happich and Boray, 1969). Similarly, the MHCT for the detection of trypanosomes probably has a sensitivity of only about 50%, and so 50% of positive cases will be missed by the test. Although not used in the present study, the detection of schistosome eggs in faeces has a sensitivity of 44% in adult cattle (De Bont, 1995). Considering these weaknesses in the veterinary investigation toolkit, the diagnosis of diseases such as trypanosomosis and fasciolosis in the live animal remains problematic and highly dependent on clinical judgement. This research was not able to verify whether the clinical judgement of vets was more accurate than that of livestock keepers.

Despite problems with the poor sensitivity of diagnostic tests mentioned above, the research showed that post mortem examination provides useful information on chronic wasting cases. The method is particularly suitable for diagnosing helminth diseases such as fasciolosis, haemonchosis and schistosomosis, and does not require sophisticated or expensive equipment. Therefore, the wider use of gross pathology by vets in the OLS Livestock Programme and the systematic documentation of results would assist the programme to develop more informed disease control strategies for helminth-related diseases. Also, it should be feasible to involve Animal Health Auxiliaries or other field staff in the inspection of carcasses at slaughter slabs. Ideally, results would be combined with participatory assessments, as outlined above.

Surveys and sampling methods

The operational context of southern Sudan tends to prevent the use of random sampling methods during disease surveys. Despite this, a number of workers have conducted surveys based on convenience sampling procedures and produced valuable information (e.g. McDermott et al.,1987; Majok et al.,1993). A participatory approach was adopted in the present study and the following experiences relate to the sampling method used:

- The use of participatory assessment and analysis before sampling provided an opportunity for livestock keepers to describe the chronic wasting problem and discuss the notion of mixed and complex infections. As dialogue developed, the researchers were able to explain that in common with herders, vets were sometimes unable to diagnose disease on clinical findings alone and therefore, further tests were needed. Using this approach and due to the local importance of *liei* and *noi*, herders quickly grasped the rationale for allowing their animals to be sampled. However, it was important to organise the work so that the participatory assessment preceded the sampling.

[17] Diagnostic tests are also assessed by their 'specificity'. Specificity of a test is a measure of the test's capacity to correctly identify the disease agent in question. In the present research, poor specificity was not considered to be a problem for the detection of fluke eggs, worm eggs or trypanosomes using the methods described, because the visualisation of eggs or parasites by the researchers affords high specificity.

- The sampling teams comprised CAHWs and AHAs who had been selected locally and who were members of the communities concerned. This approach probably improved the acceptance of the researchers and showed that basic-level workers could play a very useful role in sample collection.

- Perhaps due to the initial participatory assessment and use of local animal health workers described above, the sampling was not affected by some of the restrictions described by Majok et al. (1993) when sampling Dinka cattle. In Dinka cattle camps around Thiet, all ages and both sexes of cattle were sampled. When herders refused to allow animals to be sampled, this was usually because the cattle owner was absent and the people looking after the cattle were unwilling to make decisions on behalf of the absentee owner.

In theory, a random sampling method could have been developed for the present study. For example, in dialogue with local chiefs and cattle camp leaders, it might have been possible to produce maps showing the distribution and numbers of cattle in specific areas. These maps could then have been used as a sampling frame. However, in the researchers' opinion it was likely that logistical and security factors would have prevented the use of a more rigorous sampling procedure.

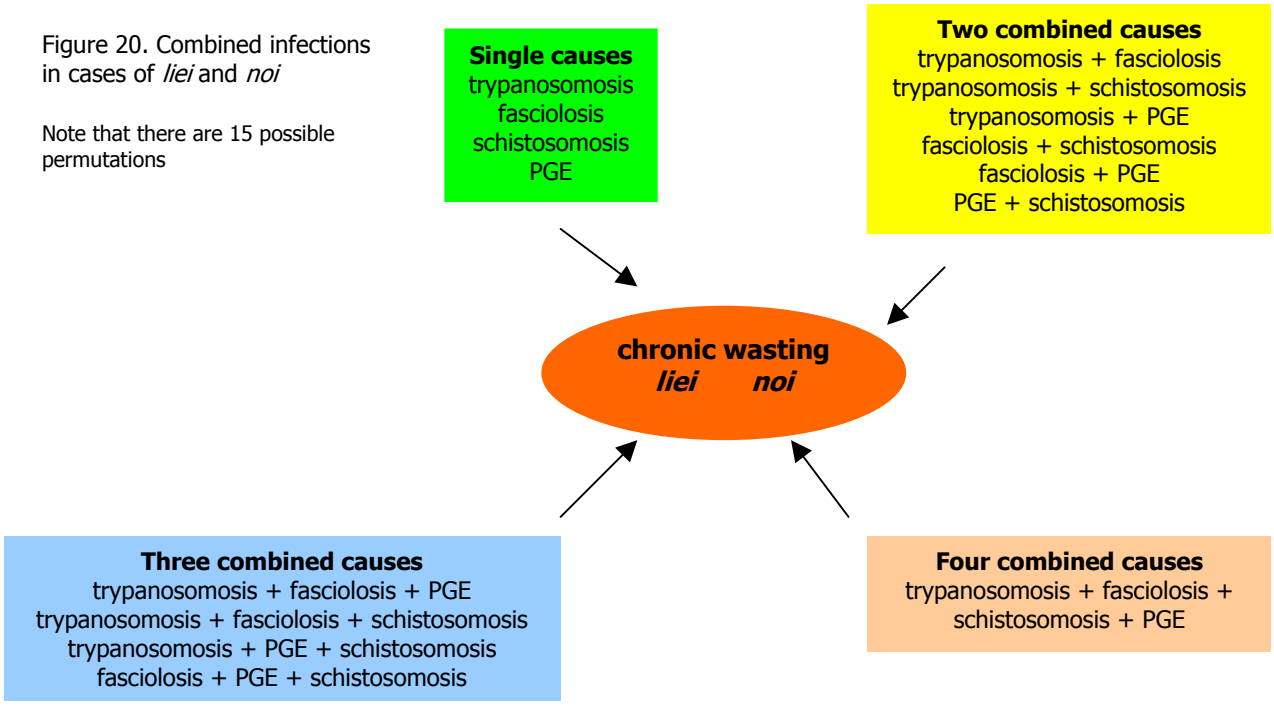
4.3 Ideas for further work

4.3.1 Testing different combinations of drugs for the treatment of liei *and* noi

A disease syndrome that incorporates both single and mixed parasite infections raises many technical questions concerning parasite interactions, relative importance of the difference parasites and appropriate control methods. In terms of prioritising further work within the existing veterinary programme in southern Sudan, the immediate need is probably to optimise the use of the veterinary medicines that the programme is already supplying. These medicines include ethidium and homidium for the treatment of trypanosomosis, and albendazole for the treatment of fasciolosis and PGE. However, the research indicated that in cases of *liei* and *noi*, trypanosomosis and fasciolosis often occurred concurrently with other diseases, as illustrated in Figure 20 below.

Figure 20. Combined infections in cases of *liei* and *noi*

Note that there are 15 possible permutations



This rather complex picture indicates that a specific diagnosis of 'chronic wasting' based on case history and clinical signs alone is likely to be problematic, if not impossible, for both CAHWs and vets. A further consideration is that the treatment of schistosomosis appears not to be feasible. At present, the recommended drug of choice is praziquantel and this drug is expensive and in some cases, treatment causes dead schistosomes to form emboli that cause further pathology.

In the absence of a specific diagnosis (or diagnoses) in cases of chronic wasting, an animal health worker will probably use a 'best bet' treatment. But what should this best-bet treatment consist of? The options include:

1. ***Simultaneous, combined therapy with trypanocide and albendazole*** (at flukicidal doses) in order to eliminate trypanosomes, liver flukes and parasitic gastrointestinal nematodes. This option will remove 3/4 different parasites but is relatively expensive.

2. ***Sequential use of trypanocide and albendazole.*** This option uses either trypanocide or albendazole initially, followed by the other drug in the event of poor response to the first treatment. This option might be less expensive than option 1. in some cases but when two treatment s are required, could be more expensive than option 1. because two visits from the CAHW are needed.

Despite operational difficulties in southern Sudan, it should be possible to conduct participatory assessments of these two treatment options. In short, cases of *liei* and *noi* could be assessed by livestock keepers and vets according to the severity of clinical signs before and after treatment. Results using option 1. would then be compared with results from option 2 in terms of differences in response to treatment, cost of treatment and ease of treatment.

When conducting this type of trial, it should be noted that when cattle are chronically sick due to parasitic infections, the removal of parasites does not necessarily result in recovery. In the case of trypanosomosis, anaemia can continue to develop in the absence of trypanosomes. Another consideration is drug resistance e.g. ethidium and homidium have been used in southern Sudan for many years. It is possible that poor response to treatment in *liei* or *noi* cases is associated not only with mixed infections and unresponsive anaemia, but also drug resistance. Therefore, it would be useful to assess levels of trypanocidal drug resistance when considering best-bet treatment options.

4.3.2 Combining indigenous knowledge and basic veterinary investigation methods

This report describes investigations that were conducted in three locations in southern Sudan and it is not intended that the research findings should be extrapolated to other areas. From a strictly epidemiological perspective, sampling procedures were non-random and heavily influenced by logistical factors. For much of southern Sudan information on those diseases that are associated with chronic wasting is limited.

The research highlighted the value of 'field-friendly' participatory methods for understanding local perceptions of the chronic wasting problem. If similar participatory assessments were conducted by each animal health agency working in southern Sudan, a considerable body of information would result. Ideally, a common methodology should be developed and training provided to the researchers involved.

As mentioned in section 4.2.2, useful information on helminth infections can be obtained from basic veterinary investigation methods such as post mortem examination. The extent to which this method is used in the field by vets is unknown, but there appears to be very few records of post mortem examinations in the OLS Livestock Programme. In view of this, opportunities for more systematic use and documentation of post mortems could be explored. For example, would it be feasible to implement surveys of cattle that are routinely slaughtered in villages? This might involve examination of cattle at selected sites where slaughter slabs were already established and where some kind of

incentive for local veterinary workers involved in the survey is feasible. The survey should focus on readily-detected problems such as fasciolosis and schistosomosis, and could relate gross parasitological findings to age and body condition.

4.3.3 Training

Regarding information and training needs in the livestock programme, participatory research on the chronic wasting problem highlighted the limitations of training courses based on specific western diseases rather than the clinical syndromes that are observed in the field. This training approach might encourage CAHWs and AHAs to view *liei* and *noi* cases as either trypanosomosis or fasciolosis, rather than a combination of these or other infections. Although the concept of mixed infections is a challenging training topic, the livestock programme might consider if and how CAHW and AHA training courses could emphasise the importance of mixed infections and the therapeutic implications.

At present the livestock programme provides no training in schistosomosis. It would be appropriate to include this disease in training sessions that describe *liei* and *noi* as disease families comprising single and mixed infections. Refresher training for veterinarians in schistosomosis might also be appropriate.

Although not documented in the results of this report, the researchers noted that CAHWs and AHAs commonly called tabanids 'tsetse flies'. When conducting further research and testing treatments for *liei* and *noi*, it will be necessary to ensure that this misunderstanding is corrected. Also, training messages and the identification of flies in training courses should be reviewed.

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