ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
AND
FREIE UNIVERSITAT BERLIN
FACULTY OF VETERINARY MEDICINE

PREVALENCE OF CAMEL TRYPANOSOMES & FACTORS ASSOCIATED WITH THE DISEASE OCCURRENCE IN LEBEN DISTRICT, BORENA ZONE, OROMIA REGION, ETHIOPIA

GETAHUN DEMEKE

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A thesis submitted in partial fulfilment for the degree of
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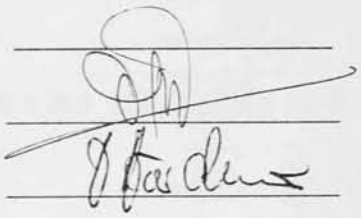
GETAHUN DEMEKE

Board of Examiners:

Dr. Yilma M.

Prof. Dr. Hörchner



Academic Advisors:

Dr. Baumann

Dr. Getachew A.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
BCT	Buffy coat technique
BLDP	Borena Lowland Development Project
CATT	Card aggultination test set
CBPP	Contagious bovine pleuropnemonia
CI	Confidence interval
DHB	Domestic herbivorous biomass
ELISA	Enzyme linked immuno sorbent assay
EpG	Eggs per gram of faeces
FMD	Foot and mouth disease
GIH	Gastrointestinal helminths
GTZ	German Technische Zusammenarbeit
IFAT	Immunoflourescent antibody test
OD	Optical Density
OIE	Office Internationale des Epizooties
PCV	Packed cell volume
PPR	Peste des petitis ruminants
SERP	South East Rangeland Project
SLDP	Southern Rangelands Development Project
TLDP	Third Livestock Development Project
Tryps	Trypanosomiasis
WBF	Wet blood film

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ABSTRACT

A cross-sectional study was undertaken to determine the prevalence of camel trypanosomiasis and to identify factors associated with the disease in the southern rangelands of Ethiopia. Multistage sampling was employed as sampling method. Wet blood smears, buffy coat technique and antibody ELISA were utilized as diagnostic techniques to determine the prevalence. A herd health management questionnaire was also used to collect relevant information on factors associated with the disease. Furthermore, a parallel survey of the helminth status was undertaken in dry season to assess a possible association with low PCV readings.

A total of 324 camels in 81 herds and 285 camels in 74 herds were sampled during wet and dry season, respectively. In rainy season samples prevalences of 10.2 % using parasitological methods and of 56.5% using antibody ELISA were found whereas parasitological methods revealed an infection rate of 2.8 % in dry season. Age, ecological conditions and season were found to be likely risk factors for the disease. A cumulative incidence of 0.03 and an incidence density of 3 cases per 10,000 animal days points to an extremely low disease dynamic during the dry season. *T. evansi* was the most common cause of camel trypanosomiasis; *T. vivax* was found in two camels.

Seasonal as well as age group differences in PCV values were observed. Moreover, the median PCV value of parasitologically infected individuals was found to be significantly lower than that of non-infected ones. However, there was no significant difference between serologically positive and negative animals. Infected camels which were treated during the first visit showed significant improvements in PCV at the second visit. It was also observed that concurrent infections with *Trypanosoma evansi* and gastrointestinal helminths significantly depressed the PCV compared to a single infection.

Camel helminthiasis was also found to be highly prevalent in the study area and may explain the low PCV values observed also in seronegative camels. Furthermore there is an indication that the EpG counts of parasitologically infected animals are higher than that of non-infected camels, however, not significant at the 5 % level ($P = 0.08$).

Data on production variables retrieved through a questionnaire are presented and compared to figures reported elsewhere. No associations were observed between crude mortality, age at first calving and calving interval and the factors ecological zone, management units, camel type, and individual as well as herd serological trypanosomiasis status.

Trypanosomiasis or locally known as *Dukane* was found to be the most important cause of camel death in immature (1-4 years old) and mature camels (4 years).

From the results it may be concluded that the disease is endemic in the area with considerable effect on camel production. Further longitudinal studies to identify the possible vectors and reservoirs of the disease seem meaningful to control the disease to a lower rate. Equally important is the establishment of a sound animal health extension system to create the awareness of the pastoralists for drug use and application. To address the needs of pastoralists, research has to be directed not only to camel trypanosomiasis but also to other camel diseases which appear to have also a considerable effect on camel production in southern Ethiopia.

1 INTRODUCTION AND OBJECTIVES

Ethiopia has one of the largest camel population in the world. Over one million camels were estimated to exist in the country. The proportion of camels in the total domestic herbivorous biomass (DHB) is 4% at the national level, and 35% in the semi arid and arid parts of the country. Camels are kept in the arid lowlands which cover 50% of the country and are the home range of over 2 million pastoralists. The major product is milk, with an official estimate of 174,000 tons per year, followed by 20,000 tons of meat. Hides, hairs and draught power are recognized as potential products but are not exploited to any significant extent (Schwartz and Dioli, 1992). Camels are also used as beasts of burden. The seasonal mobility of households and the social position of an individual in a community is determined by the numbers of camels kept.

Among many diseases known to affect camels, trypanosomoses is considered the most important protozoan disease and probably the most important health constraint to camel production. An infection rate ranging from 20-70% and mortality reaching up to 3% is common in enzootic area (Wilson, 1988).

Trypanosomoses generally takes a chronic course and production losses occur due to decreased milk production and meat yields in adults. Chronically infected animals may survive for three to four years. The chronic form is characterized by anaemia, emaciation, recurrent fever, disappearance of the hump, atrophy of the thigh muscles, oedema of the lower parts of the body, corneal opacity, diarrhoea, sexual excitement, abortion and premature births, and the inability to feed the suckling young greatly reduces the reproductive potential of herds (Boid *et al*, 1986).

Little research was done on camel trypanosomoses in Ethiopia. Literature available for Ethiopia indicates that the disease is a problem in this country (Pegram and Scott, 1976; Richard, 1979; Zeleke, 1982; Melaku, 1985; Wosene, 1991; Ketema, 1990; Tenaye, 1993; Theodros, 1995).

As it has been stated by Belete (1984) the Borena zone of the southern rangelands of Ethiopia is loosing grazing areas through bush encroachment and the Borena pastoralists, who have lost a large number of cattle due to droughts, have started to rely more on small livestock, particularly goats, and camels as a more reliable insurance against bad years. As a matter of fact the small stock and camel research programme in the Borena area had intended to assess the disease status during different seasons and to design sound and rational disease control strategies as one of its main objectives. No information is available as to the further progress of the programme.

Hence considering the growing reliance on camels and the importance of trypanosomoses in the pastoral production systems this study was undertaken to determine the prevalence of camel trypanosomoses in Leben, the district with the highest camel population in Borena zone of Oromia Region.

The objectives of this study are therefore to determine the prevalence of camel trypanosomoses and to identify intrinsic and extrinsic factors associated with the disease occurrence through individual clinical, parasitological and serological examinations and through herd level observations on relevant health and production parameters.

2 LITERATURE REVIEW

2.1 General description on the pastoralist areas in Ethiopia with camel husbandry

2.1.1 Pastoralist areas in Ethiopia

The pastoralist areas of Ethiopia are located in the lowlands of the country and cover 48% (590,000 sq. km) of the country, partially encircling the central highlands and in most cases including an international border. Free cross-border movement of livestock is possible depending on the availability of grazing resources. A wide variety of ethnic groups is dependent on rangeland production to support their livelihood. Benamir in the north, Afar and Issa in the north east and east, Somali in the south east, Borena and Gujji in the south and Arbore, Geleb, Hamer and Mursi in south west are the major pastoralist groups in Ethiopia (Solomon, 1993).

2.1.2 Climate

In the pastoralist areas of Ethiopia the rainfall patterns is unimodal and bi-modal (Table 1).

Table 1: Rainfall pattern in pastoral areas

Rain fall pattern	Time period	Region	Amount (in mm)
Unimodal	Dec. - Feb.	North and North East	200 - 600
Unimodal	June - August	Areas bordering Sudan	800 - 1200
Bimodal	March. - May Sep. - Nov.	Ogaden	250
Bimodal	March - May Oct. - Nov	Borena	700
Bimodal	March-May Dec. - Feb.	South west (Geleb and Bodi)	300 - 600

Source: Coppock, 1994.

2.1.3 Agro-ecological division of Ethiopia

The pastoralist area covers the arid, semi-arid and subhumid zones.

Arid zone

The arid zone has 90 growing days per year and includes the lowest areas such as Dallol in Afar territory near Djibouti. This zone engulfs areas with the lowest elevation, i.e. 100 meter below see level. This zone covers 64% of the lowlands including territories of Beniamir, Afar and Issa in the North and north east and the Somali region (Coppock, 1994).

Semi-arid zone

The semi-arid zone has 90-180 growing days per year. This zone stretches to the periphery of the highland massif up to 1500m elevation, and in the west up to 1000m. It includes higher

elevations in the Rift Valley (Kereyou), the Nuer region of north west, the Guji and Borena territory of the south and the western portion of Ogaden (Coppock, 1994).

Subhumid zone

The subhumid zone has 180-270 growing days per year. This area occurs near an elevation of 1500m (particularly in the west) and has a longer growing season than the drier zones due to higher annual rainfall (800-1300 mm) and lower temperatures (Coppock, 1994).

2.1.4 Livestock population

As reviewed by Coopock (1994) Ethiopia had about 29 million cattle, 24 million sheep and 18 million goats in 1987-88, and 6.8 million equines in 1979. The highlands harbour 80% of the cattle and 75% of the sheep but only 70% of the goats, that translating in to 44 TLU/km^2. The lowlands with about one million camels brings the lowland total to 11 TLU/km^2 with 49% cattle, 16% goats, 16% equines, 12% camels and 7% sheep of the total livestock population in the lowlands.

2.1.5 Animal diseases and animal health constraints

As reported by Wario (1996) Rinderpest, CBPP, FMD, PPR, anthrax, blackleg, haemorrhagic septicemia, flukes and round worms (especially where irrigation agriculture is practiced), copper deficiencies in the Rift Valley, and mechanically transmitted trypanosomoses as well as tsetse transmitted trypanosomoses (in the Barro and Akobe river areas in the west) are a serious menace to livestock development in pastoralist areas.

Poor knowledge of the pastoral production system, poor access, ease of disease transmission, inadequate epidemiological and economical data, low veterinary staff morale and work efficiency, and, furthermore the absence of a policy to support animal health auxiliaries were incriminated as the major handicaps of veterinary services delivery in pastoralist areas of Ethiopia (Wario, 1996).

2.1.6 Pastoral development projects

Pastoral development activities had focused on three major areas, the Afar area in the north east, the Borena area in the south east and the Somali area in the east and south east. Historically, the first rangeland development programme was initiated in 1965 by the Ministry of Agriculture to develop a small area of Borena rangelands near Yabello. Funds were donated by the USA. The Livestock and Meat Board which was established in 1964 had also been involved in the provision of veterinary services and facilitated the implementation of the Second Livestock Development Project (SLDP) and the Third Livestock Development Project (TLDP). So far, the projects implemented in the pastoral areas in Ethiopia include further an USAID project and the South Eastern Rangelands Project (SERP). The achievements, draw-backs and obstacles encountered during project implementation were thoroughly reviewed by Coppock (1994). The South East Rangeland Project (SERP) is still functioning in the Somali region of Ethiopia. The Borena Lowland Development Programme (BLDP) funded by the German Technische Zusammenarbeit (GTZ) had launched its programme in 1997. The BLDP is a bilateral project between the Oromia Bureau of Agriculture and the Government of Germany with the overall goal of improving the living standard of the pastoral people in the Borena Zone of Oromia Region.

2.2 Epidemiology of Camel Trypanosomoses

2.2.1 Global situation

Etiology

Trypanosomoses in *Camelus dromedarius* is commonly caused by *Trypanosoma evansi*. However, *T. brucei, T. congolense* (Mohamoud and Gray, 1980; Boid *et al.*, 1986; Wilson, 1988) and *T. vivax* (Boid *et al.*, 1986) as causative agents have been reported. Contrary to a report of by Zweygarth *et al.* (1987) who failed to establish *Trypanosoma simiae* in experimentally infected camels, *T. simiae* was reported as the cause of an outbreak in dromedaries introduced to the Tsavo National Park in Kenya (Mihok *et al.*, 1994)

Morphology

Trypanosoma evansi is a unicellular flagellated protozoa parasite belonging to the subgenus *trypanozoon*. Morphologically *T. evansi* is monomorphic and similar to the slender form of *T. brucei* with centrally placed nucleus, a small subterminal kinetoplast, a well developed undulating membrane, a long free flagellum and a blunt or truncated posterior end (Hoare, 1970)

Vectors

Due to the fact that *T. evansi* infection is characteristically found outside the tsetse belt it is considered that *T. evansi* is transmitted mechanically by biting flies. Camel trypanosomoses has been reported to be mechanically transmitted by a number of species of haematophagous flies including *Tabanus, Stomoxys* and *Lyperosia* spp. (Boid *et al.*, 1986) which are present around river banks and watering places in arid zones. Dirie *et al.* (1989) had incriminated tabanids of *Philoliche zonata* and *Philoliche magretti* as major vectors of the disease in Somalia.

Hosts

T. evansi affects a wide range of hosts including horse, dog, buffalo, elephant, pig, and in Mauritius also deer. Laboratory rodents, rabbits, rats and guinea pigs are readily affected. In cattle and water buffalo the infection is subclinical in nature and thus considered to be the main reservoirs of infection for equines. Nevertheless, in these species occasional outbreaks of acute disease with sudden death may occur (Soulsby, 1982). Franke *et al.* (1994) had also reported naturally occurring infections in cattle, horses, dogs and *Capybara* in Brazil.

Camel trypanosomoses is reported from almost all areas where camels are kept (Boid *et al.*, 1986). Recent studies using various diagnostic techniques indicate that the disease is widely distributed over the world (Dirie *et al.*, 1989; Latif *et al.*, 1990; Hussein *et al.*, 1991; Waitumbi and Connor, 1991; Baumann and Zessin, 1992; Diall *et al.*, 1993; Egabe Niwiyi and Chaudhry, 1994; Jacqueit *et al.*, 1994)

T. evansi is pathogenic to most domestic animals but its effect on different host species varies according to the virulence of the particular stock of the parasite, the susceptibility of the host and the local epidemiological conditions such as the presence of carrier animals and the vector. In camels the acute form of the disease is characterized by intermittent fever, subcutaneous edematous swellings, progressive anaemia, dullness, lethargy, petechial haemorrhages of the mucosa and discharges from the eye. In the more chronic form which may last up to a year, there is a continuation of anaemia and progressive emaciation and weakness, often accompanied by the development of skin abscesses.

Disease outbreaks of mechanically transmitted trypanosomoses are associated with the number of flies increasing during and shortly after the rainy season. Occurrence is also correlated with fly abundance. No cyclical development occurs in the fly and the trypanosomes do not survive for more than 10 to 15 minutes outside the host (Soulsby, 1982)

Egabe Niwyi and Chaudhry (1994) reported that climatic seasons had no influence on camel trypanosomoses based on their study on slaughter camels in Nigeria. However, in Sudan, there is a definite correlation between seasonal outbreaks of *T. evansi* infections and an increase in the number of tabanids during rainy season (June to October). However, there is a degree of variation in the prevalence of different species of tabanids during the year. *Tabanus taeniola* is prevalent throughout the year but its numbers vary directly with rainfall. *Atylotus agrestis* and *Atylotus fuscipes* appear at the end of the rainy season whereas *Tabanus biguttatus* is commonly found throughout the year. Its numbers increase especially after the rains but are less numerous than *Tabanus taeniola*. *Ancala latipes* and *Philoliche magretti* were only seen during the rainy season and only in small numbers. Experimental studies also indicated that ticks cannot be efficient transmitters of *T. evansi* (Mahamoud and Gray, 1980).

All age groups are susceptible but immature, stressed and lactating animals are extremely vulnerable (Schwartz and Dioli, 1992). However, the infection rate is said to be higher in camels aged one to four years (Latif *et al.*, 1990; Egabe Niwyi and Chaudhry, 1994). A survey conducted in Mauritania using IFAT and blood smears indicates that young calves below one year seem to be free of *T. evansi*, while in lactating camel average infection rates of 7.3% (blood smear) and 24% (serological results) were found (Jacquiet *et al.*, 1994). Diall *et al.* (1993) also described a trend of prevalence increasing with age. The same authors also stated that the disease appears to be non-existent in calves below one year of age and reaches peaks in camels aged one to four years. In experimental trials in small East African goats trypanosomes were also demonstrated apart from blood smears, in smears from extravascular locations like in synovial, peritoneal and cerebrospinal fluids, and furthermore in lymph fluid through the inoculations of mice (Ngernawa *et al.*, 1993). In a similar experimental study in Mauritania Jacquiet *et al.* (1993) showed that only sheep developed the disease whereas goats did not. Further field surveys conducted by these investigators showed that all the blood smears and serum samples taken from sheep and goats were negative to parasitological and serological examinations, respectively. However, sheep and goats sera from Sudan reacted positive in the antibody ELISA (Boid *et al.*, 1981). Similarly, Caille (1987) revealed that a considerable proportion of cattle, sheep and goats in Somalia had reacted in the antibody ELISA.

Ecological conditions

As reviewed by Mohamoud and Gray (1980), ecological conditions favouring the breeding and abundance of tabanids (especially with regard to rainfall, moisture retaining clay soil and surface water pools) also support the development of suitable camel browsing conditions where *Acaccia senegal* shrubs grow in abundance. Thus, the riverine ecology creates a favourable atmosphere for the multiplication of flies which in turn favour the transmission of camel trypanosomoses. With regard to this Baumann and Zessin (1992) reported that the prevalence of camel trypanosomoses in riverine areas significantly differed from non-riverine areas.

2.2.2 The Ethiopian situation

T. evansi is said to be the only agent incriminated for camel trypanosomoses in Ethiopia. Nevertheless, Zeleke (1982) reported mixed infections of *T. vivax* with *T. evansi* in the eastern parts of Ethiopia. The disease is endemic in the arid lowlands of the country. Table 2 provides an overview of the studies carried out so far in Ethiopia.

Stomoxys, *Tabanus*, *Haematobia* and *Hippobosca* were identified as possible vectors in Eastern Ethiopia (Zeleke, 1982). *Hippobosca* was also identified in the Borena area (Richard, 1979). No information is available as to the involvement of other species of domestic animals in the epidemiology of camel trypanosomoses.

Table 2: Camel trypanosomoses in Ethiopia: prevalence and diagnostic methods and regional distribution.

No of camels examined	Diagnostic test	No of positives	Infection rate (%)	Region	References
104	Thin and thick smears	13	13.5	Negele (Borena)	Pegram and Scott, 1976
	Mouse inoculation	38	36.5	"	
	Serological				
	Takata reaction*	74	71	"	
	Formol gel test	68	65	"	
	Mercuric chloride test	55	53	"	
	Thymol turbidity	44	42	"	
88	Blood smears	11	12.5	Borena	Richard, 1979
1100	Blood Smears	237	21.55	Borena	Ketema, 1990
294	Blood Smears	94	31.97	Borena	Tenaye, 1993
391	Blood smears	43	11.0	Borena	Theodros, 1995
226	Blood smears	20	8.8	Eastern Ethiopia (Ogaden)	Zeleke, 1982
327	Blood smears	1	0.3	Eastern Ethiopia (former Diredawa and Issa and Gurgura awraja)	Melaku, 1985
321	Blood smears	21	6.54	Eastern Ethiopia	Wosene, 1991

* A modified mercuric chloride precipitation using the Haury commercial test kit (Heinz Haury, Chemische Fabrik, München 23, West Germany)

2.3 Brief review on diagnostic methods

The diagnosis of a disease is important both in clinical medicine and epidemiological investigations. The provisional diagnosis of surra is often based on clinical grounds such as emaciation and anaemia. However, the symptoms are not pathognomonic for the disease. Confirmation is still largely carried out by the relatively insensitive methods of examining wet, thin or thick blood films. The micro-haematocrit centrifugation technique, silicone centrifugation technique, mini-anion exchange chromatography technique, animal inoculation

as well as serological tests improve the diagnostic efficiency of tradtional diagnostic techniques by detecting low level parasitaemia, antibodies and circulating antigens.

2.3.1 Clinical diagnosis

The clinical diagnosis of surra, the disease caused by *T. evansi* in susceptible animals is based on pyrexia, progressive anaemia and loss of condition. Edema, particularly of the lower parts of the body, urticarial plaques and petechial haemorrhages of serous membranes are often observed. However, these symptoms are not sufficiently pathognomonic and the diagnosis has to be supported by laboratory methods (OIE, 1990)

2.3.2 Direct methods

The usual field methods involve sampling from blood vessels and tissues since *T. evansi* inhabits the deep blood vessels and tissues. The direct methods include wet blood films, thick /thin blood smears, lymph node biopsies, concentration methods such as buffy coat dark ground microscopy (Murray *et al.*, 1977), haematocrit centrifugation techniques (HCT), mini-anion exchange chromatography technique as well as animal inoculation.

Wet blood films and thin and thick blood smears are relatively insensitive techniques and in most instances reveal acute cases. Thin smears particularly permit morphological studies and the identification of the agent. Lymph node biopsies usually obtained from the prescapular and prefemoral lymph node may also assist in the diagnosis (OIE, 1990).

Concentration methods such as the haematocrit centrifugation and mini anion exchange techniques are used to detect low level parasitaemias in the case of mild subclinical or chronic infections. Laboratory animal inoculation is employed to reveal subclinical parasitemias in domestic animals. The range of sensitivity values for thin, thick and wet smears, haematocrit centrifugation techniques (HCT), buffy coat dark ground phase contrast technique and animal inoculation for diagnosing *T. congolense*, *T. vivax* and *T. brucei* is described by Paris *et al.* (1982). Animal inoculation was found to be highly sensitive detecting infections even at concentration as low as 1.25×10^2 to $1,25 \times 10^3$ in case of *T. brucei*.

T.evansi and *T.brucei* have a broad infectivity spectrum for small rodents so rats and mice can be used. However, this method is not very useful for diagnosis due to the long prepatent period in commonly used laboratory animals and the expenses involved. Nevertheless, it is said to be extremely sensitive in the diagnosis of camel trypanosomoses (Pegram and Scott, 1976; Godfrey and Kendrick, 1962).

The buffy coat dark ground phase contrast technique was found to be a more sensitive technique than thick, thin and wet smears and the haematocrit centrifugation technique. In addition, identification of the trypanosome species can be made on the basis of behavioural patterns observed in the buffy coat dark ground illuminated preparation. *T. congolense* can be recognized by its small size in relation to the blood cell diameter, its sluggish activity, and its invariable attachment to red blood cells whereas *T. vivax* is large and strikingly apparent by the speed it traverses the microscopic field. The *T. brucei* group could be recognized by its large size and marked activity which, unlike *T. vivax*, seems to take place on a limited area where the parasite is going in circles (Murray *et al.*, 1977).

2.3.3 Indirect methods

Indirect methods involve haematological, biochemical and serological tests to demonstrate the effects of the parasite on its host rather than directly detecting the parasite itself.

Haematological examination, especially the PCV determination, is often a reliable indicator of a *Trypanosoma* infection. However, camels with subclinical disease can have parasitaemia without any evidence of anaemia (Wilson *et al.*, 1983).

Biochemical tests, including the mercuric chloride test, thymol turbidity test and formol gel test depend on an increase in serum euglobulins as a result of infection. These tests were used in the diagnosis of *T evansi* in camels but are not specific for trypanosomoses (Pegram and Scott, 1976). Serological tests are used to detect specific humoral antibodies and circulating antigens. The tests employed include the immunoflourescent antibody test (IFAT), the enzyme linked immunosorbent assay (ELISA), the complement fixation test (CFT), and the passive haemaglutination test (Boid *et al.*, 1986). Nevertheless, none of these tests based on antibody detection could differentiate between past and present infections as antibodies persist for up to hundred days or more after a chemotherapy has cleared trypanosomes from the circulation (Luckins 1977; Luckins *et al.*, 1978; Luckins *et al.*, 1979). Olaho Mukani *et al.* (1992) reported high antibody levels up to 90 days in the antibody ELISA after the elimination of trypanosomes by trypanocidal drugs. Indirect haemagglutination (IHA), the card agglutination test (CATT), the antibody ELISA and the complement fixation test (CFT) had been utilized to investigate camel trypanosomoses (Boid *et al.*, 1981; Olaho Mukani and Wilson, 1983; Wilson *et al.*, 1983; Zweygarth *et al.*, 1984; Zweygarth *et al.*, 1986)

Greiner *et al.* (1997) reported an apparent increase in sero-prevalence with age and incriminated age as a major biological risk factor for bovine *Trypanosoma* spp antiboby detection using ELISA. The authors stated that antibody titres were not associated with the current status of infection and suggested a mixed distribution analysis using C. A. MAN software for selecting cut-off values in the absence of a reference population.

Antigen ELISA is supposed to detect circulating degradation products of trypanosomes and to differentiate current from past infections. The technique is currently under investigation and is believed to have promising perspectives in the diagnosis of surra. Nantulya *et al.* (1989) showed the potential use of the antigen ELISA in the diagnosis of an infection and proposed a further evaluation of the test for its wide application. The test has also been used to evaluate the success of treatment (Olaho Mukani *et al.*, 1992). Diall *et al.* (1992) stated that antigen ELISA could not detect early infections and the antigens detected by the test are structural components of the plasma membrane which are not released until trypanolysis occurs.

2.4 Health and production parameters of *Camelus dromedarius*

Knowledge and quantification of health and production indicators is indispensable to assess the present status of camel production. This can subsequently be used to quantify the benefits gained after implementation of project interventions. Thus, parameters which are considered in our study are reviewed.

2.4.1 Packed cell volume (PCV)

The normal PCV range in camel has been given by various investigators but has no consistency. Ghodsian *et al.* (1978) reported PCV values of calves (< 1 year), immature (1-5 year) and mature camels (> 5 years) in the range of 21-35 (mean: 29), 18-35 (mean: 28) and 22-34 (mean: 28), respectively, whereas Abdelgadir *et al.* (1979) found a mean PCV of 30 (range 25-34) in adult Sudanese camels. Higgins and Kock (1984) also reported a PCV range of 24-42. An investigation carried out in Kenya showed significant differences between age groups and in seasons. The mean PCV of calves was found to be 22, and of immature and adults 27.2 and 27.7, respectively (Mutagi *et al.*, 1993). Similar age group differences, were also noted in cattle and goats (Schalm, 1965). The differences were attributed to the haemodilution which occurs after birth and the relatively high worm burden usually encountered in younger animals.

Anaemia in animals can be due to infectious and non infectious causes which includes trypanosomes, other haemoparasites, helminths, heavy tick and lice infestation, chronic diseases and nutritional factors (Radostits *et al.*, 1994).

Camels infected with trypanosomes show a depression of the PCV (Egabe and Chaudhry, 1994; Jatkar and Purokit, 1971). Concurrent infections of *Trypanosoma evansi* with *Haemonchus longistipes* are said to cause a severe depression in camel PCV when compared to animals infected with gastrointestinal helminths or *Trypanosoma evansi* alone (Yagoub, 1989). Furthermore, Karram *et al.* (1991) had stated that, beside the clinical signs observed in camels infected with trypanosomes the blood picture shows a significant drop in haemoglobin, packed cell volume and a normocytic hypochromic anaemia.

Gastrointestinal helminths are also likely to cause of drop in the PCV value of camels. Partani *et al.* (1995) found mixed infections of gastrointestinal nematodes (*Haemonchus longistipes*, *Trichuris*, *Strongylus* and *Nematodirus* spp) with EpG of 1,400 - 28,000 in 20 male camels in India where the blood parameter results showed a drop in the total erythrocyte count, haemoglobin, PCV, and a total leucocyte count of 40.6 %, 37.2 %, 50.3 % and 29.2 %, respectively, when compared to normal values. Wilson *et al.* (1982) reported a seasonal variation in EpG counts and an EpG peak of 150-450 in rainy season. However, PCV findings were not reported. Ibrahim *et al.* (1992) reported that the mean PCV values of 26.1 of females infected with gastrointestinal helminths were less than the mean values of their non-infected counterparts with 29.5. Botros *et al.* (1980) indicated that camels infected with gastrointestinal helminths show symptoms of anaemia.

In Ethiopia the existence of gastrointestinal helminths in camels is well known (Dynes and Richard, 1974; Richard, 1976; Melaku, 1985; Berhanu, 1986). However, their role in causing anaemia and associations with other diseases have not yet been elucidated.

2.4.2 Herd composition and herd size

Pastoralist camel herds normally consist of calves, immature and mature animals. The composition and size of a herd generally depend on the purpose of camel keeping, on the diseases affecting particular age groups, and the offtake and reproductive capacity which is a function of the age at first calving, the calving interval and the prolificacy.

A study conducted on herd composition by Hjort and Hussein (1986) in Somalia revealed that 16.5 % were calves, 39.2 % immature, 8.6 % mature males and 35.7 % mature females. As to the herd size in the Borena zone, Coppock (1994) stated that each Borena encampment has at least one camel with a mean herd size of three camel. Assefa and Corra (1991) found an average household camel herd size of 8 in a low aerial survey. Baumann and Zessin (1992) reported an average herd size of 38 in Somalia and associations of herd size with management units and ecological conditions.

2.4.3 Reproduction parameters

As reviewed by Mukasa (1981) the age at first calving of camels was 5-7 years whereas the calving interval ranges from 12 to 36 months. Wilson (1986) reported a mean age at first calving of 51.3 months and a mean calving interval of 20.2 months on four ranches in Kenya. The values differ significantly between dams and herds, and are influenced by the survival of the previous offspring. Season, however, had no marked effect on calving and 11.6 % of all pregnancies resulted in abortions.
In Niger calvings were seasonal with a mean age at first calving of 4.9 ±1.6 years and a mean calving interval of 26.3 ± 10.6 months (Wilson, 1984). Studies conducted in the Emirates revealed a mean age at first calving of 55.3 months, a mean calving interval of 26.6 months and seasonal calving (Abou Ela and Zaeid, 1990). Recent studies in Tunisia also showed an average age at first calving of 5.25 years (Dejellouli, 1992), and in Somalia a mean age at first calving of 7 years and mean calving interval of 34 months (Baumann and Zessin, 1992). The latter authors have also noted seasonal calving in Somalia.

2.4.4 Mortality, birth rate and offtake

Mortality and birth rates of a population determine the trends in camel production in a given area. The productive offtake indicates the advantages exploited from a respective husbandry practice. If reliable figures are available for a sufficient period of time it may give a clear indication of the level of a production system and might call for particular interventions. Moreover, these values can be used for monitoring the herd health status and for project evaluation.

A study conducted by Babiker (1984) indicated that the camel population studied in Sudan is proliferating rapidly with a birth rate of 4.5 % and a mortality rate of 3 % per annum. Djellouli *et al.* (1992) had reported a mortality rate of 17 % in calves in the first year.

A more comprehensive survey on camel production parameters and their association with ecological conditions and management parameters in Somalia was carried out by Baumann and Zessin (1992). The authors reported general fertility, young stock and adult stock death rates of 39.7%, 19.6%, and 7.3%, respectively.

With regard to the Ethiopian conditions Mukasa (1981) quoting Cossins (1971) stated a mortality rate of 31%, 49%, and 59% in three clans of Somali pastoralists around Jijiga in the south eastern part of Ethiopia. He attributed the latter two high values to the fact that the herds were maintained all year round in a tick and predator infested area.

3 MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location

Leben district is located in the Borena zone of the Oromia region, southern Ethiopia (see Annex 8). The land cover of the area is 8950 sq. km. For administrative reasons the area is divided into 34 peasant associations. The divisions of peasant associations in the district change from time to time, and this study is based on the current division in March, 1997. Each peasant association is again divided into zones (*Ketenas*) with its own representative accountable to the chairman of the peasant association.

3.1.2 Ethnic groups

The Boran, Arssi and Gujji are the major ethnic groups in the area. However, small groups of Gabra, Waat and Somali are found interspersed among the major ones.

3.1.3 Human population

111,696 people dwell in the district. Out of this 25,046 are urban dwellers and the rest live in the rural area. The population growth rate is reported to be 2.23 % and 4.11 % for the rural and urban population, respectively (Central Statistics Office, 1994).

3.1.4 Livestock population

Table 3: Livestock population in the study area

Types of livestock	Population
Cattle	433 512
Goats	425 464
Camel	328 080
Sheep	153 295
Donkey	28 317
Mule	579
Horses	88

Source: Coppock, 1994

Cattle and goats are the major livestock species in the area followed by camels, sheep and donkeys. Mules and horses exist but are few in numbers (Table 3).

3.1.5 Climate

The area has a typical semi-arid climate. An average rainfall in the area of 757.2 ± 50.4 mm was recorded in the years 1981-1989. The rainfall pattern is bimodal with about 60% of the rain usually falling in the period from March to May and 40% from the middle of September to November. The average annual temperature is constant with an average daily temperature of 21.6 ± 0.1°C. The annual average maximum temperature is between 27.7 ± 0.1°C and the average minimum temperature between 15.5 ± 0.1°C. The probability of rainfall exceeding 60 mm is 0 in the months of July and August (Coppock,

1994). The rainy seasons in the area are known by the local names *Genna* and *Haggaya* which are the long and the short rainy seasons, respectively, whereas the dry seasons are known locally as *Adolessa* and *Bonna*. *Adolessa* is the period from June to August and *Bonna* extends from December to February.

3.1.6 Altitude

The altitude of the district varies from 700 metre around Melka Gouba where the Dawa river is located, up to 1500 metre around Negele town (Richard, 1976). During this investigation an altimeter was used to measure the elevation of the survey areas, and it was found that the elevation varies from 780 metre around Melka Gouba to 1550 metre around Air Marfia, Miessa Darole peasant association.

3.1.7 Camel husbandry

In camel husbandry the typical seasonal shortage of water and forage led to the evolution of a special management system: the *warra* herd and the *forra* herd. The *warra* herd consists of lactating cows and a few bulls whereas the *forra* herd consists of non lactating and pregnant animals. The *forra* herd is a free-ranging herd covering a large area in search of water and pasture. The majority of camels are kept mainly with a *warra* herd. According to herder's information and my personal observation, camels move from one place to another to cope with feed and water shortage during dry season and to avoid flies in wet seasons. Generally, four types of movement can be expected:(i) moving the homestead and the herds to watering wells within the same peasant association, (ii) moving the whole camel herd to relatively high land areas where green forage is available, (iii) moving a part of the herd within the same peasant association where green forage is available while leaving the recently calved ones around the homestead, and (iv) keeping the whole herd as a *warra* herd all year round.

3.1.8 Water resources

Surface water is a serious problem. Deep wells, ephemeral ponds, perennial springs, the perennial Dawa and Genale rivers, seasonal streams and shallow temporary wells are sources of water for livestock and people. Deep wells are used during dry season and ponds in rainy seasons. Ponds usually dry out after a few days during dry season. Although wells never dry out they entail high concentrations of animals during dry season (Coppock, 1994).

3.1.9 Camel diseases

Beside camel trypanosomoses, diseases of camel were reported by various investigators in Ethiopia (Daynes and Richard, 1974; Melaku, 1985; Berhanu, 1986; Wosene, 1991). A detailed account of camel diseases present in the study area is also available (Richard, 1979).

3.2 Sampling design, strategies and sample size

To determine sample size in this cross-sectional study a trypanosomoses prevalence rate of 20% (roughly the average prevalence of Borena region as presented in Table 2) was taken into consideration. The sample size required is calculated using Epi Info 6.04 programme, with an estimated prevalence of 20%, a precision level of 5% and a 95% confidence interval. This resulted in a sample size of 246 which was rounded up to 250. However, when cluster

sampling is used the sample size, by rule of thumb, is to be inflated twice. This would have resulted in a sample size of 500 units to be sampled in each season, i.e., two point measurements. When considering that the average camel herd size per house hold is estimated to be eight (Assefa and Corra, 1991) then in this cluster sampling design four samples i.e., individual camels are to be taken from each herd stratified for age groups. This would lead to a total of 125 camel herds to be included in each seasonal sample. However, due to logistic constraints (in time and mobility) the number of camel herds had to be reduced to the practically achievable number of 80. Subsequently it was possible to sample 81 herds in wet season resulting in 324 camel samples and 74 herds with 285 camels in dry season. Thus, the cluster sampling inflation factor became 1.3 for wet season sampling. From 81 camel herds investigated in rainy season seven of these herds had moved during dry season to other places in search of feed.

In the end a four stage sampling technique was applied. Peasant associations, zones (Ketenas), herds, and individual animals were taken as primary, secondary, tertiary and quartery sampling units. 27 peasant associations (PSU) were selected by purposive sampling on the basis of accessibility whereas 81 zones (SSU) were selected by systematic random sampling from a list obtained from the Central Statistics Office. Within each zone one herd (TSU) was selected purposively on the basis of collaboration due to the inavailability of a list of herds. The quartery sampling units (QSU), i.e. four individual camels, were taken from each herd randomly within the defined age group: one from those aged below one year (<1 year), one from those one to four years (1-4 years) and two from those above four years of age(>4 years).

3.3 Parasitological and haematological examination in the trypanosomoses prevalence survey

3.3.1 Collection of samples

324 and 285 camels were bled from the jugular vein at the wet and dry season investigations respectively. Five ml of blood was taken from each animal and put into EDTA coated vacutainer tubes; another five ml for serum separation was placed in plain tubes. Blood samples in plain tubes were not collected at the dry season investigation as no serological test system was available at that time. The blood in the EDTA coated tube was used for the parasitological examination of trypanosomes by the buffy coat technique (BCT) according to the methods described by Murray *et al.* (1977) in the field, and for the determination of PCV (Woo, 1969). From the other tube, after clotting of the blood staying overnight, serum was separated by centrifugation of the tubes at 1500 g for 10 minutes. Serum was then stored at -20°C until screened for antibody ELISA. Whenever the BCT was found positive thin blood smears were prepared for species identification. For each sampled animal sex, age, physiological status, condition and clinical symptoms observed as well as the owner's opinion on trypanosomoses were recorded.

Further investigations were made to determine the gastrointestinal parasite infection status in the dry season and its possible association with low PCV readings in parasitologicaly negative camels without detectable levels of antibodies in wet season. Thus, in dry season 285 faecal samples were collected.

3.3.2 Diagnostic Methods

Wet blood film examination (WBF) in the field

A small drop of blood from each animal was placed onto a clean glass slide and covered with a cover slip to spread the blood monolayer of the cells. The slides were then examined under light microscopy (250 x) for any motile trypanosomes.

Thin blood stained smears (TSS)

Thin blood smears were prepared from those animals found positive in the WBF and / or buffy coat technique. The smears were then fixed with methanol and stained with 10 % Giemsa. Blood smears were examined under a microscope and species identification was done according to Hoare (1970).

Buffy coat technique in the field

A micro haematocrit tube containing 70 µl of blood was centrifuged for 5 minutes using the Hawksley micro-haematocrit centrifuge. The PCV was read and the buffy coat examination was done as described by Murray *et al.* (1977). The capillary tube is cut with a diamond pointed pen 1 mm below the buffy coat to include the upper most layer of RBC and 3 cm to include the plasma. Then the contents of the capillary tube were expressed onto a slide, mixed and covered with a cover slip (22 x 22 mm) and examined using dark ground phase contrast microscope (250x).

A case in this context is defined as an animal with parasitological positive diagnosis of *T. evansi* and for *T. vivax* using the buffy coat technique (Murray *et al.*, 1977).

Indirect antibody ELISA

A. Buffers, reagents and consumables

1. Coating buffers used

1.1 Carbonate buffer, 0.05m, pH 9.6

Na_2CO_3 -------1.12 g
Na_2HCO_3 -------2.94 g
in 1000 ml distilled water

1.2 Phosphate buffered saline with Tween-20 (PBS-T) for washing, pH 7.2

KH_2PO_4 ----------0.2 g
Na_2HPO_4. 12 H_2O) ----------2.94g
NaCl ----------8.0 g
Kcl ----------0.2 g
in 1000 ml distilled water
then Tween 20 (0.5 ml) is added.

3. Conjugate rabbit anti-camel IgG (H+L)-PO, with a working dilution 1:600, was supplied by Dr. Clausen according to Clausen (1986)

4. Sample and conjugate buffer: PBS-T plus 1% skimmed milk powder (Marvel, 99% fat free).

5. Substrate indicator system
   40 mg of ABTS (2.2-Azino-di(3-ethyl-benzthiazolinsulfonate) is dissolved in 100 ml citric phosphate buffer and stored at 4°C in the dark. Just before use, 100 µl of 1:40 hydrogen peroxide was added to 10 ml of ABTS. Citric acid phosphate buffer was prepared by mixing equal amounts of 4.2 g citric acid monohydrate in 200 ml of distilled water with Na_2 HPO_4 12 H_2O in 200 ml distilled water.

6. Positive control: a pool of serum samples from 13 experimentally infected camels (*Camelus dromedarius*) with *T. evansi* (Clausen, 1986).

7. Negative control: a pool of serum samples from camels of the Zoological Garden, Berlin.

8. ELISA plates: plates with high binding capacity (Greiner Article Nr. 655061)

9. Antigen: lyophlized *T. evansi* (Thailand, 26.4 mg/ml) (Clausen, 1986) is reconstituted with 0.5 ml coating buffer and centrifuged at 10000 g for 4 minutes. The supernatant is further diluted with coating buffer to a working dilution of 1:100.

B. Test Procedure

1. The columns 2, 4, 6, 8, 10 and 12 are charged with 50 µl of antigen in working dilution (1:100) whereas columns 1, 3, 5, 7, 9 and 11 are filled with the same amount of carbonate buffer. The plate is then incubated at 37°C for 1 hour and then over night at 4°C. The coated plates were washed under tap water followed by 3 wash cycles with PBS-T with a soaking times of 3 min./cycle.

2. Dilution of serum samples
   The camel serum samples from a reservoir plate are diluted to a dilution of 1/100 as follows: two dilution plates were used for each reservoir plate. All cups of the first and second dilution plate were filled with 180 µl of PBST-MP. Then 20 µl of serum from the reservoir plate is transferred to the first dilution plate resulting in a dilution of 1/10. Thereafter 20 µl of 1/10 serum is transferred to dilution plate two (1/100)

3. All cups of an ELISA test plate are filled with 25 µl of PBST-MP. Then test samples and control sera prediluted to 1:100 in sample and conjugate buffer are added parallel to cups with and without an antigen (final dilution 1:200). The plates are then incubated for 30 minutes in a moist chamber. After incubation, the plates are washed with tap water followed by three wash cycles with PBST.

4. 50 µl Rabbit anti-camel IgG-PO properly diluted to 1:600 in sample and conjugate buffer is added to all wells. The plate is then incubated and subsequently washed as above.

5. Finally 50 µl of substrate is added to all wells.

6. The OD results are read after 10 and 20 minutes photometrically with a photometer using a 405 nm filter and presented by column subtraction (column 2 minus column 1).

C. Test interpretation

The OD values of serum samples are expressed as percentage of the positive control serum pool using the following formula:

OD value of sample (expressed as % of positive control) = Test sample extinction OD-negative control extinction OD/by positive control extinction OD-negative control extinction OD * 100.

Cut-off: An arbitrary OD value of above or equal to 20 % (expressed as percentage of positive control) was considered test positive. The 20 minute OD readings were used throughout in the subsequent analysis.

Faecal egg count

Floatation technique using saturated salt solution (NaCl) was employed to determine the eggs per gram (EpG) of faeces (Ministry of Agriculture, Fisheries and Food, 1986), whereas differentiation of eggs was made as described by Soulsby (1982).

3.4 Herd level investigations

A herd health and management questionnaire to retrieve information on herd structure, herd composition, production system, mortality, reproduction and further production variables was administered to the herd owners of the study herds (see Annex 1, 2, 3, 4).

The calculation of production and reproduction variables was based on the pastoralists seasonal calendar where the year starts in *genna*, the month of March. Thus, one year is the period from one *genna* to the other. Data necessary for annual epidemiological rates calculation are compiled by considering events which had occurred from the previous *genna* to the current *genna*.

Table 4: Seasonal Calendar of Leben

Season	Period
Genna	March-May
Adolessa	June-August
Haggaya	September-November
Bonna	December-February

Genna and *Haggaya* are the long and short small rainy seasons, respectively, whereas *Bonna* and *Adolessa* are dry seasons in the study area (Table 4).

Breeding female history

74 camel herd owners were asked about the breeding history of each breeding female in the herd. Seven of the investigated herds were excluded due to the inability of the owners to recall events. Thus, data on the breeding history of 384 camels were collected on the breeding female history record form (see Annex 3). For each breeding female in a herd sampled, the herd owner was asked about the age, type/breed of the camel, whether that particular camel was bought or born at his hand, the season the camel was bought or born, and, if bought, how long it has been in the herd.

Then the total number of births the camel cow gave so far and the number of abortions were recorded in the first place. After starting from the year of the interview the year the offsprings were born or an abortion occurred (from the last event to the first), season, sex and status of the offspring birth, i.e. dead or alive, and the current status in the herd were recorded. If the given offspring was withdrawn from a herd or if it died the age the event has occurred as well as the local name of the disease or the symptoms were recorded.

From these data calving intervals and age at first calving were calculated using the methodology of the International Livestock Center for Africa (ILCA) (Bourzat *et al.*, 1988).

3.5 Definition of rates and the terminology used in this study

3.5.1 Rates

Annual mortality rate (on herd basis) = deaths from all causes in a defined year / average numbers of camels

The average number of camels was calculated by adding the camel number one year ago to the current number and then again dividing it by two. Camel herd size one year ago was calculated by considering camels introduced into the herd and camels taken out of the herd as questioned from the owner. Camel numbers taken out were calculated adding all deaths due to diseases, all camels sold, slaughtered, lost, eaten by predators, died due to accident, and given away as a gift. Camels introduced into the herd include all new born calves still within the herd, introduced as a gift, and purchased camels. Camels born and died during the year were not included when calculating the camels which went into a herd.

All production and management rates are calculated on a herd basis:

Offtake rate = all animals withdrawn (taken out) from the herds in a defined year / average number of camels

Withdrawn camels = slaughtered + given away as gift + sold + lost + eaten by predator + died due to accident.

Productive offtake includes all camels withdrawn from a herd from which a particular value was exploited in relation to the average number of camels during that particular year. The numerator includes all camels slaughtered, given away as gift and sold.

Productive offtake = all camels withdrawn and values generated in a defined year / average number of camels during the year

Non productive offtake = all camels withdrawn from the herd from which no value was exploited in a defined period / average no. of camels during the year

The numerator was calculated by adding all camels lost, eaten by predator, death due to accidents and all deaths due to diseases.

Slaughter rate = all camels slaughtered in a defined year / average number of camels during the year

Predator rate = all camels eaten by predators in a defined year / average number of camels during the year

Marketing rate = all camels sold (above one year of age) in a defined year / average number of camels during the year

Accident rate = all camels lost by accidents in a defined year / average number of camels during the year

'Gift-out' rate = all camels given away as a gift in a defined year / average number of camels during the year

'Gift-in' rate = all camels received as a gift in a defined year / average number of camels during the year

The following rates are calculated on individual animal basis:

Proportional mortality rate = number of deaths from a specific disease or syndrome / total deaths from diseases

Age specific proportional mortality rate = deaths from a specific disease/syndrome in a particular age group / all deaths due to disease in the particular age group

Cumulative incidence (risk rate) = number of new cases in the dry season / average number of camels at risk during the study period.

The average number of camels was calculated by considering half of the camels withdrawn in the study period and then subtracting those from the number present at the beginning of the study period.

The study period includes the period from the last quarter of wet season to the end of dry season, 1997.

Incidence density(true rate) = number of new cases occurring during the dry season survey / animal days at risk

Animal days at risk were calculated by multiplying the average number of animals by the average number of days each animal was at risk. The average number of animals was calculated by considering all camels, withdrawn from a herd in the study period, were at risk at least for half of the period. Thus, half the number withdrawn was subtracted from the number at the beginning of the study period. The average number of days at risk was calculated by averaging the number of days between the first and second visit in the herds investigated.

3.5.2 Definition of terms

A herd
is a group of camels owned by an individual or a group of people and herded communally or privately and is subjected to the same sort of management.

A riverine herd
is a herd which is kept and herded in riverine areas.

A non-riverine herd
is a herd which is kept and herded away from riverine areas.

A household herd
is a herd owned by a family with one wife and respective children

A polygamous herd
is a herd owned by a polygamous family with more than one wife and respective children.

An extended family herd
is a herd owned by close relatives and consists of more than one household and their families.

A positive herd:
is a herd with at least one test positive camel or at least one case diagnosed in the parasitological investigations.

A negative herd
is a herd with no test positive camel or without a parasitologically detected case.

3.6 Data analyses

Raw data for parasitological and serological examinations and data obtained by means of the herd management questionnaire were entered in to MS Excel spread sheets programme (Microsoft Corp.) to create a data base. Statgraphics Plus 2.1 (Manugistics, Inc., Rockville, Ma., USA), Win Episcope (Blas *et al.*, 1996) and Epi info (Dean *et al.*, 1994) were used in the statistical analysis.

For sample sizes up to 100 the 95 % confidence intervals for the trypanosomoses prevalence results were obtained using Exact confidence interval (Documenta Geigy, 1960) whereas for sample sizes above one hundred the approximate confidence interval formula described by Martin *et al.*, (1987) was used.

$$95\%\ \text{confidence interval} = \text{prevalence} \pm 1.96 * \frac{p(1-p)}{n}\,\hat{}\,0.5$$

p = prevalence rate, 1-p = 1 - prevalence rate and n = number of samples

Descriptive statistics on parasitological and serological results and production parameters were obtained using the Excel programme whereas Statgraphics was utilized for graphically displaying the distribution of PCV and EpG values using Box-and-Whisker Plots. In a Box-

and-Whisker Plot the middle horizontal line dividing the box represents the median of a parameter value, and the notches represent the 95 % confidence intervals around the median. The whiskers represent the largest and the smallest values within 1.5 interquartile ranges from the third and first quartile. The points lying beyond are called outliers. The upper and lower edges of the box represent the third and the first quartile values respectively and The vertical width of the box is directly proportional to the square root of the sample size. The mean is noted as +.

In the Epi Info programme the chi-square test was applied to determine possible association of trypanosomoses with intrinsic and extrinsic factors such as age, sex, physiological status and ecological conditions. Odds ratio calculations in Win Episcope were used to quantify the strength of an association. Furthermore the Mantel-Haenzel technique in Win Episcope was used to correct for the confounding effects of age and sex.

The Mann-Whitney and Kruskal-Wallis test procedures were employed to see differences in the median PCV and EpG values for different factors. The paired t-test was used to test seasonal differences as well as differences of PCV infected camels before and after treatment as these data appeared to be normally distributed. Moreover the Mann-Whitney and Kruskal-Wallis tests were used to see differences in herd size and crude mortality rates for factors designated as ecological zones, herd serological trypanosomoses, herders experience, and management units. ANOVA and t-test were used to determine differences in age at first calving and calving intervals for factors such as camel types/breed, ecological zones, herd and individual trypanosomoses status. To carry out these tests Statigraphics software was used.

4 RESULTS

4.1 Description of demographic production characteristics

The ethnic groups investigated in this study include Gujji (33.3%), Boran (28.4%), Arssi (14.8%), Meriana (9.9%), Gabra (3.7%), Dugodie (3.7%), Gurra (2.5%) and Hawiaa (1.2%).

Bush encroached land with some plots of cultivated land and savanna land are the major features of the district. Among the 81 camel herd owners investigated 74 (91.4 %) had an average of 0.49 hectares (range 0.3-3.6) of cultivated land. The rest, 9 (8.6%) are pure livestock keepers. The camel herd owners in the savanna area do also cultivate land in other peasant associations. Farming activity in this area is unreliable due to erratic rainfall.

The experience in camel keeping in general varies from two years to lifetime. The Boran and Gujjis were primarily cattle breeders; however, due to recurrent drought conditions they had started camel keeping very recently. Their experience varies from two to twenty-two years. The other ethnic groups investigated have lifetime experience. Among the 81 camel keepers investigated 53 (65.4%) have recently acquired camel keeping. Responses given by camel herds men who recently acquired camel keeping revealed bush encroachment, higher milk production, and a better ability to survive droughts as the basic reasons for starting camel production.

Beside camels, cattle, goats, sheep, donkey and mules are kept by the herdsmen investigated. Camels are mainly kept for milk production followed by transportation, sale of live animals, meat and security (see Annex 6). Except the Keriou Berei and Ouditu all clans in Borena consume camel meat.

Hodkii, Geleba and *Eldimma* (a cross between the two types) camel types are kept by the pastoralists. Based on the description of the pastoralists, the *Hodki* type camel is a large camel praised for its high milk as well as for meat production, whereas *Geleba* camels are stout and are said to be drought resistant. The *Eldimma* type lies in between with its production performance.

Warra, forra and *warra* and *forra* type of management is practiced in 95% ,1.2% and 3.7% of the camel herds investigated. Camels are owned by individual households, polygamous family extended families.

Camels do not normally drink water during the wet seasons. The sources of water for camels in the herds investigated include wells, rivers (the perennial Dawa and Genale river), and wells and rivers and are used by 69 (85.2%), 3 (3.7%) and 9 (11.1%) of the herds investigated. Girls and boys are usually involved in camel herding and, whenever necessary assisted by the older age groups.

Animal health service in the area is rendered through the district clinic and in nine animal health posts in villages. Paravets trained by former SORDU and very recently by Safe the Children-America are also involved. Vaccination and general animal health care are major components of the government animal health services in the area. Annual vaccination is given for contagious bovine pleuropneumonia and, whenever there is an outbreak, ring vaccination is undertaken for anthrax, blackleg and pasturellosis. Drugs, vehicles and budget are the major constraints for running a proper animal health service in the district.

Questionnaires directed to 81 camel herd owners indicated *Dukane* (Camel trypanosomoses) as the most important camel production constraint (see Annex 7). Though the district animal health office and animal health posts are involved in rendering animal health services, paravets, and largely the herdsmen themselves are treating sick animals with trypanocidal drugs, antibiotics, acaricides, anthelminthics and indigenous herbs. Among them Berenil, penicillin and tetracycline capsules are particularly worth mentioning.

Cymelarsan, Berenil and Novidium are used for the treatment of camel trypanosomoses. Berenil, the most commonly used drug, is mostly available in local shops in Negele. Nevertheless, Berenil is toxic at the recommended dosage of 7 mg/kg in camels. Cymelarsan is, however, obtained solely from the district clinic or animal health posts. Treatments with trypanocidal drugs are usually administered by the owner himself. The effectiveness of Berenil is ranked good in 52%, fair in 15.3% and poor in 11.1%, Cymelarsan is ranked good in 67% and fair in 33% of the households interviewed.

Table 5: Local names of biting flies, its seasonality and ecological preference as judged by 81 camel herdsmen in Leben district, Borena zone Oromia Region, Ethiopia, 1997.

Fly name (local)	Seasonality	Ecological preference
Bombissa/Elwenkie	end of dry season to first week of wet season (March-April)	everywhere when Accacia tree blossom watering wells, riverine areas
	all year round	riverine areas and wells
Facha/Metena/ Kobbadie	during wet season (*Genna*) March -April)	everywhere except denuded land
Werena/Baltag	last weeks of *Genna* to first weeks of *Adolessa*	woody vegetation around wells
Sorondissa	during wet season (*Haggaya*) (September to November)	woody vegetation

4.2 Parasitological and serological results

4.2.1 Prevalence of camel trypanosoma infection and risk factors

Table 6: Results of parasitological and serological findings for season, sex and age in 81 camel herds in Leben district, Borena zone, Oromia Region, Ethiopia, 1997.

FACTORS	PARASITOLOGICAL RESULTS						SEROLOGICAL RESULTS					
	No inv	Positives	%	Confidence interval	P-value	Odds ratio	No inv	Positives	%	Confidence interval	P-value	Odds ratio
Season												
wet season	324	33	10.2	6.9-13.5	0.0005**	4 (1.9-8.2)	324	184	56.5	51.1-61.9		-
Dry season	285	8	2.8	0.9-4.7								
Both seasons	609	41	6.7	5.8-7.7								
Sex												
Wet season												
male	107	11	10.3	4.5-15.9	0.8	-	107	49	45.8	36.3-55.8	0.006**	0.84 (0.5-1.5)*
female	217	22	10.1	4.5-15.9			217	135	62.2	55.7-68.7		
Dry season												
male	93	4	4.3	1.2-10.7	0.4	-						
female	192	4	2.1	0.1-4.1								
Both seasons												
male	200	15	7.5	4.3-12.1								
female	409	26	6.4	4.1-8.7	0.6	-						
Age group												
Wet season												
Below one year	65	3	4.6	1.0-12.9	0.3	-	65	21	32.3[a]	21.2-45.1	0.0000***	1
1-4 years	97	13	13.4	7.3-21.8			97	45	46.4[a]	36.2-56.8		1.8 (0.9-3.5)
above 4 years	162	17	10.5	6.2-16.3			162	118	72.8[b]	65.9-79.7		5.6 (3.1-10.2)
Dry season												
Below one year	57	1	1.8	0.0-9.4								
1-4 years	82	4	4.9	1.3-12.0	0.8	-						
above 4 years	146	3	2.1	0.4-5.9								

**Highly significant difference ($p < 0.01$). ***Very high significant difference ($p<0.001$.

a, b proportions denoted by different letters are significantly different from each other

Table 7: A break down of parasitological and serological findings for physiological conditions and ecological zones in 81 herds in Leben district, Borena zone, Oromia Region, Ethiopia, 1997.

FACTORS	PARASITOLOGICAL RESULTS						SEROLOGICAL RESULTS					
	No inv.	Positives	Proportion	Confidence interval	P-value	Odds ratio	No.inv	Positives	Proportion	Confidence interval	P-value	Odds ratio
Physiological status												
wet season												
calves	65	3	4.6	1-12.9			65	21	32.3[a]	(21.2-45.1)		1
immature animals	97	13	13.4	7.3-21.8			97	45	46.4[a]	(36.2-56.8)		2.2 (0.9-3.7)
bulls and Rutting bulls	12	3	25	5.5-57.2	0.3		12	8	66.7[b]	(34.9 - 90.1)	0.0000***	4 (1.1-15.5)
non pregnant camel	26	2	7.8	1.0-25.1			26	22	84.6[b]	(65.1-95.6)		11.5 (4-33.5)
pregnant/lactating camel	124	12	9.7	4.5-14.9			124	88	71[b]	(61.8-78.8)		5 (2.7 -9.6)
Dry season												
calves	57	1	1.8	0.0-9.4								
immature animals	82	4	4.9	1.3-12.0	ND							
bulls and rutting bulls	11	0	0	0.0-28.5								
non pregnant camel	25	25	8	1.0-26.0								
pregnant/lactating camel	110	1	0.9	0.0-5.0								
Ecological factors												
Wet season												
Riverine	36	4	11.1	3.1-26.1	0.92	-	36	28	77.8	60.9 - 89.9	0.007**	3 (1.3-6.4)
Non riverine	288	29	10.1	10.1-3.5			288	156	54.2	48.4 - 60		
Dry season												
Riverine	35	4	11.4	3.2-26.7	0.008**	8 (1.4 - 4.32)						
non riverine	250	4	1.6	0.4 - 4.1								
General	71	7	9.9	4.1 - 19.3								
Riverine	538	33	6.1	4.1 - 8.1	0.3	-						
Non riverine												

** Highly significant difference ($p < 0.01$), *** Very high significant difference ($p < 0.001$)

ND : Chi- square analysis not done since one of the proportions is zero.

a, b proportions denoted by the different letters are significantly different from each other.

During wet and dry season a total of 324 and 285 camels, respectively, were examined out of which a prevalence of 10.2% (parasitological) and 56.5% (serological) was observed, whereas during the dry season only 2.8% were found parasitologically positive (Table 6).

A marked seasonal difference with a significant odds ratio of 4 was observed, meaning that cases of trypanosomoses are 4 times more likely to occur in *Genna* (rainy season) than in *Adolessa* (dry season) (Table 6).

Based on the means of parasitological results in wet season no significant differences were observed between sexes, age groups, different physiological status and ecological conditions, whereas in dry season associations between the ecological condtions and the trypanosomoses status became apparent. The odds ratio is eight, meaning that camels in the riverine area are 8 times more likely to be positive for trypanosomes than camels in the non riverine area (Table 6 and 7)

With regard to the serological results it seems that there is a difference between sexes ($P < 0.01$) but when this difference was analyzed for the confounding effect of age on sex by Mantel-Haenzel-technique it was found that the effect wanes (summary odds ratio: 0.84 (0.5-1.5)). However, significant differences between age groups, physiological condition of the animal and ecological conditions were observed: camels above 4 years of age are 5.6 times more likely to be seropositive than camels below one year. Camels one to four years old seemed to be 1.8 times more likely to be seropositive than calves; however, the 95% confidence interval includes one indicating the possibility of no difference (Table 6 and 7).

Looking at camels of different physiological status the odds ratio is only significant when pregnant/lactating camels as well as non-pregnant camels are compared to calves: non-pregnant animals are 11 times more likely to be antibody positive than calves, whereas pregnant/lactating animals are 5 times more likely to be positive in the antibody ELISA. Similarly, camels from riverine areas have a 3 times greater rate of seropositivity than non riverine camels (Table 7).

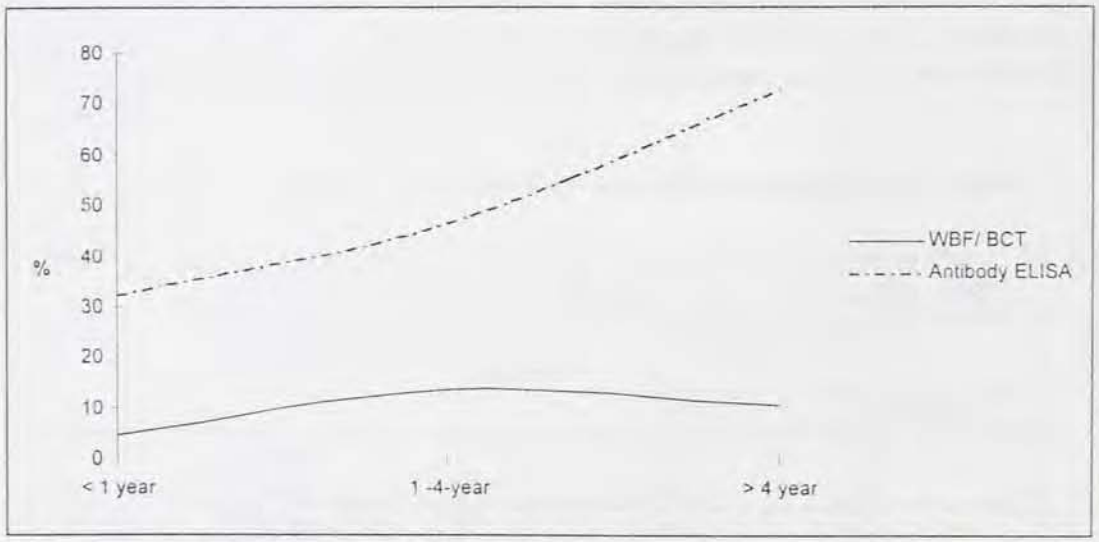

Figure 1: Smoothed curve of the results of parasitological and serological tests for age in 81 camel herds in Leben district, Borena zone, Oromia region, Ethiopia, 1997.

Figure 1 displays that all age groups of camels are affected by trypanosomiasis with a parasitological prevalence reaching a peak in immature animals (1- 4 years), whereas serological prevalences increase with increasing age.

4.2.2 Incidence of *Trypanosoma* infection during dry season

285 animals out of 74 herds examined in the first survey were again examined at the end of dry season. Eleven camels were withdrawn from the study population during this period. For calculating cumulative incidence and incidence density, these animals are taken into account as if they were at risk for half of the study period. The average period of observation was 86.5 days. All animals positive during the first survey were treated with Cymelarsan (Rhône Mérieux) at a dosage of 2.5 mg/kg, as recommended by the manufacturer. All treated animals were negative to the parasitological examination during the dry season survey. Eight new cases were found during the second survey. The cumulative incidence and the incidence density were then calculated to be 0.03 and 3 cases per 10,000 animal days, respectively.

4.2.3 Herd level trypanosomoses results

Out of a total of 81 herds examined during wet and 74 in dry season 24.7% (20) and 9.5% (7), respectively had at least one case of trypanosomoses diagnosed using parasitological techniques. Using the antibody ELISA technique 90% (74) of the herds examined during the wet season were found with at least one positive animal with *Trypanosoma evansi* antibodies. There is a significant difference between the proportion of herds positive during dry and wet season ($P < 0.05$).

Generally, the herd level results indicate a clustering of infections. Out of 20 parasitologically positive herds in rainy season three were again positive in the dry season examination. Herds which were found positive during the wet season examination had one to three camels positive out of the four samples taken.

Only nine out of 81 herds are categorized as riverine herds. During the wet season checks 2 (22.2%) from the riverine herds and 18 (25%) from the nonriverine herds were parasitologically positive. In contrast to this in dry season 33.3% (3) of the riverine herds and 6.2% (4) from the nonriverine herds were found infected based on the constant four individual samples taken from each herd.

4.2.4 Parasitological trypanosoma differentiation results

Table 8: Parasitological differentationof the positive samples from 81 herds, Leben district, Borena zone Oromia region, Ethiopia, 1997.

Season	*Trypanosoma* spp	Buffy coat positive	Thin blood smear	
			Positive	Negative
wet season	*T. evansi*	32	26	6
	T. vivax	1	0	1
dry season	*T. evansi*	7	6	1
	T. vivax	1	0	1
Total		41	32	9

During wet season *T. evansi* was identified in 32 (97%) and *T. vivax* in one (3%) samples using buffy coat technique, whereas in dry season 87.5% (7/8) of the cases were due to *T. evansi* infection and again one was identified as *T. vivax*. Out of 33 thin smears taken in the wet season from parasitologically *T. evansi* positive animals 26 (78.9%) were confirmed, whereas in dry season six (75%) out of eight smears were seen as having *T. evansi* morphologically. No *T. vivax* could be confirmed the parasitaemia was very low in the buffy coat technique (Table 8).

4.2.5 Test agreement between 10 and 20 minute Antibody ELISA results

Table 9: A comparasion of 10 and 20 minute antibody ELISA results

ELISA reading	20 minute +	20 minute -	Total
10 min. +	172	0	172(53.2%)
10 min.-	8	139	147
Total	180(56.4%)	139	319

Kappa value=0.949

Confidence interval =(0.915-0.984) and Confidence level = 95%.

A total of 324 sera samples collected during the wet season were subjected to antibody ELISA. For 5 samples no ELISA reading were obtained at 10 minutes. Thus, 319 sera were compared. The results indicate a good test agreement between 20 and 10 minutes ELISA readings. One parasitologicaly positive case of *T. evansi* was negative at 10 minute antibody ELISA readings but positive at the 20 minute reading. The parasitologically positive serum for *T. vivax* was positive at 10 and 20 minute ELISA readings (Table 9).

4.3 Packed cell volume, trypanosomoses and gastrointestinal helminths.

Table 10: Comparison of PCV and parasitological results (WBF/BCT) in 81 camel herds in Leben district, Borena zone, Oromia Region, Ethiopia, 1997

Factor	No.of observation	Mean PCV +CI	Median	Range	P-value
Wet season [x]	324	24.4 (24-4.8)	23	12-34	
infected	33	20.8 (19.4-21.2)	21	13-29	0.005**
not infected	292	22.6 (22.2-23)	23	12-34	
Age group					
Below 1 year	65	20.6 (19.6-21.6)	21	12-30	
infected	3	19.3 5.2-33.4)	21	13-24	0.7
not infected	62	21 (20-22)	21	12-30	
1-4 year	97	22.4 (21.7-23.1)	22	13-34	
Infected	13	21.8 (20.2-23.4)	22	18-27	0.2
not infected	84	22.5 (21.7-23.3)	23	13-34	
> 4 year	162	23.0 (22.5-23.5)	24	13-31	
infected	17	20.2 (18-22.4)	20	13-29	0.002**
not infected	145	23.3 (22.8-23.8)	24	13-31	
Dry season [x]	285	22.4 (22-22.8)	25	9-34	
infected	8	18.9 (18.5-19.3)	20	12-34	0.002**
not infected	277	24.6 (24.2-25)	25	9-34	
Age group					
Below 1 year	57	23.7 (22.7-24.7)	24	10-30	
Infected	1	19	-	-	ND
Not infected	56	23.7 (22.7-24.7)	24	10-30	
1-4 year	82	24.5 (23.7-25.3)	25	12-30	
infected	4	18.8 (8.9-28.7)	19	12-25	0.04*
not infected	78	24.8 (23.9-25.7)	25	18-32	
> 4 year	146	24.7 (21.1-25.3)	21	9-34	
infected	3	19 (4.5-34.5)	21	12-24	0.04*
not infected	143	24.8 (24.2-25.4)	25	9-34	

* significant at $P < 0.05$ ** highly significant at $P < 0.01$
ND no statistical comparsion

[x] Seasonal PCV differences were tested using the paired t-test and found significant at $P < 0.001$.

A comparison of the PCV status of infected versus non-infected individuals as revealed by parasitological tests showed significant differences in both seasons. The PCV of parasitologically infected versus non-infected in different age groups showed significant differences only for animals above four years in wet season whereas in dry season significant differences were observed in immature animals (1-4 years) and animals above 4 years (Table 10). Irrespective of the trypanosomoses status highly significant differences in PCV values between age groups in wet season ($p < 0.001$), however not in dry season. were observed. Kruskal-Wallis test was employed to test for age group differences.

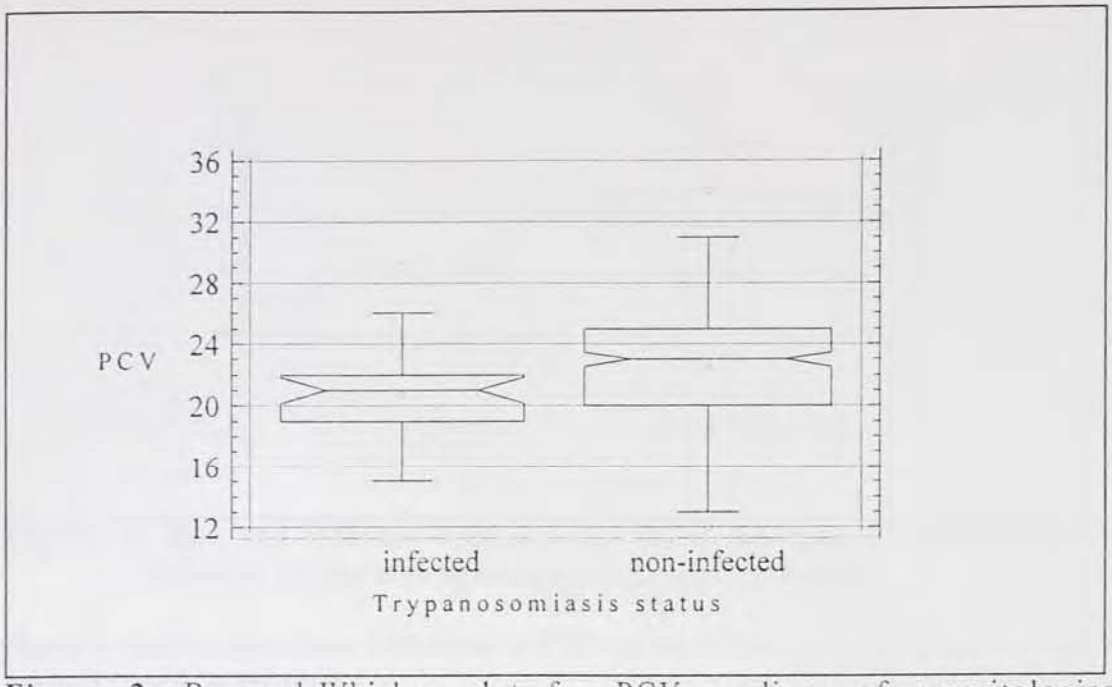

Figure 2: Box-and-Whisker plot for PCV readings of parasitologically infected versus non-infected camels in wet season

The Box-and-Whisker plot shows the PCV of parasitologically infected and non-infected camels in wet season. The median notches (confidence intervals of the median) do not overlap showing that there is a significant difference between the PCV of infected and not infected camels (Figure 2).

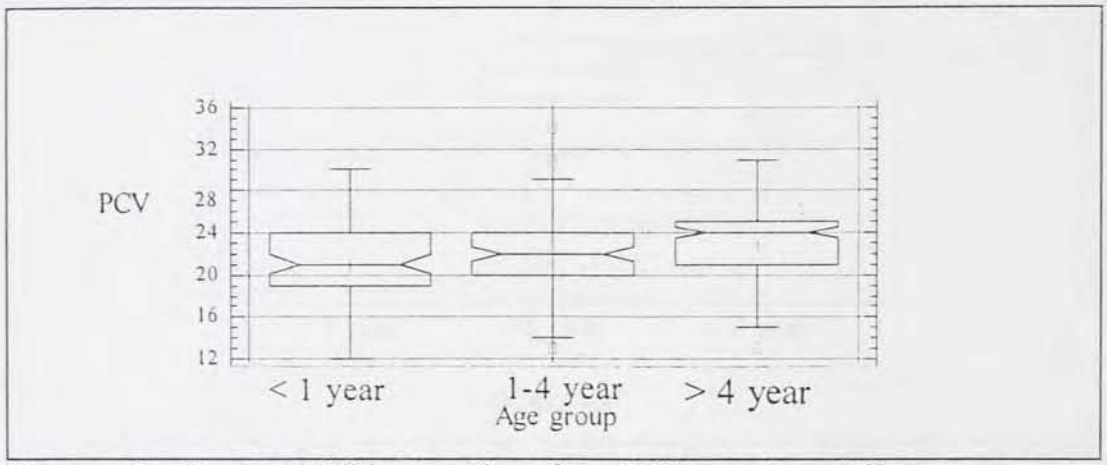

Figure 3: Box-and-Whisker Plot for PCV among different age groups irrespective of the trypanosomoses status in wet season.

Figure 3 shows that the median PCV of the age group > 4 years is significantly different from the other two as indicated by non-overlapping median notches whereas no significant difference became apparent between calves and immature camels (1-4 years).

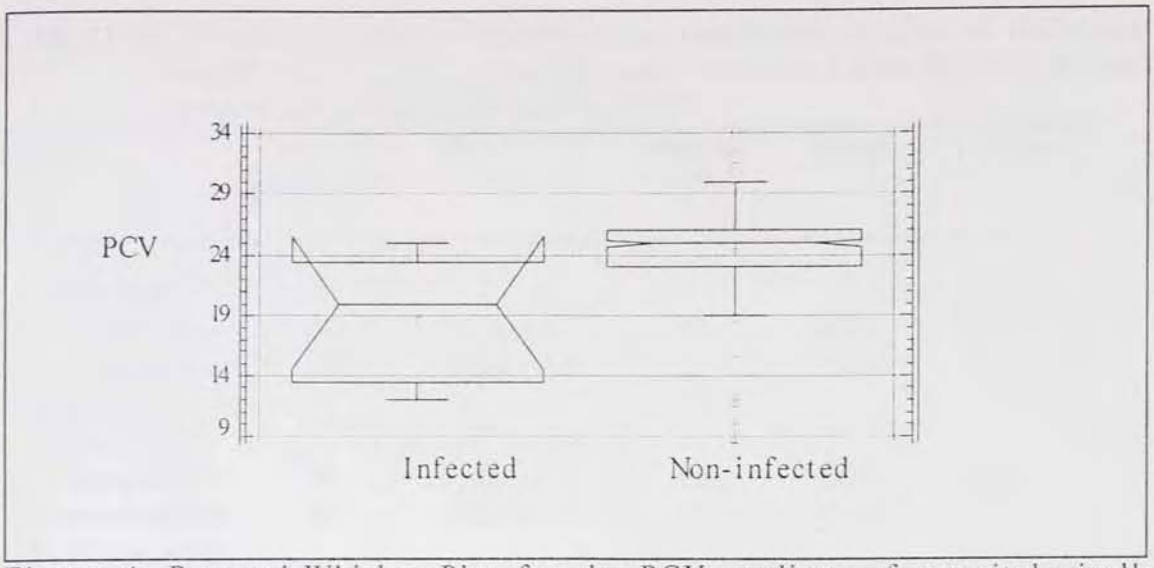

Figure 4: Box-and-Whisker Plot for the PCV readings of parasitologically infected versus non-infected camels in dry season

Figure 4 displays significant differences in PCV values of parasitologically infected and non-infected camels in dry season.

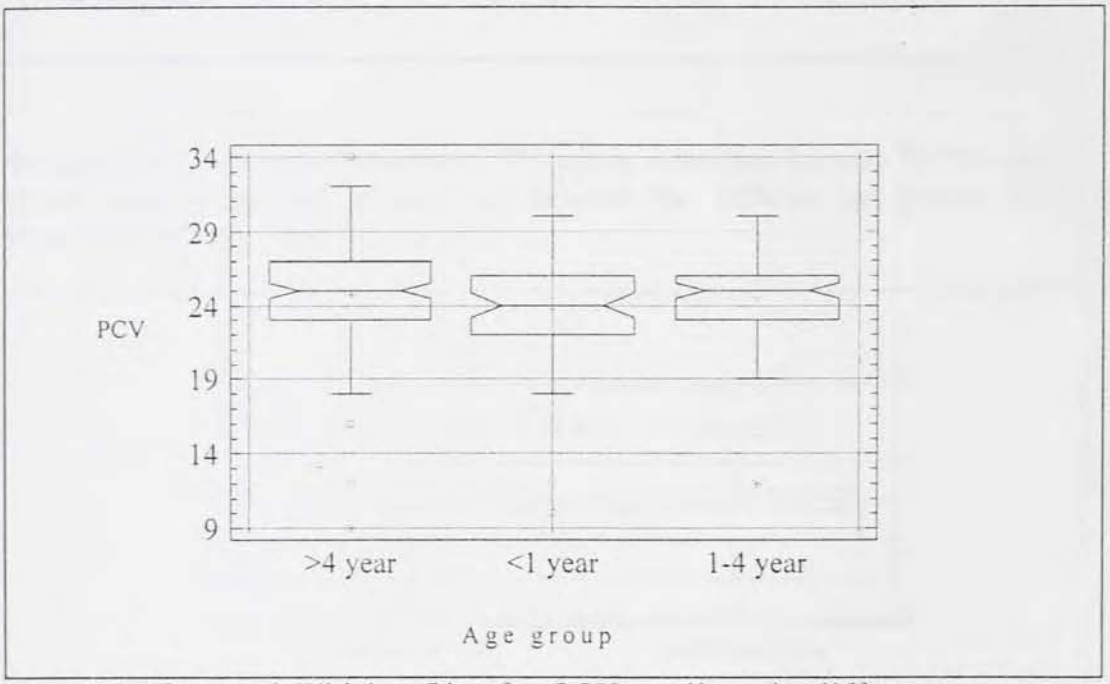

Figure 5: Box-and-Whisker Plot for PCV readings in different age groups in dry season irrespective of trypanosomoses status

Figure 5 depicts the absence of any significant difference in median PCV values in different age groups.

Table 11: PCV Values and serological status (antibody ELISA) of individual camels in wet season from 81 camel herds in Leben district, Borena zone, Oromia region, Ethiopia, 1997.

Factor	No. of observations	Mean PCV+ CI	Median PCV	Range	p-value
Wet season					
seropositive	184	22.4 ± 0.5	23	12-31	0.8
seronegative	140	22.4 ± 0.6	23	13-34	
Age group					
below 1 year					
seropositive	21	19.9 ± 2	20	12-30	0.1
seronegative	44	21.5 ± 1.2	22	13-28	
one to four years					
seropositive	45	22.1 ± 0.9	22	13-28	
seronegative	52	22.6 ± 1.2	23	13-34	0.4
above 4 years					
seropositive	118	23 ± 0.6	24	13-31	0.7
seronegative	44	22.9 ± 1.0	24	13-29	

No significant differences in median PCV values were seen between ELISA positive and ELISA negative animals in total and between the different age groups ($P > 0.05$; Mann-Whitney test) (Table 11).

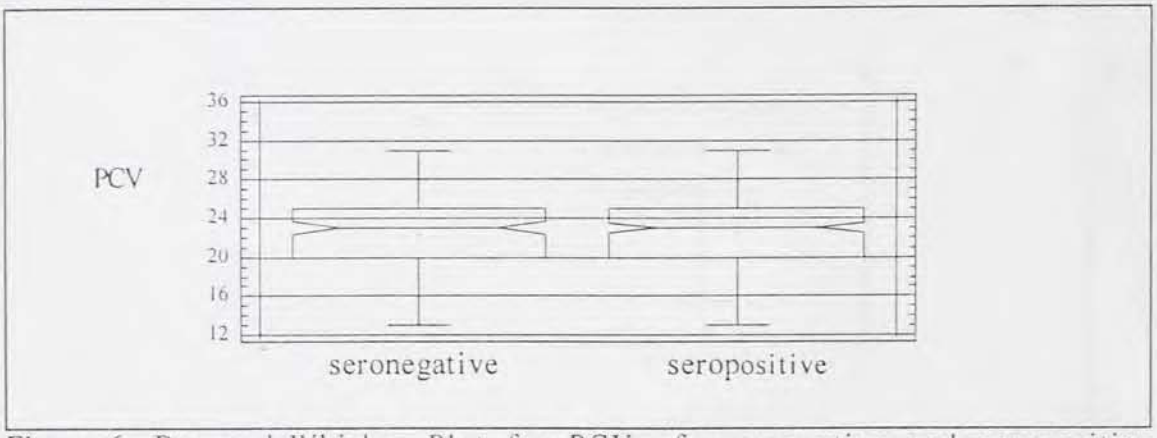

Figure 6: Box-and-Whisker Plot for PCV of seronegative and seropositive camels in wet season

The Box-and-Whisker-Plots in Figure 6 show the distribution of PCV readings of seropositive and seronegative camels in wet season. The overlapping median notch indicates that there are no significant differences in the median PCV values between seropositive and seronegative camels.

Table 12: Comparison of PCV values of parasitologically negative camels in wet and dry season from 81 camel herds, Leben district, Borena zone, Oromia region, Ethiopia, 1997.

Age group	Category	No. of observation	Median ± CI	Mean	Range	P value
below a year	PCV dry season	54	23.5 ± 1.0	24	10-30	0.000**
	PCV wet season	54	21.4 ± 1.1	21,5	12-30	
1-4 years	PCV dry season	69	24.7 ± 0.7	24	18-32	0.000**
	PCVwet season	69	22.6 ± 0.7	23	13-34	
above 4 years	PCV dry season	127	24.5 ± 0.6	25	9-34	0.000**
	PCV wet season	127	23.4 ± 0.6	24	13-31	

**Very highly significant difference (P < 0.001)

Significant differences in median PCV values were observed in age groups of camels which were parasitologically negative in both seasons (P< 0.001, paired t-test) (Table 12).

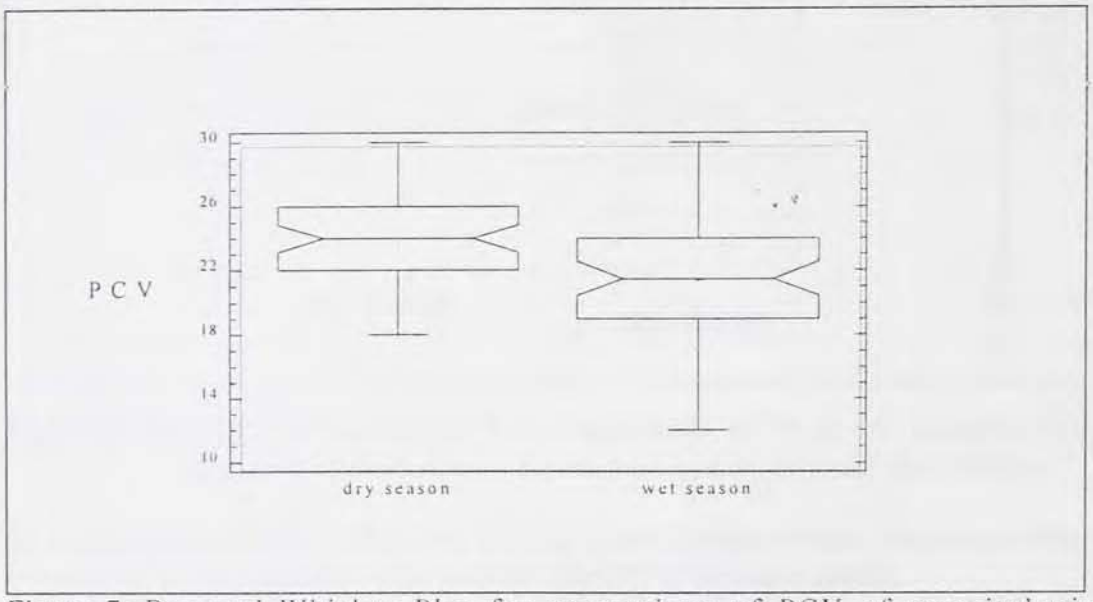

Figure 7: Box-and-Whisker Plot for comparison of PCV of parasitologically negative camels below one year in dry and wet season

The Box-and-Whisker Plots in Figure 7 show significant differences for the median PCV values of calves in wet and dry season.

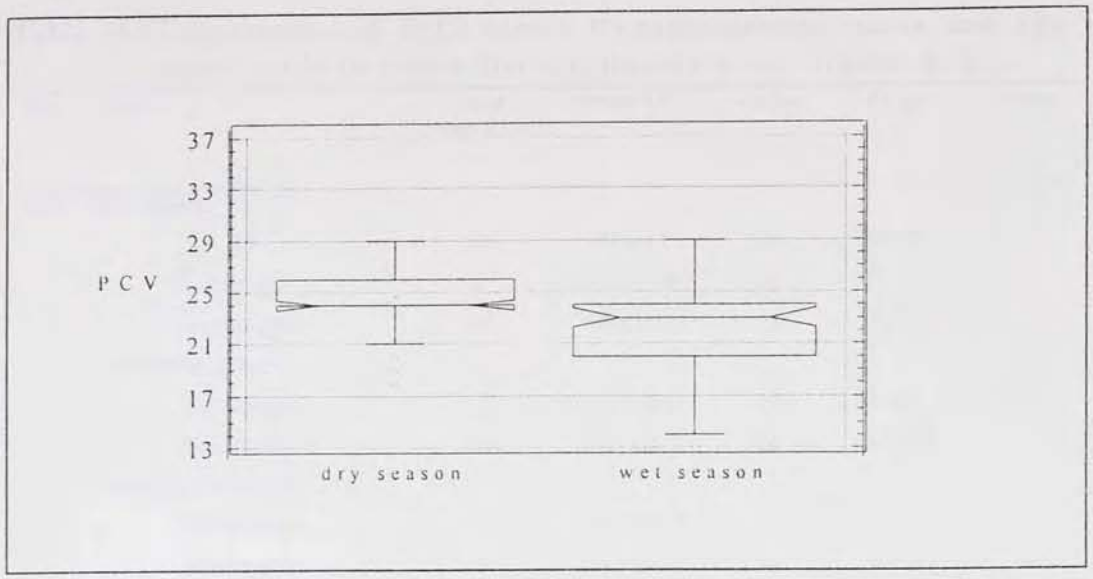

Figure 8: Box-and-Whisker-Plot for comparison of PCV of parasitologically negative camels 1-4 years of age in dry and wet season

Also for immature camels (1-4 years of age) the median PCV values differ significantly between wet and dry season (Figure 8).

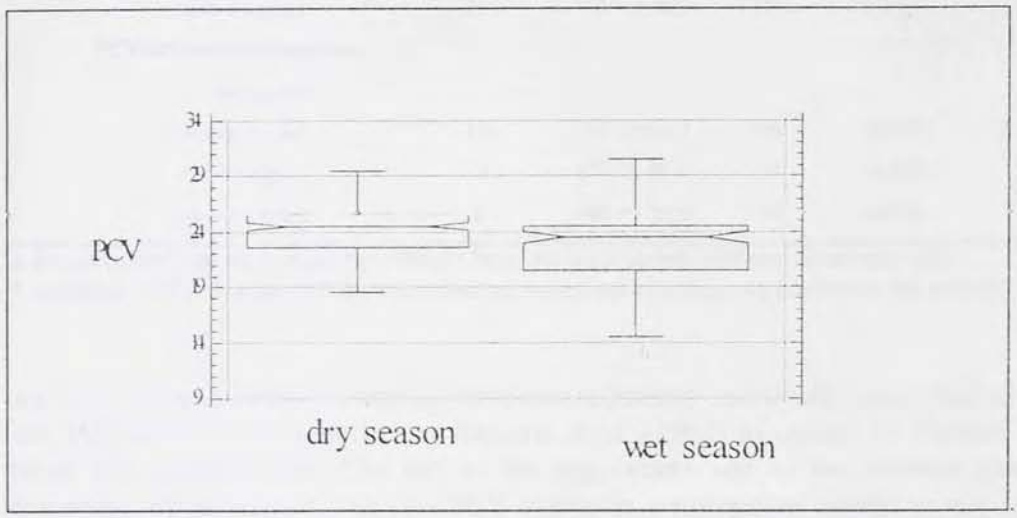

Figure 9: Box-and-Whisker plot for comparison of PCV of parasitologically negative camels above 4 years of age in dry and wet season

As for immature camels the Box-and-Whisker Plots in Figure 9 show significant differences between wet and dry season for the median values PCV of mature camels.

Table 13: Comparison of EpG versus trypanosomoses status and age in 81 camel herds in Leben district, Borena zone, Oromia Region

Test	Factor	No.of observations	Mean + CI	Median	Range	P-value
EpG	**Dry season**					
	all	285	91 ± 17	31	0-1100	-
	Infected	8	158.8 ±198.7	82	21-740	0.08
	noninfected	277	89 ±16.6	28	0-1100	
	Serological status[1]					
	Seropositive	127	91.3 ± 25.5	36	0-600	0.4
	seronegative	158	90.6 ±20.4	26	0-1100	
	Serological status (PCV<20[1])					
	Seropositive	42	130.6 ± 6.9	61	0-1100	0.2
	seronegative	35	116.9 ±35.2	82	6-470	
	PCV<20, irrespective of trypanosomoses status					
	Age group					
	below 1 year	24	135.5 ±43.1	99.5[a]	8-470	0.04*
	1-4 years	21	87.8 ±37.3	55[b]	3-250	
	above 4 years	32	140.1 ± 90.6	37[b]	0-1100	
	PCV<20, and seronegatives					
	Age group					
	below 1 year	14	150.3 ± 64.7	126	36-470	0.15
	1-4 years	13	87.5 ± 49.4	54	6-250	
	above 4 years	8	186.4± 92.9	59	6-385	

a, b median EpG values denoted by different letter are significantly different from each other.
* significant difference ($p < 0.05$); [1] not including camels parasitologically positive in dry season.

As PCV values from the literature have no consistency to classify an animal as anaemic or not, the lower margin reported by Banjerie *et al.* (1962) as quoted by Clausen (1986) was taken into consideration. The aim of the egg counts was to see whether gastrointestinal helminths are associated with low PCV values in seronegative camels in wet season under natural conditions. However, the investigation was undertaken in dry season, assuming no change of serological status. The results obtained indicated a gastrointestinal helminths prevalence of 90.5%. The prevalence of Strongyle eggs was 88.1%, of *Strongyloides* spp 27.7%, of *Trichuris* spp. 14% and of *Monezia expansa* 4.2%.

The results depicted in Table 13 showed the following situation: A marked difference in EpG of between infected animals and not infected camels was observed in dry season (P=0.08). However, the differences between serologically positive and seronegative camels were not significant but significant differences were seen between age groups which have PCV values below 20, irrespective of the serological status in wet season. The median EpG of calves was significantly different from immature (1-4 years) and adult camels (> 4years). A comparison of EpG counts in seronegative animals with a PCV below 20, stratified for different age groups, revealed no significant difference in egg output in dry season. Nevertheless, camels in all age groups were seen excreting one or more types of eggs

Figures 10 to 14 provide graphical illustrations of the values presented in Table 13, demonstrating the variability of the parameters measured.

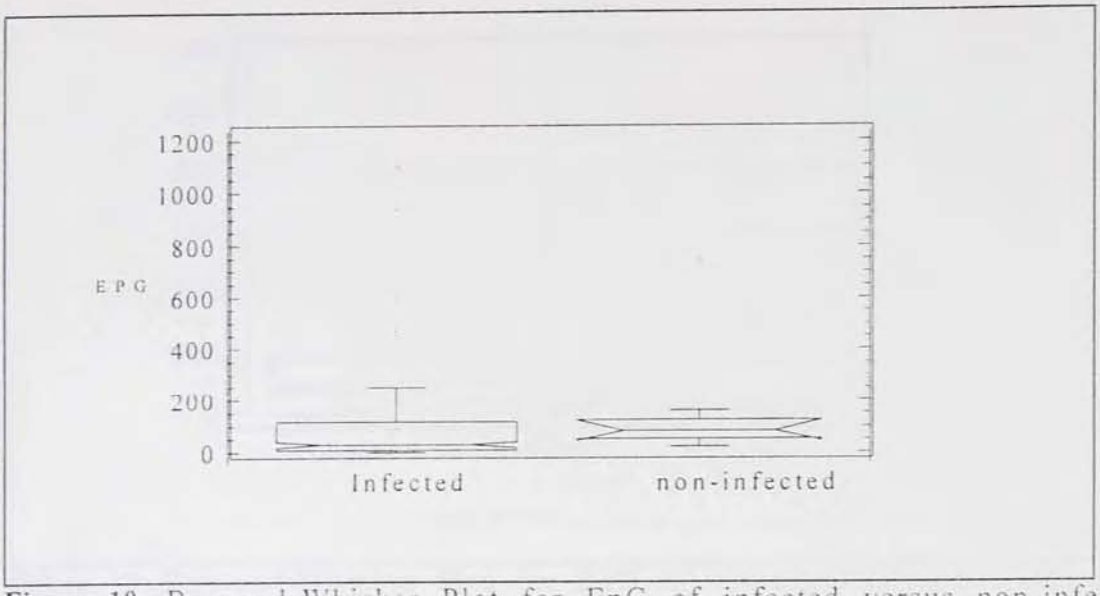

Figure 10: Box-and-Whisker Plot for EpG of infected versus non-infected camels in dry season

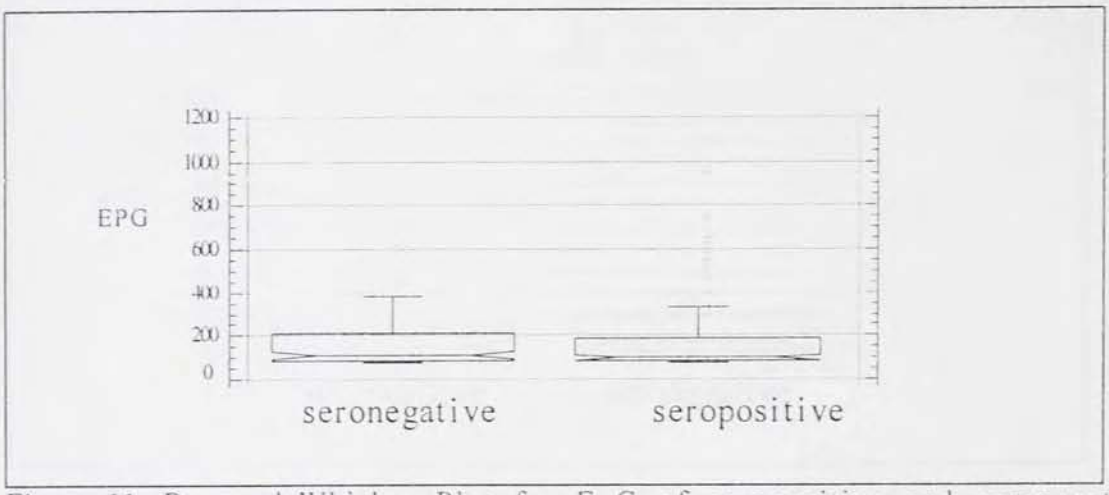

Figure 11: Box-and-Whisker Plot for EpG of seropositive and seronegative camels.

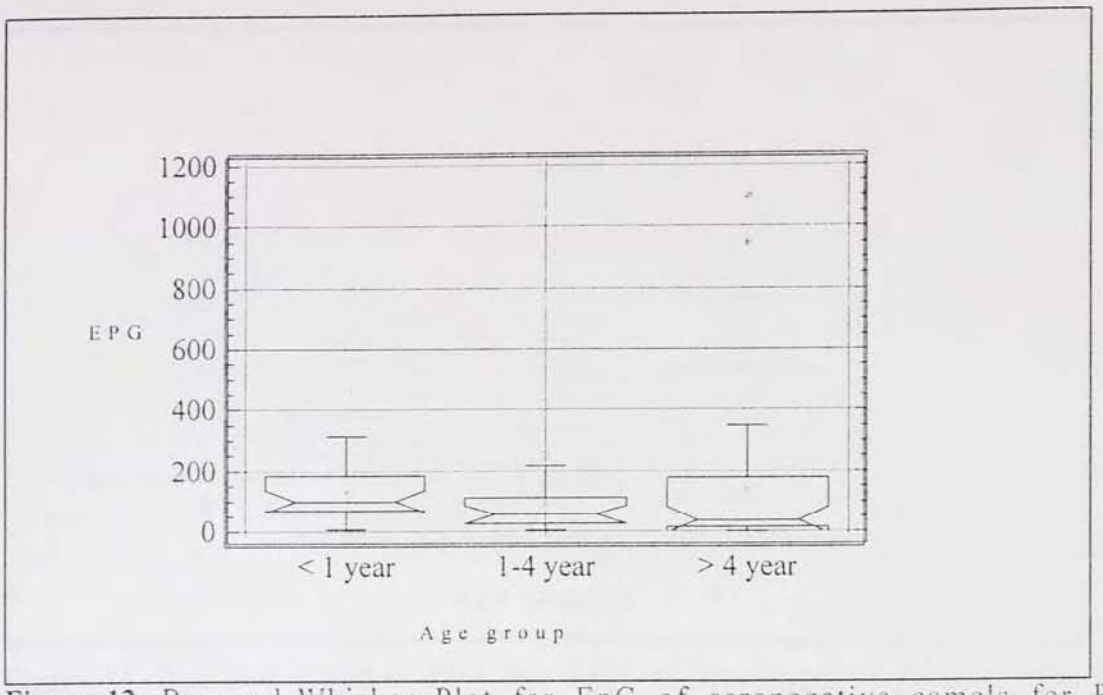

Figure 12: Box-and-Whisker Plot for EpG of seronegative camels for PCV below 20 among different age groups

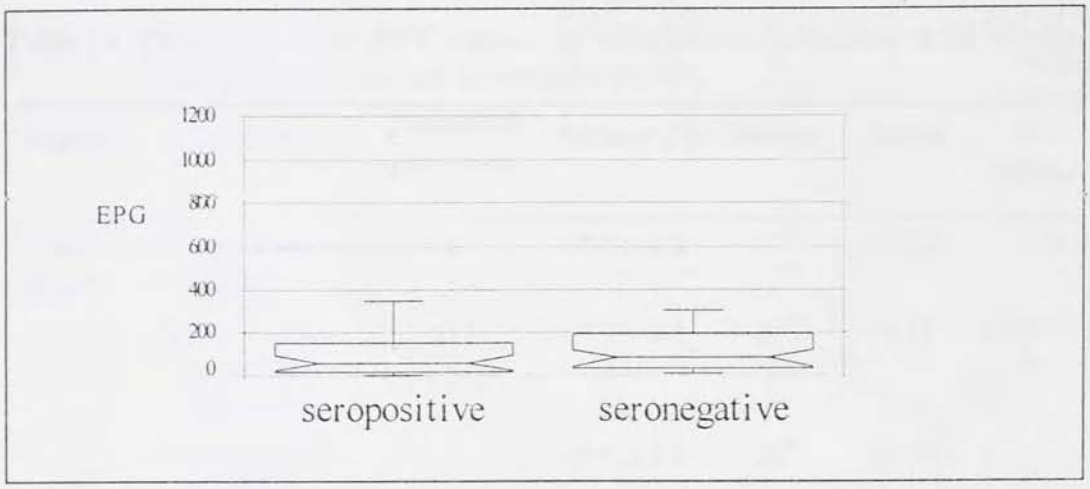

Figure 13: Box-and-Whisker Plot for EpG of seropositive and negative animals with PCV below 20

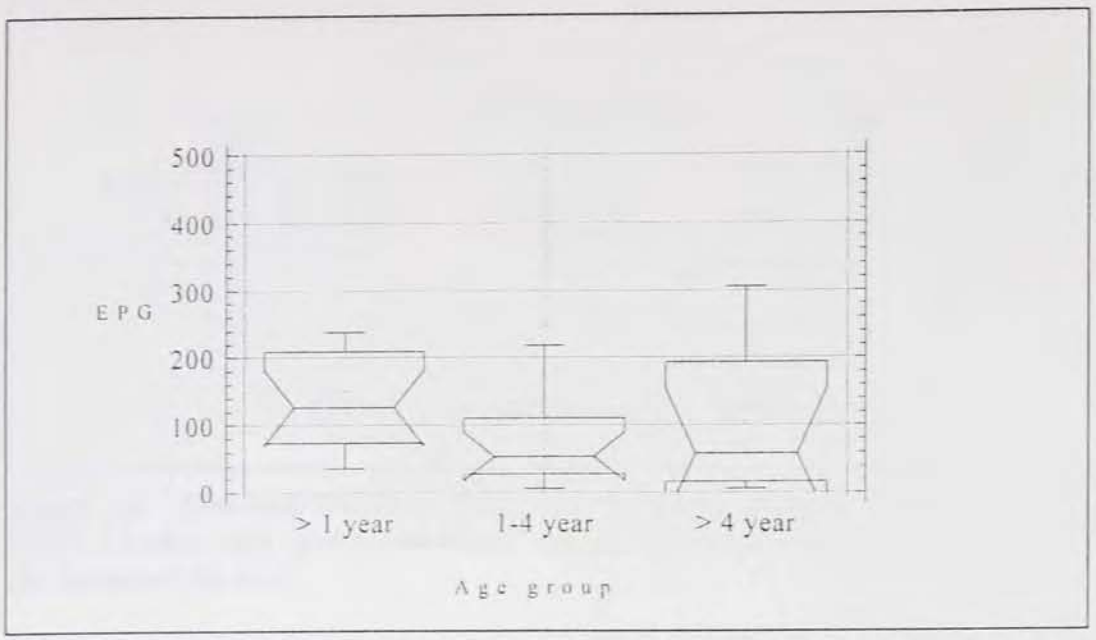

Figure 14: Box-and-Whisker Plot for EpG of seronegative camels with PCV below 20 stratified for age group

Table 14: Comparison of PCV values of concurrent infection with trypanosma and gastrointestinal helminths (GIH)

Season	Category	Number of observations	Mean + CI	Median	Range	P-value
Dry season	Tryps.+ and GIH+	8	18.9 ± 4.4	20[a]	12-25	
	Tryps negative and GIH positive	253	24.4 ± 0.4	25[b]	9-34	0.001**
	Tryps and GIH negative	24	25.9 ± 1.0	26[b]	21-31	

a, b median PCV values denoted by different letters are significantly different from each other.
** highly significant difference ($p < 0.01$).

The median PCV values of camels concurrently infected with both trypanosomes and gastrointestinal helminths were significantly lower compared to those infected with helminths alone and those not infected at all (Kruskal-Wallis test; $P < 0.01$).

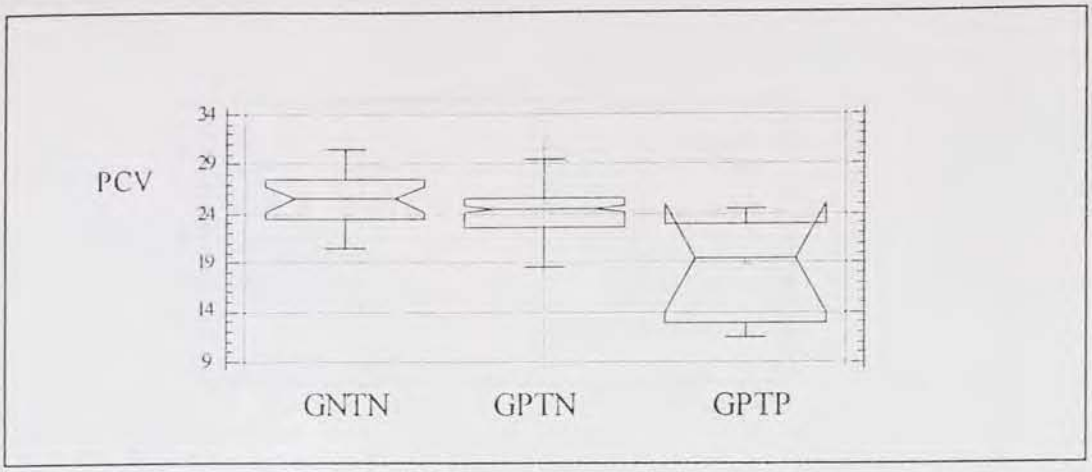

Figure 15: Box-and-Whisker Plot for PCV of camels infected both with trypanosomes and gastrointestinal helminths, gastrointestinal helminths and not infected by both

GNTN: Gastrointestinal helminths and trypanosomes negative
GPTN: Infected with gastrointestinal helminths but trypanosomes negative
GPTP: Infected both with gastrointestinal helminths and trypanosomes

The Box-and-Whisker plots in Figure 15 reflect the distribution of PCV values of camels neither infected by gastrointestinal helminths nor by trypanosomes, infected with gastrointestinal helminths alone, and infected with concurrent infection of trypanosomes and gastrointestinal helminths as provided in Table 14.

Table 15: Comparison of PCV of infected camels before and after treatment

Season	Category	Observations	Mean + CI	Media n	Range	p-value
wet season	before treatment	27	20.6 ± 1.6^{a}	21	18-31	0.000***
Dry season	after treatment	27	26.5 ± 1.2^{b}	28	13-29	

a. b mean PCV values designated by different letters are significantly different from each other.
***Very highly significant ($P < 0.001$), paired t- test.

The median PCV of animals treated at the first investigation (wet season) showed significant improvement at the second visit (Table 15).

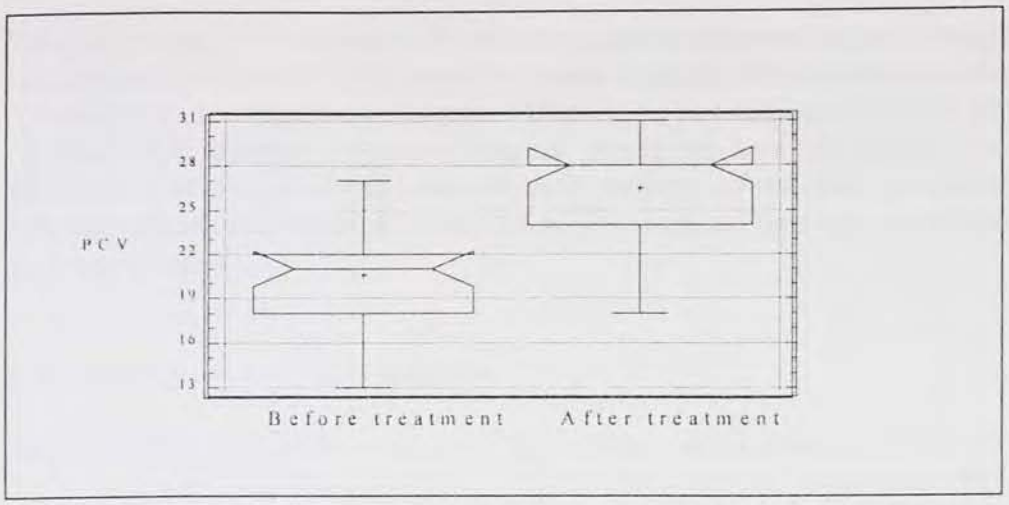

Figure 16: Box-and-Whisker Plot for PCV of infected camels before and after treatment

The Box-and-Whisker plots in Figure 16 show the distribution of PCV values of camels after and before treatment. The median PCV of treated animals was significantly different from the mean values before treatment as indicated by the non overlapping 95 % confidence interval of the median.

4 4.Clinical symptoms observed

Table 16: Clinical symptoms observed in parasitologically infected and seropositive camels in wet season

Clinical symptoms observed	WBF/BCT positive	serologically positive	Total No. of camels showing the symptoms
Anaemia			
as sole symptom	5 (13.2%)	42 (53.8%)	78
in combination with others	16 (18.6%)	53 (61.6%)	86
Loss of condition			
as sole symptom	0	31 (56.4%)	55
in combination with other symptoms	12 (13.5%)	56 (62.9%)	89
Lacrimation			
as sole symptom	0	0	0
in combination with other symptoms	15 (17.6%)	54 (63.5%)	85
Fever			
as sole symptom	0	0	0
in combination with other symptoms	20 (90.4%)	21 (95.5%)	22
Pneumonia.			
as sole symptom	0	0	0
in combination with other symptoms	1 (50%)	2 (100%)	2
Diarrhoea			
as sole symptom	0	0	0
in combination with other symptoms	3 (100%)	3 (100%)	3
Abortion	0	1 (100%)	1
No signs	3 (33.3%)	46 (50.5%)	91

Table 16 provides the frequency of clinical symptoms observed in parasitologically infected and seropositive camels in wet season. In parasitologically infected animals anaemia is, when it occurs, the most important symptom indicating trypanosomoses infection whereas loss of condition and anaemia are more frequent symptoms seen in seropositive animals. A combination of symptoms was observed in the majority of the cases. Nevertheless, cases of infection or seropositive camels which did not show any of the symptoms of trypanosomoses were also observed.

4.4 .Production parameters

Table 17: Descriptive statistics of production parameters in 81 Camel herds in Leben District, Borena zone, Oromia region, Ethiopia, 1997.

Production variable	No of observations	Mean value	Median	Standard deviation	Range
Herd size	81	14	12	9.8	4-47
Offtake rate	81	29.3%	26.3%	26.3	0 - 116.7[x]
Productive offtake	81	5.7%	0	10	0-50
Slaughter rate	81	0.6 %	0	2.9	0-23.5
Marketing rate	81	4%	0	8.3	0 - 40
'Gift out' rate	81	1.2%	0	3.2	0-16.6
Non productive offtake rate	81	20.7%	19.7%	22.6	0-109.6
Crude mortality rate	81	20.7%	15.3%	22.6	0- 109.6[xx]
Loss rate	81	1.1%	0	4.3	0-25
Predator rate	81	1.3%	0	4.4	0 25
Accident rate	81	0.5%	0	2.9	0 - 25
'Gift in rate'	81	0.85%	0	2.5	0 -18.2
Purchase rate	81	3.5%	0	9.2	0-50

[x] In one herd an offtake rate of 116.7% was computed. In this herd 7 animals were withdrawn (six deaths and one sold) with an average herd size of six.

[xx] In one herd a crude mortality rate of 109.6% was calculated. In this herd a total of 17 camels were reported to have died of camel trypanosomoses (*Dukane).* In 22 herds no cases of death were reported.

Table 17 provides descriptive statistics for production variables in 81 herds investigated The results indicate a high offtake rate in the preceding year, whereas the birth rate (Table 18) and the number of animals introduced (purchase rate and 'gift in' rate) were quite low.

Table 18: Descriptive statistics for reproduction parameters in 81 camel herds in Leben District, Borena zone, Oromia region, Ethiopia, 1997.

Production variable	No of observations	Mean	Median	Standard deviation	Range
Birth rate	81	17.7%	15.4%	14.5	0 - 66.7
Age at first calving	384	5.9 years	5.75 years	1.3	4-11
Calving interval	271	2.1 years	2 years	0.8	1.1 -8.5

Table 18 shows a low birth rate, a wide range for the age at first calving of 5.9 years (range 4-11) and a mean calving interval of 2.1 years (range 1.1- 8.5). It was also reported that camels can give birth every year depending on the quality of the seasons.

Table 19: Herd size differences according to ecological zones, management units and herders experience in 81 camel herds in Leben District, Borena zone, Oromia region, Ethiopia, 1997.

Factor	No of observations	Median	Mean	Standard deviation	Range	Test applied	p-value
Ecological zone							
Riverine	9	6^a	7	2.4	4 -11	Mann-Whitney test	0.005**
Non riverine	72	13^b	15.8	10.5	4 - 47		
Management unit							
Household	41	10^a	11.9	7.1	4 - 38	Kruskal-Wallis test	0.02*
Polygamous family	37	14^b	16.2	11.3	4 - 44		
Extended family	3	47^c	37	17.3	17 - 47		
Experience (years)							
1-10	39	9^a	11.4	7.6	4 - 33	Kruskal-Wallis test	0.02*
11-22	14	14^b	17.6	12	5 - 44		
23-37	28	15.5^b	18.1	12.4	4 - 47		

* Significant ($p< 0.05$); **Highly significant ($P < 0.001$).
a, b and c median herd sizes denoted with different letters are significantly different from each other

Table 19 shows significant differences in herd size between different management units, ecological zones and different levels of experience.

Table 20: Crude mortality differences in (%) according to herd trypanosomoses status, ecological zones, management units and herders experience in 81 camel herds in Leben district, Borena zone, Oromia region, Ethiopia, 1997.

Factor	No of observations	Median	Mean	Standard deviation	Range	Test applied	p-value
Serological trypanosmiasis status of herd							
Positive	74	5.1	21.6	22.9	0 - 109.7*	Mann-Whitney test	0.15
Negative	7	19.1	10.9	17.9	0 - 50		
Management unit							
Household	41	22.2	24.9	24.7	0-109.7*	Kruskal-Wallis test	0.07
Polygamous	37	11.9	15.5	19.6	0 - 100		
Family	3	14.9	13.5	12.8	0 - 25.5		
Ecological zone							
Riverine	9	7.6	17.6	25.9	0 - 82.4	Mann-Whitney test	0.2
Nonriverine	72	18.6	21.2	22.1	0-109.7*		
Experience							
1 - 10	39	18	19	12.4	0-100		
11 - 22	14	11.7	17.8	19.1	0-71.4	Kruskal-Wallis test	0.6
23 - 37	28	19.6	24.7	12.3	0-109.6*		

* Crude mortality as a single value calculated for each herd is treated as continuous variable when treated for statistical differences.

*see page 60 how a crude mortality rate of 109.6 was computed.

No significant differences of crude mortality became apparent between different levels of management, ecological zones, experience and the serological status of a herd (Table 20)

Table 21: Age at first calving and calving interval differences according to breed, ecological zones, and individual trypanosomoses status in 74 camel herds in Leben District, Borena zone, Oromia region, Ethiopia, 1997.

Factor	No. of observations	Mean	Median	Standard deviation	Range	Test applied	p-value
Age at first calving (in years)							
Breed/ type	171	5.9	5.8	1.3	4-6	Anova	0.6
Geleba	202	5.8	5.8	1.3	4-11		
Hodkka	11	5.5	5.5	0.6	5-6.8		
Elidimma							
Ecological condition							
Riverine	25	6.1	6	1.4	4.3-10.3		
Nonriverine	359	5.8	5.8	1.3	4-11	t-test	0.3
Individual serological *Trypanosoma* status							
Positive	86	6	6	1.3	4-10.3	t-test	0.4
Negative	33	5.7	6	1.1	4-8		
Calving interval (in years)							
Breed/ type							
Geleba	113	2.1	2	0.7	1.1-6.3		
Hodkka	151	2.2	2	0.9	1.2-8.5	Anova	0.6
Elidimma	7	2.0	2	0.6	1.4-2.9		
Ecological condition	17	2.4	2.5	0.6	1.1-8.5	t-test	0.2
Riverine	254	2.1	2	0.8	1.3-3.3		
Nonriverine							
Individual serological *Trypanosoma* status	64	2.3	2.1	1	1.3-7.3	t-test	0.9
Positive	22	2.3	2	1.3	1.3-6.3		
Negative							

Table 21 is based on the breeding history of 384 camels with at least one birth; 271 camels gave birth to more than one calf. Thus, 384 were considered for age at first calving calculation whereas 271 for calculating calving intervals. 86 of the 384 breeding females were tested in the antibody ELISA. No significant differences were apparent between the reproductive variables calving interval and age at first calving and factors such as management, ecological zones, and the serological status of the herd and the individuals (Table 21).

Table 22: Herd composition of 81 camel herds in Leben District, Borena zone, Oromia region, Ethiopia, 1997.

Category	Proportion of the herd
Below one year	12.4%
Male	54.1%
female	45.1%
One to four years	34.6%
male	43%
female	57.
pregnant	1.3%
Non-pregnant	98.7%
Above four years	53%
Male	15%
Bulls	36.3%
Rutting bulls	63.7%
Female	85%
Non-pregnant	15.1%
Pregnant/ lactating	84.9%

Table 22 gives an overview of the compostion of an average camel herd. Such a herd consists mainly of mature (> 4 years) and immature camels (1-4 years) whereas calves form a small proportion.

Table 23: Proportion of deaths in different age group in 81 camel herds in Leben district, Borena zone, Oromia region, Ethiopia, 1997.

Age group	Number of deaths	Proportion (%)
< one year	86	34.3
one to four years	65	25.9
> four years	100	39.8
Total	251	100

Out of all deaths recorded in 81 camel herds investigated the lowest proportion is found in immature camels (Table23).

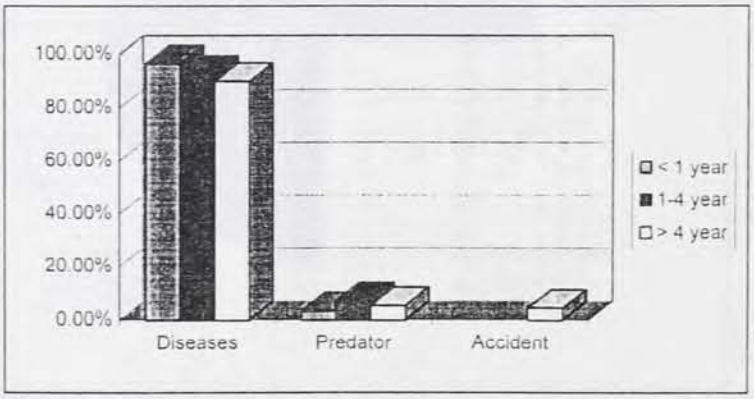

Figure 17: Causes of losses in different age groups of camels in 81 Camel herds in Leben district, Borena zone, Oromia region, Ethiopia, 1997

Figure 17 shows that diseases are the major cause of losses of camels in the area, whereas losses due to predators and accidents have a minor contribution.

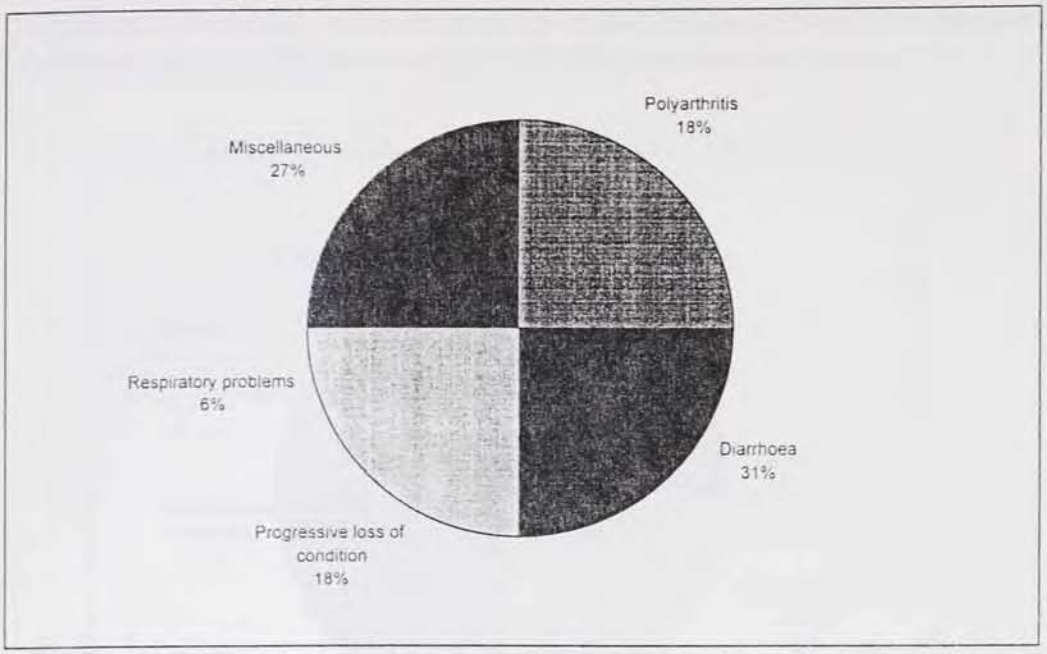

Figure 18: Causes of death in calves in 81 camel herds in Leben district; Borena zone, Oromia region, Ethiopia, 1997.

Diarrhoea, diseases characterized by swelling of the joints (*Dabta*) and progressive loss of condition (*Kolie/Elkot*) were reported as major cause of death in young calves (Figure 18). Miscellaneous causes include camel pox (one case reported), contagious skin necrosis (one case reported), sudden death, bloating, weakness and deaths of unknown causes.

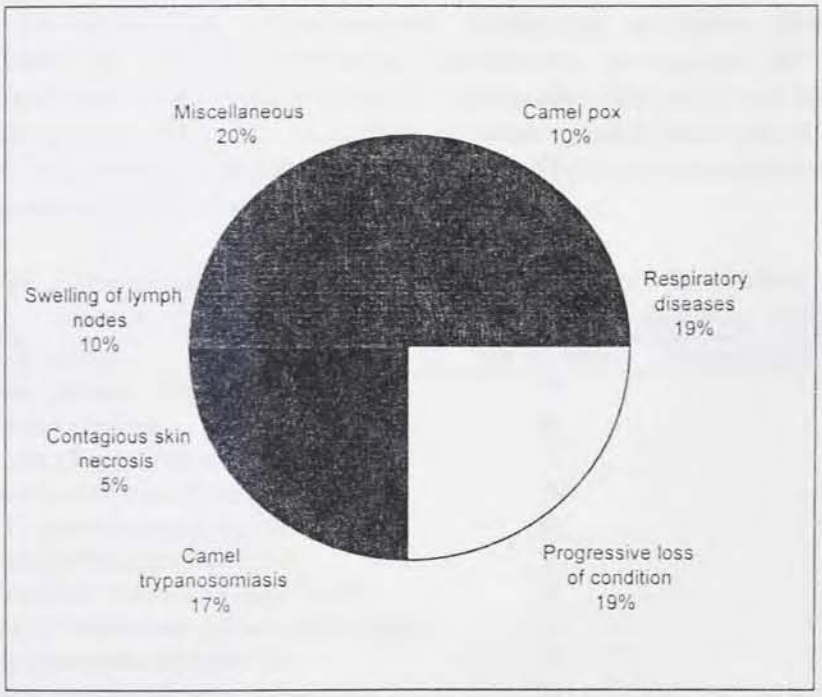

Figure 19: Causes of death in camels 1-4 years of age in 81 camel herds, Leben district, Borena zone, Oromia region, Ethiopia 1997.

The piechart in Figure 19 shows the distribution of causes of death in animals aged 1-4 years. Progressive wasting disease (*Kolie/Elkot*) respiratory diseases (*furi, Kufa*), camel pox (*Bototie*), camel trypanosomoses (*Dukane*), a disease characterized by swelling of lymphnodes (*kierierkie*) were reported as major causes of death in immature camels. Miscellaneous causes include toxic plants, bloating and unknown causes.

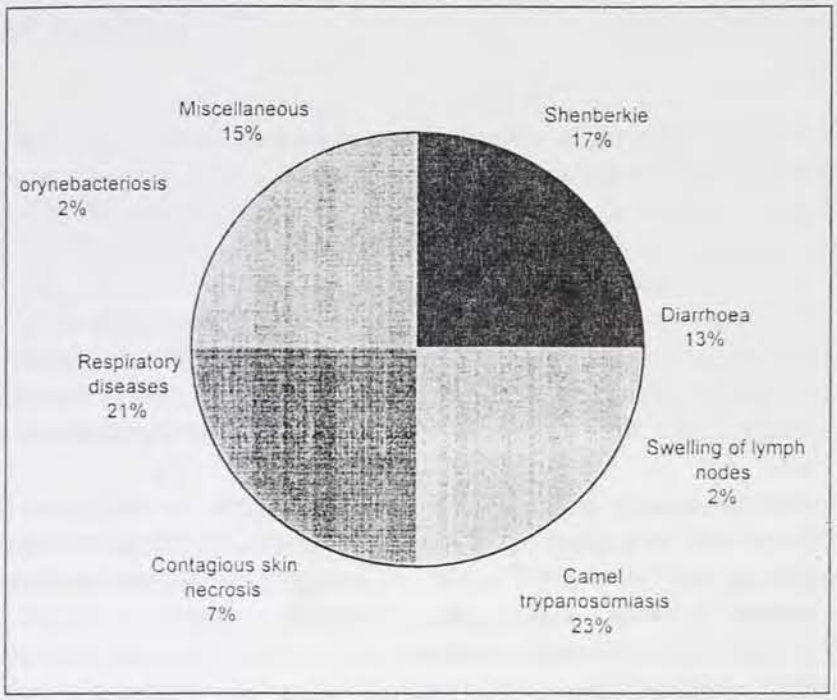

Figure 20: Causes of death in camels above 4 years age in 81 camel herds Leben district, Borena zone, Oromia region, Ethiopia ,1997.

Figure 20 shows that trypanosomoses, respiratory problems (*Furi, Kufa*), diseases characterized by nervous symptoms (*Shenberkie*), contagious skin necrosis (*Chifio*), corynebacteriosis (*malla*) and swelling of lymphnodes (*kierierkie*) are major causes of death in camels aged above 4 years. Miscellaneous causes include toxic plants, lameness, sarcoptic mange (*Chito*), dystocia, and diseases characterized by symptoms characteristic for milk fever at late gestation (*Chechebsa*).

Table 24: Proportional mortality of diseases in 81 camel herds in Leben district, Borena zone, Oromia Region, Ethiopia, 1997.

Disease/syndrome	No. of deaths	Proportional mortality (%)
Diarrhoea (*Albathi, Shugdie, Dukaa*)	38	15.1
Polyarthritis (*Dabta*)	15	6.o
Camel pox (*Bagga/Bototie*)	7	2.8
Respiratory problems (*Furi, Kufa*)	38	15.1
Camel trypanosomoses (*Dukane*)	34	13.5
Corynebacteriosis (*Malla/Bulka*)	2	0.8
Contagious skin necrosis (*Chifto/Dulla*)	11	4.4
Swelling of lymphnodes (*Kierikie/Kendecha*)	8	3.2
Nervous symptoms (*Shenberkie*)	18	7.2
Progressive wasting disease (*Kolie/Elkot*)	27	10.8
Miscellaneous	53	21.1
Total	251	100

In annex 5 a detailed description of the diseases and syndromes mentioned above is presented. Trypanosomoses, diseases characterized by nervous symptoms, diseases of calves characterized by progressive wasting, diarrhoea, respiratory diseases and polyarthritis were the major causes of death (Table 24). It should be mentioned that 17 deaths due to camel trypanosomoses (*Dukane*) are reported in one camel herd.

5 DISCUSSION

In the study area camels are kept by a wide variety of ethnic groups. Camel husbandry started in the late nineteen seventieth by the Gujjis and Borenas who otherwise used to be cattle breeders. Bush encroachment and the versatile nature of camels to survive and to produce even in the days of drought were found to be the underlying reasons to start camel husbandry. This finding confirms the statements given by Belete (1984). The main purpose for keeping camels in the study area is for milk production followed by transportation services, sale of live camels, slaughter and as a security to cope with the recurring drought conditions. Contrary to this Coppock (1994) stated that transportation is the major objective of camel keeping in Borena lowlands except for the small pockets of Gabra and the Somali in the east.

Among many diseases known to affect camel, camel trypanosomoses was found to be the most important problem to camel herdsmen in the study area. The investigation carried out on this disease revealed a prevalence of 10.2% and 2.8% in wet and dry season respectively using parasitological techniques to demonstrate the parasite. However, the seroprevalence is as high as 56.5% using antibody ELISA. The prevalence reported in our study in the rainy season is in agreement with earlier reports by Richard (1979) and Theodros (1995) but lower than the figures reported by Pegram and Scott (1976), Tenaye (1990) and Ketema (1993) for the Borena region. Basic differences in study design, particularly the absence of a proper sampling frame in all above mentioned studies undertaken in the area seem to account for the variations and, thus, make comparisons and inferences more complicated.

Contrary to the parasitological findings a large proportion of camels was found to be seropositive. The chronic nature of the disease, the possible presence of trypanosomes in extravascular locations (Clausen, 1986; Ngernawa *et al.*, 1993) and the fact that an antibody ELISA cannot differentiate between past and present infections as detectable levels of antibodies can still be found in animals which are self-cured or after treatment with trypanocidal drugs (Luckins *et al.*, 1979; Olaho Mukani *et al.*, 1992) might explain the difference. However, from the point of view that the conventional parasitological methods might not detect low level parasitaemia in the chronic stage of the disease, the possible extravascular localization of the parasite, and the indiscriminate and quite common use of trypanocidal drugs such as Berenil in inappropriate doses, one might understand that a large proportion of test positive cases are not detected parasitologically.

The seroprevalence figures obtained in the present study are similar to the findings in Somalia where Caille, (1987) reported 57.6% reactors in the antibody ELISA. Pegram and Scott (1976) found 42-71% of camels in the Borena area reacting to the Takta reaction, formal gel, mercuric chloride and thymol turbidity tests, and, however, stated that these tests are not specific for trypanosomes and not sufficiently reliable for an accurate diagnosis. In contrast to these techniques antibody ELISA is said to be more sensitive and specific for trypanosomes (Luckins *et al.*, 1979).

Age, sex and the physiological status of the animal had no significant effect on the infection with trypanosomes (detection of the parasite) in both study seasons. However, ecological condition was found to have an effect on the prevalence during the dry season. The abundance of flies all year round in the riverine area in contrast to the abundance of flies in the wet season favours the transmission process from an infected camel to a non-infected camel. Sheep and goats (Boid *et al.*, 1981) as well as cattle in Somalia (Caille, 1987) reacted positive to the antibody ELISA suggesting their possible involvement as reservoirs of infection in the Borena area as well.

Even though age has no influence on parasitaemia in our studies a larger proportion of camels aged one to four years is affected. These findings are in accordance with the reports of Schwartz and Dioli (1992), Diall *et al.* (1993) and Egabe Niwyi and Chaudhry (1994). However, the differences observed between age groups were not significant ($p > 0.05$). In contrast to this Rowlands *et al.* (1993) reported age as risk factor in bovine trypanosomoses in Ethiopia.

The seasonal difference reported in the present study goes along with the abundance of flies in the wet season even outside the riverine areas. Baumann and Zessin (1992) found a similar situation in Somalia. As reported by Mohamoud and Gray (1980) for the Sudan fly population and trypanosoma status are correlated. However, Egabe Niwyi and Chaudhry (1994) indicated that season had no influence on trypanosomoses in camels in Nigeria. Since such inference was made based on slaughter camels findings it is usually difficult to generalize this to a population in the field.

Looking at the serological findings, which, in fact, relate to previous as well as to present exposure to trypanosomoses, age, physiological status and ecological conditions were found to be factors associated with the disease. The significant differences seen between different physiological status might be confounded by age as pregnant/lactating and non-lactating animals were on average older than four years. The increase in seroprevalence with age might be explained by an increase in exposure as an animal ages and by the higher risk of infection in riverine areas all year round. Greiner *et al.* (1997) had revealed an increase in seroprevalence, however in cattle, as an animal ages, and stressed the need for the consideration of intrinsic cut-off values for each stratum to add to a meaningful interpretation of the ELISA. Dia *et al.*(1997) using card agglutination test set (CATT) and indirect fluorescent antibody test (IFAT), had also indicated an increase in seroprevalence as camel ages particularly up to the age of 10 years. Seroprevalence data showed that the disease is endemic in the area as a considerable proportion of herds were found test positive.

The cumulative incidence and the incidence density are very low (0.03 and 3/10000 animal days). This indicates that as the fly population decreases only a few new cases of trypanosomoses will be encountered in the population. Nevertheless, taking into account the periodic parasitaemia, the chronic nature of the disease, and the methods utilized to determine the incidence which might not detect low level parasitaemia, it appears to be more meaningful to determine the incidence by more sensitive methods such as antigen ELISA. However, the antigen ELISA system is still under evaluation and not yet commercially available for field work.

Trypanosoma evansi had been found as the most common cause of camel trypanosomiasis. However, two cases of *T. vivax* were also encountered during this study using the buffy coat technique. Nevertheless, *Trypanosoma vivax* was not identified in blood smears as the

parasitaemia was very low in the buffy coat examination. Camels might contract infection from cattle since *Trypanosoma vivax* is reported in cattle in the study area (Richard, 1979). *Trypanosoma vivax* was reported as cause of camel trypanosomoses in camel in Sudan (Boid *et al.*, 1986) and in Ethiopia (Zeleke, 1986). In contrast to our findings *T. evansi* was incriminated up to now as the sole cause of trypanosomoses in the Borena zone (Pegram and Scott, 1976; Richard, 1979).

Good test agreement was observed between the 10 and 20 minutes ELISA readings. This signifies that one can read antibody results at 10 and 20 minutes with similar results. The antibody ELISA based on *T. evansi* antigen has given positive results for both *T. evansi* and *T. vivax*. Antibody ELISA tests based on different antigens, however, in cattle, normally do not differentiate between infections with different organisms (Luckins, 1977). Our finding goes along with this finding due to the fact that the antigen used (*T. evansi*) could not differentiate *T. evansi* from *T. vivax* infection.

A significant difference in median PCV values was seen between wet season and dry season values. Similar seasonal differences were noted by Abdulgadir *et al.* (1979) and Mutagi *et al.* (1993). The former author attributed the differences to haemodilution in wet season due to access to green succulent forages whereas the latter attributed this to heavy tick load and gastrointestinal infestations during rainy season. Haemodilution and infestation with ticks and gastrointestinal helminths might also explain the differences noted in our survey. The range of PCV values recorded in our survey was 9-34 and 12-34 in wet and dry season irrespective of the health status of the animals. The range is wider and particularly the minimum values are lower than what has been recorded by Ghodisan *et al.* (1978), Abdelgadir *et al.* (1979), Higgins and Kock (1984) and Mutagi *et al.* (1993). The differences might be attributed to the sampling method, age, management conditions, and the health situation in a given area. Age group differences were observed only in wet season. A similar situation was also noted in camels in Kenya (Mutagi *et al.*, 1993), and described in cattle and goats (Schalm, 1965). However, no significant differences were observed between age groups in dry seasons which might be attributed to haemoconcentration, and a lower burden of helminths and ticks.

The PCV values of infected camels differ significantly in both seasons from those camels which are not infected. This finding is in accordance with the report given by Egabe Niwyi and Chaudhry (1994) who observed anaemia as one of the important symptoms of surra. It goes also with the findings of Jatkar and Purokit (1971) who found a lower PCV of 21.9 in experimentally infected versus 28.9 in non-infected animals. Our findings are also in agreement with Wilson *et al.* (1982) who reported cases of trypanosomoses which did not show anaemia as in this study; cases without anaemia were found as well. The PCV ranges observed in infected and non-infected camel are in agreement with figures reported by Diall *et al.* (1993). Nevertheless, the median PCV values of serologically positive animals do not show significant differences when compared to seronegative counterparts since being test positive does not necessarily mean to be infected as self-cured or treated animals still produce detectable antibodies (Luckins *et al.*, 1979; Mutagi et al., 1992). Moreover, animals with a mild subclinical infection can have parasitaemia without evidence of anaemia (OIE, 1990).

Our study also showed that concurrent infections with gastrointestinal worms may significantly depress the PCV more than single infections with helminths alone. This is in line with findings of Yagoub *et al.* (1991) who reported severe depression of PCV in camels infected with both *T. evansi* and *Haemonchus longistipes*. Even though larval identification was not undertaken due to time limit of the study programme *Haemonchus longistipes* was

reported as one of the most common worms in camel in Borena area (Richard, 1979), and elsewhere in Ethiopia (Berhanu, 1986).

Treatment of camels with Cymelarsan® showed substantial health improvement when a significant increase in PCV at the second visit is regarded as an indicator. Moreover, all the animals treated at first visit were free of parasites during our second visit. In line with this Gool *et al.* (1992) reported that Cymelarsan® was effective against trypanosomoses in doses of 0.25, 0.5 and 0.625 mg/kg with complete elimination of parasites within the 90 days observation period.

A marked difference in EpG between trypanosomoses infected and non-infected camels as detected by parasitological tests was observed in dry season (P = 0.08). Kaufmann *et al.* (1992) reported that N' Dama cattle experimentally infected with *T. congolense* and then with *Haemonchus contortus* had significantly higher EpG counts than those which are infected with *Haemonchus contortus* or *T. congolense* alone. The finding was attributed to a depression of host immunity by *T. congolense* and, thus, favouring the establishment of infection as well as enabling a greater fecundity of the larvae. Depression of immunity which is a usual phenomenon observed in trypanosomoses infected animals might explain the observed differences. Nevertheless, no significant difference was observed in the EpG output between seronegative and seropositive camels as a whole and when stratified for those camels which had PCV readings below 20.
A comparison of the EpG status in different age groups of camels which had PCV values less than 20 showed that there is a significant difference between the different age groups The EpG of young animals were significantly higher than that of immature and adult camels. High morbidity and mortality of young animals due to gastrointestinal helminths (Soulsby, 1982) is attributed to neonatal immune unresponsiveness. Thus, the lower ability of young animals to mount immunological response may account for higher EpG count in calves as compared to older ones.

Subsequent EpG output analysis of seronegative camels between age groups with PCV readings below 20 revealed the absence of a significant difference. Faecal egg counts are not an actual reflection of the worm burden and are influenced by various factors such as the resistance of the host, the number of female worms and the stage of development of particular helminths (Ministry of Agriculture, Fisheries and Food, 1986). Thus, gastrointestinal worms probably might just be considered as one cause for the depression of PCV as all camels with a PCV below 20 did excrete eggs of one or more different helminth species. As also nutritional deficiencies, heavy infestation with ticks and lice, chronic abscesses, and infections with various organisms may lead to a depression of the PCV (Radostits *et al.*, 1994), further investigations are desired.

The high mortality rate in combination with the low birth rate in the preceding year (1996 to 1997) indicates at least that the population growth was negative during the year. In contrast to our findings Babiker (1984) reported a much lower figure for camels in Sudan. Baumann and Zessin (1992) also reported a lower mortality rate in Somalia. The higher mortality rate in this study might be attributed to the relatively short experience of the herders in camel management as well as to an epidemic camel disease in 1996-1997. This finding calls for a longitudinal study further to observe the negative trend in camel production in the study area. Between the factors ecological zones, herders experience, management units and the serological herd status no significant differences with respect to mortality rates were observed.

Beside trypanosomoses, respiratory problems, diseases characterized by nervous symptoms *(Shenberkie)*, diarrhoea (*Albathi, Shugdie and Dukaa*), a disease of calves and immature animals characterized by progressive wasting (*Kolie/Elkot*), camel pox, corynebacteriosis, contagious skin necrosis and a disease characterized by swelling of the lymphnodes (*Kierierkie*) are the major causes of death in the study area. All these diseases were described in one way or another by Richard (1979). Coppock (1994) also attempted to show the diseases/syndromes of camels as conceived by the Gabra herd owners in the area. However, the exact etiologies, the disease process and treatment of camel diseases were still untouched by Coppock (1994) and need further investigation so as to assist pastoralists in the treatment and control of camel diseases.

With regard to the total losses in camel, disease accounts for the major part whereas predators and accidents have a minor contribution. Among the diseases affecting camels, trypanosomoses is one of the most important causes of death. Death due to trypanosomoses was reported in camels aged 1-4 years and in those above 4 years. The parasitological results as well as the serological results indicate an increase in prevalence as an animal ages. This corresponds well to the proportional mortality rates for trypanosomoses in different age groups. Death in calves due to trypanosomoses was not reported; this could be attributed to the chronic nature of the disease and the lower rate of infection. In general, the proportional mortality rate for trypanosomoses is one of the highest in immature (1-4 year) and adult (< 4 years) animals which again confirms the earlier statements made. Respiratory diseases, a disease characterized by nervous symptoms (*Shenbekie*) and diarrhoea might be considered a sequel to trypanosomoses.

The herd composition in the study area compares well to the findings of Hjort and Hussein (1986). The lower proportion of calves in a herd appears to be linked to the late age at first calving, the longer calving interval of camels in general (Mukasa, 1981), abortions, and in particular to the high mortality rate of calves below one year. The average herd size in the study area was lower than what has been reported by Baumann and Zessin (1992) for herds in the pastoral production system in Somalia. The greater experience in camel keeping may account for this difference. Our study further showed considerable herd size variations with regard to the factors management unit, herders experience and ecological zone. The mean size of herds owned by an extended family and by a polygamous family is significantly larger than for individual household herds. In the subsistence economy of pastoralists, this fact can be ascribed to the need for building up larger herds as family size increases, both for their daily needs as well as for security. The larger herd size in the non-riverine area might be related to the better availability of green forage for camels almost all year round and to relatively more farming activities in riverine areas, especially along the Genale river.

The figures obtained for the average age at first calving and the calving interval are comparable to the reports given by Abou *et al.* (1990) and Mukasa (1981). However, the age at first calving was higher than Wilson (1984) reported for Niger, and Wilson (1986) reported for Kenya but lower than in Somalia (Baumann and Zessin, 1992). The difference might be explained by different management and ecological conditions and, thus, possibly by the diseases associated, which in turn have an effect on the reproductive ability.

An attempt was also made to relate differences in calving interval and age at first calving to the prevailing camel types and ecological conditions. However, no significant associations between these factors were revealed. Furthermore, there are no associations between the individual serological results and the above mentioned reproduction parameters. The present

trypanosomoses status as determined in our cross-sectional study does not indicate past exposure as camels which have been cured by successive therapy or self-cured several months ago and which have not been infected, might be negative reactors in a serological test. However, animals which had been exposed to the infection after the first few parturitions and which are still chronic carriers of the disease will give positive reactions. Thus, it would be more desirable at least from a theoretical point of view to further evaluate likely associations by undertaking a cohort study, i.e. following camels with and without the disease over time. The significance of and interrelationship with other diseases, nutritional factors and management conditions are also worth to be studied in the future.

6 CONCLUSIONS AND RECOMMENDATIONS

Camel husbandry has been a recent exercise for the major ethnic groups in the district, the Gujjis and the Boran, who otherwise used to be major cattle breeders. Bush encroachment as well as the versatile nature of camel to survive and to produce even in the days of drought are the major initiating factors for the beginning of camel keeping. However, this start has been threatened by camel diseases on which little knowledge has been made available as to etiology, diseases process and control. Surprisingly, ethnoveterinary knowledge of the herdsmen has had more impact on camel health than interventions.

Among many diseases known to affect camel and camel production camel trypanosomoses locally known as *Dukane*, is the most important complaint of camel breeders. The investigations carried out in this particular study indicated that camel trypanosomoses is endemic in the study area. Age of the camel, season and ecological conditions are apparent risk factors for the disease. Important is that in dry season herds in riverine areas are more at risk of infection than herds in non-riverine areas and that more cases of trypanosomoses were encountered in the rainy seasons than in the dry seasons.

Seasonal and age group differences and significant depression of PCV between infected and non-infected camels as detected by parasitological methods were observed. Furthermore, it was found that concurrent infections with trypanosomes and gastrointestinal helminths resulted in a significant depression of PCV values when compared to single infections of gastrointestinal helminths and to values of camels which were neither infected with gastrointestinal helminths nor with trypanosomes.

Helminths were found to be very prevalent in the study area and there was also an indication that the EpG output of camels infected with trypanosomes was markedly different from non-infected camels.

Even though the EpG count was undertaken in dry season gastrointestinal helminths might also be considered as one cause for the depression of PCV values in seronegative camels as all negative camels were found to be excreting eggs. As nutritional deficiencies, heavy tick infestation as well as chronic infections could lead to anaemia, the real situation remains to be investigated.

Various production variables are also presented. No significant associations were apparent between crude mortality rates and ecological zones, herders experience, management units and the herd serological status. Higher offtake rates with high mortality rates in combination

with low birth rate in the preceding year (1996-1997) are responsible for a negative herd growth in the study year. This calls for a further monitoring of camel production in the area.

The mean age at first calving and mean calving interval of camels were found to be 5.9 years and 2.1 years. No association was observed between reproduction variables and camel breed/type, ecological zones and individual trypanosomoses serological status.

The absence of proper animal health extension and the indiscriminate use of camel trypanocidal drugs often underdosed are major constraints in camel health delivery in the study area. Thus, attention has to be given to provide sensible animal health extension systems, and ways have to be sought to do so urgently. Furthermore, longitudinal studies had to be directed not only to *Trypanosoma* spp. infections but also to other maybe equally important camel health problems to meet the needs of camel pastoralists with regard to veterinary health.

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8. ANNEX

Annex 1: Herd Inventory Sheet

Region _____
Date _____
District _____
Peasant association _____
Zone/Ketena _____
Herd Ref. No. _____
Season _____

Ethnic group _____
Herd ownership _____
Household size _____
Herd investigated (Type)_____
Uninvestigated herd (Type)_____
Uninvestigated herd size _____

Code No.	Sex	Age	Physiological Status	Condition	Clinically Apparent disease symptoms

ANNEX 2: Clinical and Parasitological Survey Sheet

Region _____ Peasant association _____ Season
District _____ Zone(Ketena) _____ Date
Herd ref. No. _____

Code No.	Sex	Age	physiological Status	Condition	Clinical symptoms	owners diagnosis	PCV	Parasitological findings		
1								Wet smear	BCT	Species
2										
3										
4										

Key: Condition scoring

Score 1: marked emaciation, hump lost lumbar transverse process project prominently, ribs visible, dorsal spines appear sharply.

Score 2: ribs and hips and lumbar transverse process clearly visible, individual dorsal spines pointed to touch, hump is barely visible.

Score 3: ribs usually visible, less prominent lumbar transverse process, dorsal spines not visible but could be felt, animal is smooth and well covered, hump is visible.

Score 4: body is smooth and well covered, hump conspicuous, ribs not visible covered with muscle, lumbar transverse process covered with muscle,

Score 5: hump well developed, ribs heavily covered with muscle, thigh, neck muscles well developed.

Key 2: Physiological status

Calves (<1 year) =1, Young male and females (1-4 years) = 2, Non rutting bull = 3, Non lactating and non pregnant female = 4, Rutting bull = 5, Pregnant and lactating female = 6

ANNEX 3: Breeding Female History Sheet

Region_____ Herd ref. No. _____

District _____

Interviewed person

Peasant association_____ Owner _____

Zone (Ketena)_____ Tender _____

Breed _____ No. of births _____

Age _____ No. of abortions _____

No. in herd inventory sheet _____

	Birth		Offspring				Remark
	No.	Date (Season)	Sex	Alive	Current status	Age	
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

ANNEX 4: Camel herd health questionnaire

Region_____ Peasant association _____

Zone _____ Zone (Ketena) _____

District _____ Herd ref. No. _____

1. What is the main activity you are engaged in?

Mixed farming (Agro-pastoralism) _____

Sedentary pastoralism _____

2. Plot of cultivable land _____
3. Years of experience in farming _____

4. What type of livestock are kept by you their number and importance? (Excluding camel)

	Type of livestock	Relative importance of livestock (rank)	Owner information	Count	* Purpose (rank)
1	Cattle				
2	Sheep				
3	Goats				
4	Horses				
5	Donkeys				
6	Camel				

*Purpose includes milk, meat, draft, sale, security, burden of beast and riding.

5. How do you herd your camels?

Private herding _____
Communal herding _____

6. What type of herd management are you practicing?

Management type	Cattle	Sheep	Goat	Camel
Warra				
Forra				

7. What are the main sources of drinking water for your camels?

Ponds _____
Traditional wells _____
Rivers _____

8. Who is herding the camels?

	Warra herd	Forra herd
Young boys Girls Adults		

9. Where do you herd your camels?

	Area	Dry season	wet season
1	Wooded plateau		
2	Wooded savannas		
3	River banks		

10. What are the 10 top major diseases affecting your camel herd? (According to the order of importance)
(Use local names)

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____

11. How many camels died/culled/sold/slaughtered/Gift away/eaten by predator/Dead due to accident from your herd since last-------? (numerical)

No	Age	Sex	Culled/Dead/ Slaughtered etc.,	Reason of dying/removal	If sick what are the symptoms observed	Remark
1						
2						
3						
4						
5						
6						
7						

Remark: Calves born and dead within the year were recorded.

12. How many camels were introduced (Born, Gift in and purchased) into your herd since last *genna*

No.	Age	Sex	Born / Purchased / Gift in	Remark

13. Did you treat your herd for trypanosomoses last year?

Yes ----------
No----------

14. If yes what is the frequency of treatment, season, age group treated and reason of treatment?

Frequency	Season	Age group	Reason of treatment

13. How many camels from your herd were treated with trypanocidal drugs last year?

14. What was the result of treatment?

- Success
- No change
- Death

15. What type of trypanocidal drugs are used in your area, the cost, source and who renders the service?

Drug type	Cost	Sources	Service rendered by	Quality of drug
Cymelarsan				
Naganol				
Berenil				
Trypamidium				

16. How is veterinary service rendered in your area?

. Field service (Govt.) _____
. Animal Health Technicians (village based)_____
. Private practitioners _____
. Community based animal health workers _____
. The owner _____

17. What are the traditional treatment methods for different disease, if there are any?

No.	Disease	Traditional treatment	Application
1	Trypanosomoses		
2	Mange		
3	Helminthiasis		
4	Cephalopsis		
5	Ticks		
6	Pneumonia		
7	Camel pox		
8	Abscess		

18. How many breeding females have aborted during last year? (numerical)

19. What type of flies are known to transmit the disease, their seasonality, abundance and ecological preference.

No.	Local name of fly	Seasonality	Ecological preference	Remark
1				
2				
3				
4				
5				

20. If flies are known to exist in the area what are the strategies of avoidance.

No strategies _____
Keeping away camels from the area at specific season _____
Keeping away the camels from the area all the year round _____

21. How many years of experience do you have in camel keeping? _____(numerical)

22. If camel keeping is a recent exercise , what were the major reasons to start camel husbandry?

Bush encroachment _____
High milk production _____
Better ability to cope with drought condition _____
Others _____

23. What is your present educational status? _____(numerical)

ANNEX 5: Ethnoveterinary Knowledge and Practice

Scope of the study

Camel diseases were ranked according to the order of importance in each herd in the first field survey. Nevertheless, the exact histories of the disease, disease process, assumed causes, losses due to the disease processes, the clinical symptoms and the treatment and control employed against the diseases had not been collected. As a matter of fact data were collected on the diseases or syndromes as perceived by herd owners. Thus, this short presentation is to give a highlight on the diseases reported by the breeders.

Importance

The pastoralist ethnoveterinary practice is indispensable not only to make particular interventions based on drawbacks but also to incorporate important modern practices, and to exploit the best out of it.

Methodology

A questionnaire was administered to 15 herdsmen of different ethnic groups, out of which 4 are *Boran*, 3 *Gujji*, 2 *Arssi*, 2 *Gabra*, 2 *Gurra*, 1 *Dugodie* and 1 *Meriana*. The questionnaire includes the age group affected, seasonality, disease history, morbidity and mortality,

assumed causes of the disease, the clinical symptoms, signs observed after death, treatment employed and control of the disease or syndrome, if there are any.

Questionnaire

Locality ----------
Ethnic group ----------
Local name of the disease ----------

1. Age group affected:

< 1 year ----------
1-4 year ----------
> 4 year ----------

2. Season:

Genna ----------
Adolessa ----------
Haggaya ----------
Bonna ----------

3. Duration of illness and prognosis ----------

4. When did the disease affected the herd in question lastly?----------

5. How often the disease recurs in the herd ----------

6. Immunity

No ----------
Short lasting ----------
Long lasting ----------

7. Morbidity ----------

8. Mortality ----------

9. Assumed cause of the disease by the herd owners----------

10. Symptoms observed----------

Appetite ----------
Skin and hair ----------
Lymphnodes ----------
Diarrhea ----------
Yes ----------
No ----------

Type of diarrhoea

Foul smelling ----------

Bloody ----------

Watery ----------

Coughing

Dry coughing ----------

Moist coughing ----------

Nasal discharge

Serous ----------

Mucoid ----------

Purulent ----------

Seromucoid ----------

Other symptoms observed

1. Clinical

_____

_____

_____

2. Postmortem

_____

_____

_____

11. Treatment and control measures

_____

_____

_____

Major diseases reported by the herdsmen are described as follows:

Dukane

Synonym: Camel trypanosomoses

Age group affected: the disease affects all age groups but common in animals older than one year.

Seasonality: the disease is common in wet seasons of the year but also occurs in dry season.

Transmission: *Dukane* is assumed to be transmitted by smelling of urine and faeces of affected animals.

Symptoms: According to camel herdsmen the symptoms generally include inappetance, and lagging behind the herd. Affected animals usually seek shadow areas, have a starring hair coat, a dark skin color and occasionally swelling of lymphnodes, diarrhoea, and coughing without discharge, in breeding females abortion, drop in milk production, late age at first calving and increased intercalving interval are usually used in diagnosis.

Control and treatment: Naganol was used effectively in the treatment of affected animals before it was out of the market. Most of the camel owners treat affected camels with Berenil (Diminazene aceturate) intravenously (jugular vein). For adult camel one sachet (1.05g) dissolved in 20 ml of boiled water (sometimes only in 10 ml) is utilized.

Diseases characterized by diarrhoea

1.Dukaa

This condition occurs sporadically in camel herds. The duration of the illness is about 3 weeks after which the animal recovers spontaneously The symptoms are a cattle-like dung, decrease in milk production and loss of condition. Anthelminthic drugs were said to be effective.

2. *Butahl/Shugdie*

The disease is mainly seen in the first weeks of the rainy season. Morbidity is sporadic and mortality can reach up to 10%. All age groups can be affected, especially adult ones. The duration of the illness can be up to 3 months.

The commonly observed symptoms include inappetance, watery diarrhoea, depression and loss of condition.

Berenil and anthelminthics are used for treatment.

3. Albathi

The disease in young calves is commonly called *albathi.* The disease is characterized by diarrhoea, which could be foul smelling and blood-tinged. The disease is commonly associated with excessive consumption of colostrum. Affected calves lose condition, become dehydrated and die at most after 2 weeks. Camel herd owners usually restrict calves to a colostoral milk intake in the first few days to avoid calf scour. However, insufficient intake of colostrom might be responsible for diseases of new born camels.

Diseases characterized by respiratory symptoms

1 Furi/Ergibikie

Synonym: Epidemic Camel disease 1996/1997

All age groups are affected in any season. Morbidity can reach up to 100% ,however mortality is very low if treated with tetracycline. The very recent outbreak of the disease was observed one year ago. As to Gabra and Somali pastoralists with long years of experience the disease had appeared 20 years before. Assumed cause of the disease is wind borne and it is said to be highly contagious.

In affected animals the appetite is not depressed. Moist coughing which is serious at the beginning and later turns sero-mucoid, extensive swelling alongside the neck, the pharyngeal and the brisket region.

Affected animals can be successfully treated by intravenous injection of 12 tetracycline capsules dissolved in 10-20 cc of water. Penicillin is also effective in the treatment of this condition.

2. Kufa
Camels above one year are affected and *kufa* is seen in all seasons. The disease is sporadic and mostly fatal. The symptoms include tremor, occasional coughing and inappetance.
Control: segregation of affected animal.
Treatment: removal of tonsils.

3. Dugato
It is not a seasonal disease and usually seen in a herd every two to three years. All age groups are affected and morbidity can reach up to 100% in previously unaffected herd. Death is rare if treated. Recovered animals have long lasting immunity. The duration of illness is one month and affected animals show inappetance, dry coughing and tremor. Abortions also are not unusual.
Treatment: tetracycline capsules are commonly used. 3-6 capsules are dissolved in 10 cc of boiled water and then injected into young and adult camels intravenously.
Control: Avoiding contact with affected herds.

Bototie/Bagga/Furuk
Synonym: Camel pox

Young camels up to 3 years are usually affected. A more severe form of the disease affects all age groups. The disease affects all previously unaffected camels. Mortality can reach up to 10%. The course of the disease lasts for 3 weeks after which an animal recovers in most cases.

Diseases characterized by nervous symptoms

1. Shenberkie
This condition is seen sporadically in a herd. 70% of affected animals die in the lowland and 20% in the highlands respectively.The disease is recognized by typical symptoms which includes lacrimation, running, excitement, madness, extended neck, recumbency, paralysis and death.

Treatment
Burning with hot iron on hind legs, hips and neck is the usual method for the treatment of this condition. Recovery is better during cold weather than hot weather .

2 Godanike
Adult animals are usually affected. The disease is sporadic and the death rate can reach 50%. Tilting of the neck is the most common sign. The usual treatment practiced is burning with hot iron on the sides of the neck.

3 Metetag/Metedab
The disease occurs sporadically within a herd. 20-30% of the affected animals die. The duration of the illness is two to three months. The symptoms observed in affected animals include stiffness of the neck and looking up position. Similar treatment is applied as for 'Godankie'

Other diseases

Kierikie/Kendecha
Synonym: Swelling of lymph nodes

Occurs in all seasons but more common in wet season This disease is usually observed in animals below 5 years of age. According to pastoralists the cause are ticks (*Shelmmie).* The morbidity is sporadic and can reach 40%. The symptoms include generalized swelling of superficial lymphnodes, dry coughing and lameness. According to Gujji pastoralists dark skin color, blackened muscle like that observed in black leg are sometimes seen. The duration of the illness is 15-21 days. The disease can be effectively treated with tetracycline capsules and penicillin intravenously.

Kolie/Elkot
Young camels up to three years of age are affected. There is no apparent seasonality and the duration of the illness is up to three months. The disease occurs sporadically and almost all affected animals die.

The symptoms observed include lacrimation at the beginning, constipation, sunken eye balls, and purulent ocular discharge, progressive wasting and even blindness. The Somali and Gabra pastoralists had some success by treating affected animals with anthelminthics and occasionally with tetracycline capsules.

Ordiga
This is a very common situation during the fly seasons. As a consequence of biting flies camels usually kick towards their abdomen to get rid of the flies. As a result of the trauma the abdominal area reddens and pregnant camels usually abort.

Chechebsa
A disease common in high milk producing camels during late gestation period. The disease is very serious in lowland areas.
Frictional joint sounds which are easily heard when the animal walks are diagnostic aids for breeders. As a result staggering gait, incoordination and lameness are seen. Camel owners had reported the condition can easily be treated by cauterization of hind legs and hips.

Malla/Bulka
Synonym: Corynebacteriosis

All age groups are affected and there is no seasonality of this condition. This disease is characterized by enlargement and abscess formation of superficial lymphnodes, mostly prescapular and supramammary lymphglands.
Abscesses can also be found on other parts of the body and the mammary glands too. Herd owners reported that this condition generalizes and extends to internal organs eventually resulting in death of the animal. Abscessed lymphnodes are usually not incised by herd

owners, thus, it is not unusual to observe an abscess which is as large as a foot ball in some camel herds.
In general when the herd owner suspects that an animal has generalized *malla* the indigenous herb '*Bergeon*' is used. The root of *bergeon* bush is chopped into pieces and dissolved in five liters of water and is given orally.

Chifto/Dulla/(maa)
Synonym: Contagious skin necrosis

This condition is characterized by swellings which are the size of a fist, mainly on the sides of the neck and hip. The swelling is hard initially and later necrotizes in the centre. The necrotic area sloughs leaving raw or abscessed areas. Three or four swellings may be seen on one animal. The situation may generalize affecting internal organs and might result in the death of the animal.
The breeders usually cauterize affected areas with hot iron.

Chito
Synonym: Sarcoptic mange

This is a disease characterized by scab formation, itching and loss of body condition. Affected animals are treated with acaricides alone or in combination with various local herbs.

Dabta
Synonym: Polyarthritis

Dabta is a condition commonly seen in young calves up to 3 months of age. This situation is characterized by generalized swelling of joints (polyarthritis).This situation is invariably fatal.

Comment on Ethnoveterinary Knowledge

Due to the fact that the pastoralists live in an area which has harsh climatic conditions government interventions are usually lower than in high land areas. As a matter of fact pastoralists developed their own way of coping with the problems they encounter in their daily life.

The nomenclature of the diseases is based on the most common symptoms observed. Thus, it is therefore difficult to attach a specific name (Synonym) to the symptoms described by the herdsmen unless investigations in particular cases are carried on. However, for Trypanosomoses (*Dukane*), Sarcoptic mange (*Chito*), Corynebacteriosis (*Malla*) and Contagious skin necrosis (*Chifto*) the causative organisms are well known. For some of the diseases the synonym just indicates the most common symptom such as swelling disease for *Kierikie*, Epidemic camel disease for *Furi* and for *Kufa* and *Dugato* respiratory disease.

Different names are attached to diseases characterized by gastrointestinal disturbances. Nevertheless, the causative agents of each complaint are not well known. Diarrhoea in camels can be due to helminthiasis, balantidiasis, secondary complications of *Trypanosoma* infections, clostridial enterotoxemia, paratuberculosis or other infections which could lead to gastrointestinal disturbances. In new born calves colibacillosis, salmonellosis, rota virus infection and others are known to lead to diarrhoea.

Respiratory symptoms are major manifestations of complaints called *Furi, Kufa* and *Dugato*. Morbilli-like virus and *Pasturella* infections were suspected to be the cause of the outbreak. However, the results are inconclusive. The whereabouts of the disease for the last 20 years might call for proper investigation on this disease. The rapidity of the disease spread suggests a highly contagious nature of the disease. Respiratory disease in camels might be caused by *Pasturella* organisms, as secondary complications to trypanosomal infections, tuberculosis, parainfluenza virus infections, lung occupying diseases such as echinococcosis as well as complications to other situations. The long lasting immunity in camels affected with *Dugato* reported by camel herdsmen may suggest parainfluenza virus infection. Richard.(1979) related *Dugato* to salmonellosis, influenza and brucellosis.

Richard (1979) related *shenberkie* to *Cephalopsis titllator*, *Metetedabe* to acute form of salmonellosis and *Godankie* with tetanus, However, the real etiologies have not been investigated. The cerebral form of *T. evansi* as well as clostrodial enterotoxemia do also show similar symptoms described for *Shenberkie*. Listeriosis in camels also show symptoms similar to *Metedab*.

Elkot is also another important complaint of camel breeders. Richard, (1979) has assumed alimentary mineral deficiencies to be the cause of this condition. Helminthiasis as well as clostridial enterotoxemia may also be related to the condition.

Furthermore the same author related *Kierierkie* to anthrax, blackleg, and pasturellosis, however with question mark. *Dabta* (Polyarthritis) is actually a result of umbilical infections in newborns due to improper management at birth.
Berenil is toxic at the recommended dosage of 7 mg/kg in camels but not toxic if 1.05g dissolved in 12 ml of water and given intramuscularly. Berenil was reported to be toxic if the dose exceeds 3.5 mg/kg. Nevertheless, the intravenous application may call attention for further investigation.

Annex 6: Purpose of camel keeping as judged by 81 camel herds in Leben district, Borena zone Ethiopia.

Purpose of camel keeping	Mean rank
Milk	1.01
Transport	2.5
Sale of live animals	2.6
Meat (Slaughter)	3.8
Security*	4.9

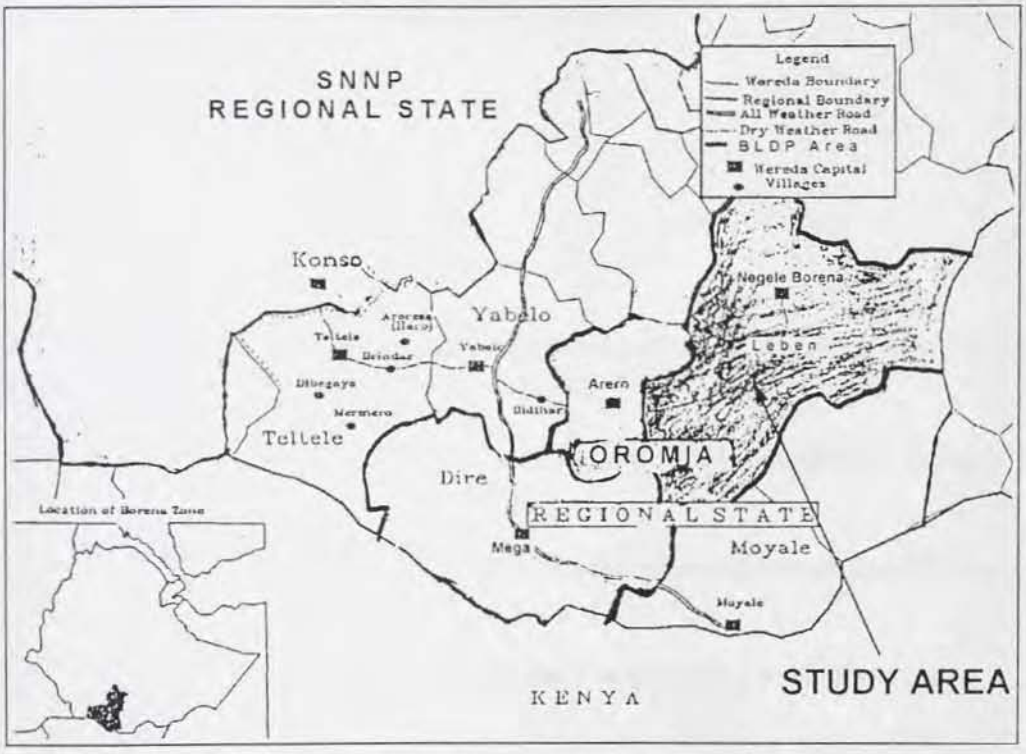
Security: to keep and to build herd size of camels to cope up with any would be faced problems as well as drought condition.

Annex 11: Camel diseases as judjed by 81 camel herds men in Leben district, Borena zone,Oromia region, Ethiopia

Disease (syndrome)	Score
Trypanosomoses (*Dukane*)	717
Contagious skin necrosis (*Chifto*)	394
Respiratory problem (*Dugato*)	377
Corynebacteriosis (*malla*)	353
Nervous signs (*Shenberkie*)	342
Sarcoptic mange (*Chitto*)	327
Swelling of lymphnodes (*Kierikie*)	322
Diarrhoea (*Shugdie*)	275
Camel pox (*Bagga*)	242
Epidemic camel disease (*Furi*)	201
Progressive wasting disease (*Elkot*)	124

Method of scoring: 81 Herds men were interviewed to rank the ten top camel diseases affecting their herd from the most important to least important. The ranks were changed to scores by multipling rank 1 by 10, rank 2 by 9, rank 3 by 8 and so on. Finally the results were added to get the score total for each disease. Thus, the scores are used to rank the disease according the order of importance in the study area.

Annex 8: Map of the study area



9 CURRICULUM VITAE

Name	Demeke, Getahun
Date of birth	August 28, 1965
Place of birth	Asebe Teferi, Western Harergie, Ethiopia.
Nationality	Ethiopian
Sex	male
Marital status	single

Educational back ground

Elementary Education	Asebe Teferi No. 2 Elementary School (1970-1975)
Secondary School	Chercher Comprehensive Secondary School (1976-1981)
University Education	Addis Ababa University, Faculty of Veterinary Medicine (1982-1987).

Professional qualification

A graduate of the Faculty of Veterinary Medicine , Addis Ababa University, Ethiopia, with DVM degree.

Professional experience

Veterinary Officer in South Gondar Adminstrative region, Ethiopia	1987-1992.
Veterinary Officer in Diredawa Adminstrative Region, Ethiopia	1991-1996.
Postgraduate student for MSc degree in Tropical Epidemiology at the Freie Universität Berlin and Addis Ababa University	1996 to date

Language skill

Amharic
Oromognaa
English
Deutsch (very little)

Publications

Epidemiology, economic and public health significance of larval Hydatidosis in Wondo Genet province, southern Ethiopia. Addis Ababa University, DVM Thesis, 1987.

Gastrointestinal helminths of dogs in and around Nefas Mewcha, Ethiopia. 1992, (Unpublished).

Prevalence of Bovine haemoparasites in south Gondar adminstrative region, Ethiopia, 1992. (unpublished)

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Dr. Getachew Abebe, Associate Professor and Associate Dean for Graduate studies and Research. Faculty of Veterinary Medicine, Addis Ababa University, Ethiopia.

Dr. Maximilian Baumann, Postgraduate Studies in Tropical Veterinary Medicine, Freie Universität Berlin, Germany

Dr. Wondwesen Asfaw, National Director of Veterinary Service, Ethiopia.
Tel No. (00251) 1155871

Address: P.O. Box 449, Diredawa, Ethiopia.

I the under signed, declare that the thesis is my original work and has not been presented for a degree in any University.

Name Getahun Demeke

Signature Getahun Demeke

Date of Submission 07/0198

This thesis has been submitted for examination with our approval as University advisors.

Dr. Getachew Abebe

Dr. Baumann

10 SIGNED DECLARATION

I the undersigned, declare that the thesis is my original work and has not been presented for a degree in any University.

Name. Getahun Demeke

Sgnature.

Date of submission. 07/01/98

This thesis has been submitted for examination with our approval as University advisors.

Dr. Baumann

Prevalence of camel trypanosomes &
Factors Associated with the disease
Occurrence in Leben district,...

Getahun Demeke