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The Bulletin of Animal Health and Production in Africa publishes articles on original research relevant to animal health and production activities which may lead to the improvement of the livestock industry in Africa and better utilisation of her animal resources. The journal is published quarterly.

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Two copies of articles should be sent to the Editor, Organisation of African Unity/Inter-african Bureau for Animal Resources, P.O. Box 30786, Nairobi, Kenya.

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The manuscripts should contain the following features:

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Introduction stating the purpose of the work.

Materials and Methods used.

Results presented concisely.

Discussion of significance.

Acknowledgements.

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I. ORIGINAL ARTICLES

1. Epidemiological Study of Dermatophytosis due to *Trichophyton schoenleinii* in Camels in Iraq
   F.K. AL-ANI, L.S. AL-BASSAM and K.A. AL-SALAH. .................................................. 87

2. Aspergillosis in Fowls
   P.A. ABDU, S.U. HASSAN, C.N. KWANASHIE and N.D.G. IBRAHIM .................................. 93

3. Light and Electron Microscopical Studies of *In Vivo* Phagocytosis of
   *Trypanosoma congolense* by Circulating Blood Leukocytes in *Mastomys natalensis* (Multimammate Rats)
   LONZY OJOK and EUGEN WEISS .................................................................................... 95

4. Preliminary Observation on Ticks: Seasonal Dynamics and Resistance of Three Indigenous and Three Cross-Bred Cattle in Ethiopia
   T. YEHUALASHET, F. GEBREAB, A. WAKJIRA and T. TSEGA ........................................ 105

5. The Prevalence of Caprine Sarcotic Mange Due to *Sarcoptes scabiei var capri* in Ile-Ife area of Nigeria, Its Control and Management
   P.A. OLUUBUNMI. ............................................................................................................ 115

6. Effects of Experimental *Fasciola hepatica* Infection and Nutrition in Minz Sheep
   TEKELYE BEKELE, A. LAHLOU-KASSI, J. SHERINGTON, S. SOVANI and S. TEMBELY ....... 121

7. Therapeutic Efficacy of Lamstreptocide in the Treatment of Cattle Naturally Infected with *Dematophilus congolensis*
   R.O.A. ARWOLE and E.O. AWE .................................................................................... 129

8. Effect of Protein-Energy Malnutrition on Serum Immunoglobulin G (IgG) Responses of Broiler Chickens in Uganda
   J.D. KABASA, W. KUGLER and J. OPUDA-ASIBO ................................................................ 133

9. Effects of DFMO Alone and in Combination with Levamisole in the Treatment of Experimental *Trypanosoma congolense* Infection of Rats
   B.M. ANENE, A.C. UDECHUKWU and S.M. ANIKA ...................................................... 143

10. Cattle, Goats, Sheep and Camel Production on range: The Kenya experience
    A. ABATE, J.W. WAKHUNGU and A.N. SAID ................................................................. 145

II. SHORT COMMUNICATIONS

11. An Attempt to Treat Paratuberculosis Diarrhoea by Acupuncture
    TEMESGEN SAMUEL and GEMECHU WRTU .................................................................. 157

12. Observations on Efficacy of Alphamethrin and Toxaphene Applied as Dips for Control of Ticks in Coast Region, Tanzania
    K.A. MAMIRO, J.M.K. HYERA and M.L. KITINYA ...................................................... 159

13. Porcine Cysticercosis in Tanzania: Preliminary Findings
    G.R.M. NSENGWA and A.N. MBISE ............................................................................. 161
Epidemiological Study of Dermatophytosis Due to Trichophyton Schoenleinii in Camels in Iraq

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Etude Epidemiologique de la Dermatophytose Due a Trichophyton Schoenleinii Chez Les Dromadaires En Iraq

Résumé
L'infection, par le trichophyton, de 80 dromadaires est décrite. L'âge des dromadaires infectés variait entre six mois et trois ans. Les principaux signes cliniques étaient caractérisés par l'apparition de lésions cutanées multiples dans différentes parties du corps. Les lésions consistaient en général en une zone d'alopecie et en une importante accumulation de squames ressemblant à une asbeste blanchâtre. L'agent responsable, Trichophyton schoenleinii, a été identifié à l'aide de l'examen microscopic de frottis direct de sang coloré et avec la culture. L'infection expérimentale d'un dromadaire sensible a provoqué le développement de signes cliniques similaires à ceux observés dans des conditions normales. Le traitement de l'infection chronique a été rapide et efficace avec 0,5% de pommade souffrée de chaux iodée appliquée fortement à la main sur les parties affectées.

Summary
Trichophyton infection involving 80 camels is described. The age of infected camels ranged from six months to three years. The main clinical signs were characterized by the appearance of multiple lesions on the skin on different parts of the body. The lesions typically consisted of an area of alopecia and a prominent whitish asbestos-like accumulation of scales. The causative agent Trichophyton schoenleinii was identified by microscopic examination of stained direct smear and by culture. Experimental infection of a susceptible camel resulted in development of clinical signs resembling those observed under natural condition. Treatment of the chronic infection was rapidly and effectively cured with 0.5% iodine lime sulfur ointment forcefully applied by hands on the affected areas.

Introduction
Ringworm is considered rare in camels\(^{1}\). \textit{Trichophyton spp.} is the most prevalent causative fungus\(^{1,4}\). Ringworm caused by \textit{T. dankaliense} which affects camels and humans has been reported in Northern Somalia and the Ogaden area\(^{3,8}\). Ringworm due to \textit{T. schoenleinii} has been recorded in India\(^{2}\). Timaway\(^{11}\) isolated \textit{T. verrucosum}, \textit{T. mentagrophytes}, \textit{Microsporum canis} and \textit{M. gypseum} from camels in upper Egypt. Ramadan\(^9\) isolated \textit{Cryptococcus neoformans} from a camel in Saudi Arabia.

A skin disorder of high prevalence has been recognized among a herd of camels in a region near Baghdad in Iraq, since 1986. This paper describes an outbreak of ringworm caused by \textit{T. schoenleinii} as the cause of the skin disorder in the camels in Iraq.

Materials and Methods
The study involved a herd of one-humped camels (\textit{Camelus dromedarius}) raised in a desert near Baghdad. The herd consisted of 460 animals of mixed ages. They were in a 50-acre land and had prairie feed (grass, shrubs and other ground herbage) and water available \textit{ad libitum}. The owner indicated that the camels had a skin condition which had afflicted them since 1985. Thus, on March, 1986 veterinary care was sought for the entire flock.
Clinical Examination
Regular clinical examination of all affected animals was performed. Evaluation of the general state of the animals, temperature, appetite, morbidity rate and mortality rate were recorded. Affected animals were treated with 0.5% iodine lime sulfur ointment (Vapco Company, Jordan).

Sampling
Samples of hair (fur) and scrapings were taken from camels with cutaneous lesions. A wet preparation was made using 10% KOH solution\textsuperscript{10}. The preparation was covered with a coverslip, heated gently and examined microscopically. Direct microscopic examination was carried out on hair and scab samples using lactophenol cotton blue stain\textsuperscript{10}. Also, samples were plated on mycobiotic agar (Difco) and incubated aerobically at 25°C and 37°C. These plates were examined every 2-3 days for 7 weeks.

Histopathological Study
Pieces of the cutaneous lesions were collected in neutral buffered 10% formalin for histopathological study. Sections of 6 μm thickness were made and stained with hematoxylin and eosin (H&E), Periodic Acid Schiff's (PAS) and Gomori's methods. The sections were examined, described and photographed.

Inoculation of susceptible animal
A one-year-old camel was inoculated with a 9-day-old subculture of \textit{T. schoenleini} which had been isolated from a naturally infected camel and grown on mycobiotic agar. The culture was inoculated percutaneously on the skin of the neck area by using a 13 gauge needle. The animal was kept under observation for 4 weeks. Samples for fungal isolation were collected as described above.

Results
Prevalence and Historical Findings
The initial outbreak occurred in March, 1986 when a desert nomad (Bedouin) reported a skin disease in his herd of one-humped camels of various ages ranging from 6 months to 3 years. Three yearlings had died because of emaciation and weakness. Ringworm was diagnosed in 80 camels of 460 camels. Both male and female were equally affected. The age of the camel at the onset of their illness was shortly after weaning (6-9 months of age). The duration of illness before the initial examination was 3 months. From 1986 to 1992 (Table 1) the outbreaks occurred each year in early winter when rain and wet conditions prevail.

\textbf{Table 1: Number of camels with clinical Trichophyton infection for the year 1986–1992}

<table>
<thead>
<tr>
<th>Animal age</th>
<th>Number of affected animals per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-9 months</td>
<td>15</td>
</tr>
<tr>
<td>1-2 years</td>
<td>57</td>
</tr>
<tr>
<td>3 years</td>
<td>8</td>
</tr>
<tr>
<td>Total herd number</td>
<td>460</td>
</tr>
</tbody>
</table>

Clinical Findings
Initial clinical signs were characterized by the appearance of slight scaling of the skin on the head around the mouth and eyes followed, by heavy incrustation on different parts of the body (Figure 1). Within two to four weeks, new multiple lesions of 5-12 cm in diameter would develop in other areas including the neck, chest, and legs. The lesions typically consisted of an area of alopecia and a prominent whitish asbestos-like accumulation of scales. The lesions expanded in size and signs of emaciation and weakness appeared on the affected animals. The same lesions developed on the camel that was infected experimentally (Figure 2). Spontaneous recovery was observed in some affected camels. The lesions regressed in size and hair growth resumed after 8-16 weeks in early spring. However, camels treated with 0.5% iodine lime sulfur had faster and better recovery rates.
Figure 1: A 2-year old camel showing lesions on the neck and chest area.
Figure 2: A one-year old camel infected experimentally with *T. schoenleinii*. See signs of rubbing of the infected area.

![Image of camel with ringworm symptoms]

Figure 3: Direct smear stain of skin scraping from a camel with ringworm. See the arthropores.
Laboratory Findings
Examination of a direct stain smear by lactophenol cotton blue stain revealed a large number of arthropores. Septated hyphae approximately 2–3 wide and chains of arthropores in the skin scales and within the hair shaft were seen. Hyphal forms were also found on some hair shafts (Figure 3). The inoculated plates and incubated at 25°C showed growth after 10 days. The colonies were similar to those described for *T. schoenleinii*.10 The growth was seen on both media, mycobiotic and Sabouraud’s Dextrose Agar. The colonies appeared as small raised white leathery types and in time the colour became tan to brown with folded surfaces (Figure 4). Microscopic examination of stained slide showed septated hyphae with very few microconidia while the macroconidia were absent.

![Figure 4: A 10 days old colony of *T. schoenleinii* on mycobiotic agar](image)

Pathological Findings
At necropsy, the carcass was weak and debilitated. Extensive skin lesions were obvious. However, no pathological lesions were found in the internal organs. The principal histopathological finding consisted of hyperkeratosis of the epidermis, folliculitis and acanthosis (Figure 5). The walls of the infected hair follicles were infiltrated by inflammatory cells consisting of neutrophils, lymphocytes, histiocytes and plasma cells.

 Discussion
The skin condition was caused by *Trichophyton schoenleinii* and affected only camels less than 3 years old. The source of infection was not established but could have been from human attendants. *Trichophyton spp.* are the principle cause of favous (Tinea capitis) in man and this condition has been frequently reported in Iraq, Morocco, Libya, Iran, Turkey and Pakistan.10 The infection might also have been brought in by introduction of new camel calves into the herd. Pal7 reported an outbreak of dermatophytosis following introduction of a three months old indigenous calf to a healthy herd. It may also be presumed that infection was perpetuated within adult camels and spread to susceptible camel calves. In cattle, Leeper6 reported that deficiency of certain dietary factors contributed to the development of widespread and chronic lesions due to *T. schoenleinii*. The high percentage of affected camels in the herd (18%) represents all calves less than three years old. This is higher than what has been previously reported5,11. For example, an incidence of 14% of *T. versicolor* has been reported in Upper Egypt.11 Khamiev5 has recorded a higher rate of *Trichophyton* ringworm in bacterial camels than dromedaries and a higher prevalence in female (77% of cases) than males (23%).
References

ASPERGILLOSIS IN FOWLS

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1Department of Surgery and Medicine
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L'ASPERGILLOSE CHEZ LES VOLAILLES

Résumé

Summary
Between January 1984 and November, 1990, Aspergillus fumigatus was isolated from the eyes, trachea, air sacs, lungs and abdominal cavity of 30 sick and/or dead fowls from 19 flocks containing 22,361 birds. A. niger, A. flavus, A. terreus, A. restrictus, Cladosporium sp., Rhizopus sp., Mucor sp., and Absidia sp. were concurrently isolated with A. fumigatus. Clinical signs, gross and histopathological lesions observed were similar to those described for aspergillosis. Clinical aspergillosis is apparently not very common as out of the 26 flocks that contained 23,463 birds from which samples were submitted for diagnosis, 19 flocks that contained 22,361 birds (95%) yielded A. fumigatus in the last 7 years, with 10% mortality in 3 flocks.

Introduction
Aspergillus fumigatus is the most commonly encountered and most pathogenic Aspergillus species in poultry. In aspergillosis, gross lesions are most commonly seen in the lungs and air sacs. Clinical signs seen are dyspnea, keratitis, torticolis, and ataxia. Histologically a granulomatous pneumonia with fungal hyphae is seen.

In Nigeria, the incidence of acute aspergillosis appears to be low. Outbreaks of the disease in turkey poults and fowls have been reported. Aspergillosis in fowl submitted to the Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria from January 1984 to November 1990 for diagnosis is reported.

Material and Methods
Between January 1984 and November 1990, sick and dead fowls were submitted to Ahmadu Bello University, Zaria for diagnosis. The flock histories and clinical signs were recorded on reception. Necropsy examination was conducted and gross lesions observed recorded. Sections of lungs were fixed in 10% buffered formalin for histopathology while fresh and aseptically collected swabs from eyes, trachea, abdominal cavity, lungs and/or air sacs were sent for mycological examination.

Results
Clinical aspergillosis is apparently uncommon as in 7 years A. Fumigatus was isolated from only 19 of the 26 flocks from which 30 birds were submitted for diagnosis. The flocks with birds that yielded the organism contained 22,361 birds while those form which birds were submitted had 23,463. Acute infection with a mortality of 10 percent was recorded in only three flocks while birds in the remaining 16 flocks
suffered chronic and sporadic infection with mortality of less than one percent. Conjunctivitis, sneezing, coughing, gasping, torticollis, diarrhoea, emaciation, weakness, and paralysis of legs were observed (Table 1). Air saculitis, peritonitis, congestion of lungs, presence of nodules and/or plaques on the air sacs, thoracic wall, mesentery, in lungs, liver, heart, and kidneys were observed at necropsy. *A. fumigatus* was isolated from the eyes, trachea, air sacs, lungs and abdominal cavity. *A. niger*, *A. terreus*, *A. restricticus* *A. flavus*, *Cladosporium sp.*, *Rhizopus sp.*, *Mucor sp.*, and *Absidia sp.* were concurrently isolated with *A. fumigatus* from either the lungs or trachea. Histopathologically a granulomatous pneumonia with fungal hyphae was seen in the lungs.

Table 1: Aspergillosis in Fowls in Zaria, Nigeria: 1984–1990

<table>
<thead>
<tr>
<th>Year No. of flock size</th>
<th>Age (wks)</th>
<th>Isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984 7 13,880 8–32</td>
<td>Asp. fumigatus</td>
<td></td>
</tr>
<tr>
<td>1985 - - -</td>
<td>Asp. niger</td>
<td></td>
</tr>
<tr>
<td>1986 4 5,086 1–20</td>
<td>Asp. flavus</td>
<td></td>
</tr>
<tr>
<td>1987 3 3,531 2–11</td>
<td>Asp. terreus</td>
<td></td>
</tr>
<tr>
<td>1988 2 0,075 5–22</td>
<td>Asp. restricticus</td>
<td></td>
</tr>
<tr>
<td>1989 4 0,605 3–7</td>
<td><em>Mucor, Absidia, Rhizopus</em> and <em>Cladosporium sp.</em></td>
<td></td>
</tr>
<tr>
<td>1990 5 70,286 1–24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 26 23,463</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The signs and lesions observed in the cases reported were those associated with aspergillosis and the isolation of *A. fumigatus Cladosporium sp. Mucor sp.* and *Absidia sp.* concurrently isolated with *A. fumigatus* have on their own been reported to cause disease in fowls and turkeys. As cases were reported in only 19 flocks within a 7 year period, clinical aspergillosis could be considered as uncommon. The chronic form of the disease with a few individual birds in a flock affected appears to be more common. Aspergillosis develops when birds are either stressed, starved, immunodepressed, under prolonged treatment with antibiotics or after inhaling large number of spores either from contaminated litter, soil, feed or air in an incubator. Sound poultry management is therefore a pre-requisite for the control and prevention of aspergillosis. Thiabendazole, copper sulphate, propionic acid and nystatin applied to litter have been found to prevent fungal growth. Fumigation with enilconazole smoke pellets (29.15mg or 208mg/m³ for 30mins) was highly successful in preventing mortality, reducing morbidity and in neutralizing growth inhibition of affected chicks. Niconazole at 10mg/kg 1/M once daily for 6–12 days given to 23 falcony birds with aspergillosis resulted in the recovery of 17 birds with no relapse.

**References**

LIGHT AND ELECTRON MICROSCOPICAL STUDIES OF IN VIVO PHAGOCYTOSIS OF
TRYPANOSOMA CONGOLENSE BY CIRCULATING BLOOD LEUKOCYTES IN
MASTOMYS NATALENSIS (MULTIMAMMATE RATS)

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ÉTUDES AVEC UN MICROSCOPE OPTIQUE ET UN MICROSCOPE ELECTRONIQUE DE
LA PHAGOCYTOSE IN VIVO DE TRYPANOSOMA CONGOLENSE PAR LES
EUOCYTES CIRCULANTS CHEZ MASTOMYS NATALENSIS (RATS MULTIMAMMELÉS)

Résumé
L'examen de frottis de sang périphérique et les études avec un microscope électronique de
prélèvements sanguins de Mastomys natalensis (rats multimammelés) infectés par voie
intrapéritonéale avec Trypanosoma congoense ont révélé la phagocytose du trypanosome par les
leucocytes circulants. Les divers stades de la phagocytose, à savoir: l'adhérence, l'ingestion et la
digestion, ont été observés. Il s'est avéré que la phagocytose du trypanosome s'est produite au pic
de la parasitémie et qu'elle a généralement été réalisée par les granulocytes neutrophiles
circulants, mais moins souvent par les monocytes du sang et les granulocytes éosinophiles. On
en a conclu que la phagocytose du trypanosome que l'on a observée joue un rôle important dans
le mécanisme de défense contre l'infection trypanosomiennne et qu'elle constitue le meilleur moyen
par lequel l'animal infecté se débarrasse ou réduit la charge de l'antigène de trypanosome.

Summary
Examination of the peripheral blood smears as well as electron microscopical studies of blood
samples from Mastomys natalensis (multimammate rats) intraperitoneally infected with Trypanosoma
congoense revealed phagocytosis of the trypanosome by circulating blood leukocytes. Different
stages of phagocytosis, namely adhesion, ingestion and digestion were observed. Interestingly,
phagocytosis of the trypanosome was found to occur around the peak of the parasitaemia and was
found to be carried out mainly by circulating neutrophilic granulocytes and less frequently by blood
monocytes and eosinophilic granulocytes. It is concluded that the observed phagocytosis of the
trypanosome plays an important role in the defence mechanism against trypanosomiasis infection,
and that it constitutes the main way by which the infected animal may rid itself of or limit the
trypanosome antigen load.

Introduction
Trypanosoma congoense plays a very important role among a group of pathogenic African
trypanosome as the causative agent of trypanosomiasis of domestic animals in Africa.
The disease is known to cause great economic loss in livestock production.
Infection with both haematic and humoral groups of pathogenic African trypanosome has
long been known to lead to occurrence of the parasites in the blood circulation. Because of
this fact, examination of the blood smears has long been the standard method of field diagno-
sis of both human and animal African trypanosomiasis.

Despite the long and extensive use of this method, however, report of the observation of in vivo
phagocytosis of the trypanosome in the blood smears is lacking. Most research work
which has been done on the phagocytosis of trypanosome has been carried out in vitro(1,2,3,4,5,6).
The report of Young, et al.(7) in which they observed phagocytosis of trypanosome by
the leukocytes in smears prepared by the centrifugation of blood collected from the African
buffalo (Syncerus caffer) led to the present study. Multimammate rats (Mastomys
natalsensis), an animal species which has frequently been used in trypanosomiasis research were chosen for this study.

Materials and Methods

Animals and Trypanosome

Three to eight weeks-old female and male Mastomys natalensis were used in this study. They were intraperitoneally infected with different concentrations (x104 - x107) of living T. congolense LRU Sw29 supplied by Dr. Mehltiz, Bernhard-Nocht Institute of Ship and Tropical Disease, Hamburg, West Germany. The trypanosome were originally isolated by Dr. Zillman and Dr. Godfrey in 1977 from Liberia, cloned and stored as frozen stabiles.

Preparation of Blood Smears

In order to determine whether the frequency of blood smear preparation and examination from infected animals has any direct relationship with the detection of phagocytosis in the blood smears and to determine the earliest occurrence of the trypanosome in the blood circulation, the infected animals were divided into three groups. Blood smears from group 1 and group 2 were made daily starting on day 0 and day 3 post infection (p.i.) respectively. The smears from group 3 were made at irregular intervals in an attempt to depict the field examinations. Two smears were made from each animal and were each stained with either Giemsa or May-Gruenwald9.

Parasitaemia

The examination of blood from the tail vein for the presence of trypanosome was carried out starting on day 0 p.i. This was done by the examination of wet blood films and by the haematocrit centrifugation technique9. In positive cases, the course of parasitaemia was followed by the daily examination of the wet blood films. Quantification of the parasites was carried out according to the "Matching Method"10.

Preparation of blood samples for scanning electron microscopy

Two to three drops of blood were drawn from the tail vein of the infected Mastomys natalensis into 1 ml of Hanks buffer salt solution which contained about 2,000 i.u. heparin and centrifuged at 1500 rpm (350g) for 10 minutes. The sample was prefixed in 1.2% glutaraldehyde 0.1 M sodium cacodylate buffer solution. 1% osmium tetroxide in 0.166 M sodium cacodylate buffer, pH7.3 was added to the sediment and allowed to postfix for one hour. The sediment was washed twice with buffer solution, and the buffy coat was drawn out and dropped onto a aluminium foil which had been dipped in sterile solution of poly-L-lysine. The sample was then dehydrated in graded ethanol, through a mixture of ethanol and iso-amyl acetate and pure iso-amyl acetate, and dried at a critical point of carbon dioxide in Balzers Union Critical point drier. It was sputtered in a Balzers Union Sputtering device at 0.1 torr and 15mA.

Preparation of blood samples for transmission electron Microscopy

About 1 ml of blood drawn from the retrobulbar plexus during the rising parasitaemia or imm
diately after the peak of the parasitaemia was centrifuged for 10 minutes at 1,500 rpm (350p). 1.6% glutaraldehyde in 0.166M sodium cacodylate buffer pH 7.3 was added to the sediment and allowed to prefix for 10 minutes. The buffy coat was removed and placed in the same fixative as above for one hour. It was then washed twice each for 15 minutes with 0.166M sodium cacodylate buffer pH 7.3. This was followed by post fixation in 1% osmium tetroxide in 0.166M sodium cacodylate buffer pH 7.3 for 1-1/2 hours. After washing twice with buffer solution, the sample was dehydrated in graded acetone and then embedded in Durcupan. Ultrathin sections were cut, stained with 2% uranyl acetate, contrasted with 1% lead acetate for 10 minutes each and examined.

Results

Parasitaemia

Trypanosome were first detected in the peripheral blood circulation by day 2 p.i. By the fourth day p.i., trypanosome were detected in about 86% of the infected animals. The concentration of trypanosome above x10⁵ in the infecting doses did not markedly affect the day of first occurrence of trypanosome in the peripheral blood circulation. However, higher trypanosome concentration in the infecting doses tended to lead to earlier occurrence of trypanosome in the peripheral blood circulation than low trypanosome concentration (Table 1). The first peak of parasitaemia was generally reached between day 6 and 8 p.i. (Figure 1). This was followed by a sharp drop in the parasitaemia and by another rise to peak value about five to seven days later. After the second peak, the course of the parasitaemia was irregular but remained nevertheless high throughout the infection.

![Figure 1: Trypanosomes (T) adhering to the surface of the phagocyte (P) with their anterior ends. x5300](image)

<p>| Trypanosome dose and the No. of positive animals with trypanosomes in their peripheral blood circulation |
|--------------------------------------------------|-----------------|-----------------|----------------|-----------------|----------------|</p>
<table>
<thead>
<tr>
<th>Trypanosome</th>
<th>No. of animals</th>
<th>No. and % of +ve animals during the early course of infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>x10⁴</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>x10⁵</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>x10⁶</td>
<td>45</td>
<td>16</td>
</tr>
<tr>
<td>x10⁷</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>Control</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Phagocytosis of trypanosome (trypanophagocytosis)

Examination of the blood smears as well as electron microscopical studies of blood samples showed trypanophagocytosis by circulating blood leukocytes. This was observed mainly
between day 6 and 9 p.i., corresponding to the peak of the parasitaemia or immediately thereafter and was observed mainly in animals in group 1 and group 2 (Table 2). Animals in which trypanophagocytosis was observed in their peripheral blood smears tended to survive longer than those which showed no trypanophagocytosis in their blood smears. Different stages of phagocytosis, namely adhesion, ingestion and digestion were observed. In the adhesion stage, the trypanosome were tightly bound to the cell membrane of the leukocytes (Figure 1). This was followed by the stage of partial ingestion in which a portion of the trypanosome was seen to lie within the cytoplasm of the phagocytosing cell.

**Figure 2:** Partial ingestion. Netrophilic granulocyte in the process of ingesting one trypanosome (T) with its cytoplasmic process surrounding it (short arrow). Note that the cell contains already phagocytosed trypanosomes in the advanced stage of digestion (long arrow). x8000

and also by the middle portion (Figure 7) but very rarely from their posterior end. In the stage of complete ingestion, trypanosomes were contained within the phagocytic vacuoles in the cytoplasm of the phagocytosing cells. The early phase of complete ingestion showed little signs of degradation of the phagocytosed trypanosome (Figure 8, 9). However, in the later phase, different degrees of the degradation process were observed. These consisted of cases where the phagocytosed trypanosome could still be recognized by their nuclei, flagellae and cytoplasm, and those where the degradation of the trypanosome was so advanced as to lead to the destruction of the trypanosomal cellular organelles. The end phase of the degradation processes consisted of the presence of optically empty vacuoles and rest vacuoles within the cytoplasm of the phagocytosing cells (Figure 4, 11). Evidence of this could be seen even in wet blood films and it assisted to some extent in determining the time for the preparation of blood samples for transmission electron microscopic studies. Frequently, leukocytes were observed which showed nearly all the stages of phagocytosis (Figure 2, 10).

**Figure 3:** Early stage of trypanosome ingestion – partial ingestion. The Trypanosome (T) is being ingested from its anterior ends by the neutrophil. Note the presence of vacuole (arrow) at the end of the Trypanosome being phagocytosed. x1400.
Figure 4: End stage of phagocytosis. The digestion of the phagocytosed trypanosomes has resulted in the formation of optically empty vacuoles (V). Note two trypanosomes (T) in close contact with the phagocyte. x1400

Figure 5: Adhesion and partial ingestion. One trypanosome (T) is tightly bound to the surface of the phagocyte (P) with its anterior end. Note that in one case the anterior portion of the trypanosome is seen buried under the cytoplasmic process (arrow). x7500

Figure 6: Phagocyte (P) with a number of trypanosomes adhering to it. Note the trypanosome (T) being engulfed from its anterior end. x4600

Table 2: Detection of phagocytosis of trypanosomes in peripheral blood smears of infected animals in the different groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>No. of animals</th>
<th>+ve cases</th>
<th>% of +ve cases</th>
<th>-ve cases</th>
<th>% of -ve cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29</td>
<td>21</td>
<td>72</td>
<td>8</td>
<td>28</td>
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<tr>
<td>2</td>
<td>29</td>
<td>23</td>
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<td>3</td>
<td>30</td>
<td>4</td>
<td>13</td>
<td>26</td>
<td>87</td>
</tr>
<tr>
<td>Control</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 7: Trypanosome (T) being phagocytosed from its middle portion (arrow). x4800.

Figure 8: Stage of complete ingestion with cross section of phagocytosed trypanosome (T) showing flagella (F) and trypanosomal nucleus (TN). x10000

Figure 9: Complete ingestion of trypanosome by blood monocyte/macrophage. The phagocytised trypanosome (T) is seen in a longitudinal cross section showing a kinetoplast (arrow) a flagellum (F) and a flagellar pocket (S). x12000

Figure 10: Neutrophilic granulocyte with already phagocytosed trypanosomes (arrow) and optically empty vacuole still showing trypanosome (T) adhering to its surface. x10000.
The phagocytosing blood leukocytes were found by both light and electron microscopy to consist predominantly of neutrophils but also eosinophils (Figure 12) and monocytes/macrophages. Neutrophils were found to contain more phagocytosed trypanosomes per cell (Figure 10, 11) than monocytes (Figure 8, 9), and most of the recorded cells involved in the trypanophagocytosis were found to be neutrophils.

**Figure 11:** Neutrophil with phagocytosed trypanosome (T) in different stages of digestion including the presence of rest vacuoles (R) and optically empty vacuoles (V).

In this study, *in vivo* phagocytosis of *T. congoense* by circulating blood leukocytes is demonstrated in the infected animals. All the three stages of phagocytosis, namely adhesion, ingestion and digestion were observed. In conformity with the findings of the *in vitro* studies of Stevens and Moulton(5), phagocytosis of the morphologically intact trypanosome was found to take place almost always along the flagella, and the degradation was observed to occur within the phagocytic vacuoles.

In the infected animals, the trypanosome concentration in the circulating blood is known to fluctuate periodically. This periodic fluctuation in the trypanosome concentration has been thought to be due to the direct lethal action of the antibodies on the parasites and to antigenic variations of the trypanosome(11,12). What happens to the damaged trypanosome and to the trypanosomal antigen load in the infected animals has long been a matter of speculation. It is generally thought that the clearance of the parasites from the blood circulation is carried out by mononuclear phagocytic cells through the antibody-dependant phagocytosis. The failure of Schmitz, et al.(6) to observe phagocytosis of intact trypanosome instead of trypanosomal granular materials, led them to suggest that except for trypanosomal debris, phagocytosis of intact trypanosome does not occur. However, the observation of apparently morphologically intact phagocytosed trypanosome in the present study as well as the study of Macaskill, et al.(13) in which they found no evidence to suggest that fragmentation or lysis of the trypanosome occurs prior to their clearance from the blood circulation argue strongly against this view.

Damages to the trypanosome caused by antibody and/or complement, antibody dependant 1G, and 1gM cytotoxic cells, antibody-independent natural killer cells, as well as cell mediated cytotoxicity and activated macrophages are reported to occur(11,12,4,14).

In addition to the trypanolysis caused by specific antibodies and complement, it is believed that such antibodies and complements
also played a role in the adhesion and phagocytosis of the trypanosomes observed in the present study. It was interesting to note that neutrophils were more active in the phagocytosis of the trypanosomes than monocytes. This is supported by the fact that neutrophilic granulocytes were found to contain more phagocytosed trypanosomes per cell than monocytes as shown in Figure 8, 9, 10, 11 and by the fact that most of the recorded cells which were involved in the trypanophagocytosis were found to be neutrophilic granulocytes. This may be due to the fact that neutrophilic granulocytes as short living haematological end cells are able to phagocytose even trypanosomes which are not opsonised. In line with this point is the fact that granulocytes are capable of phagocytosing and degrading microorganisms like fungi and bacteria in vitro in the absence of serum factor, and that their microbicidal action is greater than that of the macrophage\(^{16}\). It is believed that the \(C_3\) receptor of the neutrophils played a great role in the observed phagocytosis of the trypanosomes since the neutrophils like the inactivated monocytes lack the receptor for the Fc portion of the IgM antibodies, which is the class of antibodies reported to be markedly increased in the early course of the infection\(^{16, 17, 18}\). Whole serum as well as specific IgG, and IgM have been reported to enhance in vitro phagocytosis of trypanosomes\(^{4, 5, 16}\).

Phagocytosis of trypanosomes by eosinophilic granulocytes was also observed. The granules of the eosinophilic granulocytes contain a major basic protein which has been shown in vitro to be cytotoxic for *Trypanosoma cruzi* in very small concentrations\(^{2}\).

Trypanosomes are blood parasites which spend most of their time within the blood circulation while in the mammalian hosts (especially those belonging to the haemetic group). It should therefore be expected that elimination of these parasites from the blood circulation should take place by way of circulating blood leukocytes with which they are constantly in contact. Why this reported trypanophagocytosis has not been observed in the peripheral blood smears of trypanosomes infected animals despite the long use of this method of diagnosis, lies probably in the fact that blood smear preparations and examination in addition to being not carefully scrutinized for this phenomenon, have been made at random with great time lapse between one smear and the next. In such cases therefore, it is likely that trypanophagocytosis which may occur on days when blood smears were not made may be missed, as evidence by the very low observation of trypanophagocytosis in the blood smears from animals in group three in the present study.

It is concluded from the present study that the observed in vivo phagocytosis of trypanosome by granulocytes and monocytes in circulating blood plays a very important role in the defence mechanism against the trypanosome infection and that this phenomenon, together with the antibody dependent trypanolysis constitute the main mechanisms by which the infected animal can rid themselves of or at least limit the trypanosome antigen load.

**Acknowledgement**

This work was supported by the German Academic Exchange Programme for which support the author is most grateful.

**References**

Light and electron microscopical studies of in vivo phagocytosis of Trypanosoma congoense


the Jena, Thuringia, Germany, in July 1983. In addition, in February 1984, a small test of this procedure was performed in Jena.

Examinations: In October 1983, a blood sample was obtained from a patient with Trypanosoma brucei gambiense in the Laboratory of the Institute of Tropical Medicine, Antwerp, Belgium, and a small test of the procedure was performed in Antwerp.

Acknowledgement:

This work was supported by the German Academic Exchange Programme for which the author is most grateful.

References:
PRELIMINARY OBSERVATION ON TICKS: SEASONAL DYNAMICS AND RESISTANCE OF THREE INDIGENOUS AND THREE CROSS-BRED CATTLE IN ETHIOPIA

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REMARQUES PRELIMINAIRES SUR LES TIQUES: LA DYNAMIQUE SAISONNIÈRE ET LA RÉSISTANCE DE TROIS BOVINS INDIGÈNES ET DE TROIS BOVINS CROISÉS EN ETHIOPIE

Résumé

Des enquêtes sur les tiques, leur dynamique saisonnière et la résistance naturelle des races locales (Zébu): Boran, Barka, Horro et de trois croisements : Zébu x Jersey (F₁, F₂, 3/4, 7/8); Zébu x Frison (F₁, F₂, 3/4, 7/8) et Zébu x Simmental (F₁, F₂, 3/4, 7/8) aux tiques ont été menées pendant une année dans deux localités en Ethiopie: Holetta et Adami Tulu. Les tiques collectées et enregistrées par ordre d'abondance à Holetta étaient, B. decoloratus, R. e. evertsi, A. cahoaerens et A. variegatum, tandis que les tiques rencontrées à Adami Tulu étaient H. rufipes, R. e. evertsi, A. variegatum et B. decoloratus. A Adami Tulu, R. e. evertsi et H.m rufipes étaient présents tout au long de l'année. Dans les deux localités, A. variegatum montrait des variations saisonnières, à savoir une augmentation relative pendant la courte et la longue saison des pluies à Adami Tulu, et une diminution jusqu'à un niveau zéro pendant la longue saison pluvieuse à Holetta. La résistance de l'hôte évaluée à l'aide du nombre de tiques adultes sur les animaux de races locales (Boran, Barka, Horro) et leurs croisements avec les Jersey, Frison et Simmental, a révélé l'existence d'un meilleur contrôle des charges de tiques chez les races indigènes, suivi dans l'ordre par les races croisées: Zébu x Jersey dans le rapport 1:4:10:30 respectivement.

Summary

Study on tick fauna and seasonal dynamics as well as natural resistance of Zebu Boran, Barka, Horro indigenous breeds and three crosses: Zebu x Jersey (F₁, F₂, 3/4, 7/8), Zebu x Frisian (F₁, F₂, 3/4, 7/8) and Zebu x Simmental (F₁, F₂, 3/4, 7/8) to ticks was undertaken for a period of one year at two sites known as Holetta and Adami Tulu in Ethiopia. The ticks recovered and recorded in the order of their abundance at Holetta were B. decoloratus, R. e. evertsi, A. cahoaerens and A. variegatum while the ticks at Adami Tulu were represented by H. rufipes, R. e. evertsi, A. variegatum and B. decoloratus. At Adami Tulu, R. e. evertsi and H.m. rufipes were present throughout the year. At both sites A. variegatum showed seasonal fluctuations: with relative rise during the short and long rains at Adami Tulu and declining to nil level in the long rains at Holetta. Host resistance measured by the number of adult ticks on individual animals belonging to Boran, Barka and Horro indigenous breeds and their crosses with Jersey, Frisian and Simmental revealed the presence of better control of tick burdens in the local indigenous Zebus followed by cross breeds in the order of Zebu x Jersey, ratio of 1:4:10:30, respectively.

Introduction

It is estimated that about 80 percent of the world's 1,226 million cattle is exposed to the risk of infestation by cattle ticks. These ectoparasites adversely affect livestock production in several ways. They are responsible for losses caused through blood loss, damage to hides and udder, tick worry and the injection of toxins. Ticks also transmit devastating and often fatal diseases such as theileriosis, babesiosis, anaplasmosis and cowdriosis. In the tropics it is now known that 600 million cattle are exposed to anaplasmosis and babesiosis, 200 million to theileriosis while in Africa alone 175 million cattle are at risk from cowdriosis. The economic and food losses caused by these tick borne diseases are severe. Not only is the annual global cost estimated to run to seven thousand million dollars, but also mankind is deprived of a significant amount of animal protein that cannot be replaced from other sources.
Conventionally control of ticks and tick-borne diseases is achieved in many parts of Africa by spraying or dipping cattle regularly with acaricides. But over a period of time the method is becoming increasingly less dependable. Departments of Veterinary Services have problems making acaricides available because they are expensive and procurement involves scarce foreign currency. Furthermore dips are often vandalized, poorly maintained and managed. Water needed to operate dips may be scarce and some tick species are developing resistance to frequently used acaricides. In places where ECF is endemic the refined infection and treatment method has been used effectively to immunize cattle in field trails in several African countries. Its application in the small holder farming systems however leaves much to be desired in light of the fact that successful treatment and immunization is only possible with the use of specific targeted strains as well as efficient and high quality veterinary services.

The socio-economic impasse surrounding the feasibility and sustainability of the traditional methods and the emphasis of minimizing use of chemicals in pest control prompted search for novel approaches and strategies. Pest management through an integrated programme became the prescribed alternative. This vision and approach unfolded and brought to the forefront the knowledge base that there is significant difference between the ability of different breeds of cattle to control tick burdens and tick borne diseases. A case in point is the Boophilus microplus problem which is an excellent example. This one host Australian tick species became adapted to Bos indicus cattle which evolved in turn the ability to acquire a useful degree of host resistance. The thought of extrapolation and application of this knowledge base within the broader concept of integrated pest management in Africa and particularly Ethiopia instigated the undertaking of this work. The Australian programme has succeeded because individual resistance to ticks was quantified, and the ecology and population dynamics of the single target species were studied in depth at the same time so that the use of tick resistant cattle could be fitted into the live-stock husbandry system.

It is estimated that Ethiopia possesses 14 percent of the Africa cattle population. Harnessing, tapping and exploiting this resource is however hampered by a number of constraints of which substantial damage and toll is attributed to lack of nutrition and impact of rampant diseases. Within the rank of the latter tick and tick-borne diseases stand third to trypanosomiasis and endoparasitism. Knowledge on tick fauna, distribution and vectorial capacity is well recorded and updated since the last fifty four years thanks to the work of Stella, Ballis and Bergeon, Morel, Feseha Gebreab and extern students of the Faculty of Veterinary Medicine of the Addis Ababa University. However assessment of loss in terms of monetary value from the results of tick infestation, host resistance to ticks and tick-borne diseases, seasonal dynamics of the prevailing genera and species of ticks is unknown. In the absence of such-line data prescription of an integrated scheme for effective cattle tick control is not possible.

This paper therefore attempts to show the level of host resistance in three cattle breeds of indigenous origin and their crosses with Jersey, Freisian and Simmental genotypes to ticks. The seasonal dynamics of the prevailing tick species in the area of study has also been explored in a parallel manner, and is presented.

Materials and Methods

Study Area

This work was carried out in 1987 and 1988 in two different agroecological zones, namely:

HOLETTA: It is an area located in the central highlands of Ethiopia at an altitude of 2400 meters above sea level. It is characterized by temperate climate for most parts of the year with a mean maximum temperature of 18°C (9°C-23°C). The annual rainfall amounts to 1083mm.

ADAMI TULU: This place is situated in the southern rift valley at an altitude of 1750 meters above sea level. It is arid and relatively warm for most months of the year. The mean maximum temperature ranges from 25°C to 28.4°C. The
mean annual precipitation is 602 mm often averaging between 500 mm to 700 mm.

**Study Animals**

A total of 840 animals maintained in the research stations of Holetta and Adami Tulu kept primarily for dairy performance evaluation studies were used in this work. Herd compositions of the groups observed is as follows: Local Boran, Barka and Horro indigenous females, exotic Jersey, Freisian and Simmental males, cross bredrs represented by Zebu x Jersey, Zebu x Freisian and Zebu x Simmental. The exotic blood percentages ranged from 50 to 87 percent. The numerical distribution in terms of genotype was more or less equal. The age range of the foundation stock was between 5 to 6 years while that of crossbred off-springs was 2-3 years.

**Study Design**

Tick collection: Ticks were collected from 840 animals. Each animal was restrained in a crush and ticks were handpicked from four regions of the body surface demarcated as follows:

- Region 1 face, neck and dewlap
- Region 2 right and left ribs and abdominal regions
- Region 3 udder, scrotum and legs
- Region 4 tail, anus and back.

The collection was conducted on a monthly basis for a period on one year. Male and female ticks recovered from different animals and regions of the body were separately counted, recorded and preserved in 70 percent ethanol. Identification to the species level was done in the laboratory using stereo microscope and based on keys of Hoogstraal\(^{13}\), Walker\(^{14}\), Morel\(^{11}\), Feseha\(^{15}\) and Matthys and Colblo\(^{16}\).

Relative prevalence, abundance and seasonal dynamics of the encountered tick species was determined. Resistance was measured by the number of recovered adult ticks from the different breeds of animals.

Meteorological data was obtained from the research stations. (Figure 8, 9).

**Results**

All in all 20,380 ticks were collected from the 840 animals over a period of one year. The ticks recovered and enumerated in the order of prevalence rate at Holetta were *Boophilus decoloratus*, *Rhipicephalus e. evertsi*, *Amblyomma cohaerens* and *Amblyomma variegatum* while the tick fauna at Adami Tulu were represented by *Hyalomma rufipes*, *Rhipicephalus e. evertsi*, *Amblyomma variegatum* and *Boophilus decoloratus*. The adult tick count ranged from 0 to 300 per animal (Figure 1).

*Boophilus decoloratus* (Koch)

This species was abundantly found at Holetta with a share of more than 80 percent of the count. It dominated the tick fauna picture throughout the year. On the other hand at Adami Tulu it was less numerous and was observed only in the months of September to December (Figure 2). As indicated in Figure 4 the species was predominantly recovered from the face, neck and dewlap and to some degree from the other body surfaces of the animals.

*Rhipicephalus evertsi evertsi* (Neumann)

This tick was high in abundance at Adami Tulu and was encountered throughout the course of the year at both sites (Figures 2, 3). At Holetta even though it ranked second in prevalence the tick count was relatively very low. It was collected mostly from region 4 (Figure 5) particularly the anal area.

*Hyalomma marginatum rufipes* (Koch)

This long-mouthed tick was present only at Adami Tulu (Figure 2). It occurred throughout the year and outnumbered the other tick species in nine out of the twelve months. Region 3 was the preferable attachment site with particular predilection to the udder and scrotum area (Figure 6).
Figure 1: Mean seasonal tick-burden per beast at Holleta and Adami Tulu

No. of ticks

0 5 10 15 20 25 30 35

J F M A M J J A S O N D

Month

Holleta Adami Tulu

Figure 2: Seasonal tick dynamics at Adami Tulu

Ticks, %

0 20 40 60 80 100

J F M A M J J A S O N D

Month

H. rufipes A. variegatum R. e. evertsi B. decolaratus
Figure 3: Seasonal tick dynamics at Holleta

- **B. decolaratus**
- **A. cohaerens**
- **A. variegatum**
- **R. e. evertsi**

Figure 4: Ticks found in different regions of the host's body at Adami Tulu

- **H. rufipes**
- **A. variegatum**
- **R. e. evertsi**
- **B. decolaratus**

**Region 1**

**Region 2**

**Region 3**

**Region 4**
Figure 5: Ticks found in different regions of the host's body at Holleta

![Bar chart showing tick distribution by species and region]

Figure 6: Mean tick burden in different breeds at Holleta

![Bar chart showing tick burden by breed and generation]

Regions:
- Region 1
- Region 2
- Region 3
- Region 4

Breeds:
- Zebu x Jersey
- Zebu x Friesian
- Zebu x Simmental
- Local

Generations:
- F1
- F2 & F3
- 3/4 & 7/8
Amblyomma variegatum (Donitz)
It was collected from both sites. At Adami Tulu it exhibited seasonal fluctuations with substantial populations appearing in February, March, April and May, subsiding completely in June, July, declining in September, rising again in October and going down the ladder in November and December (Figure 2 and 3).

On the other hand at Holetta A. variegatum was not observed in the months of July, August, September and October. The relative abundance was however low in the months of its occurrence. The tick species was collected to a large extent from regions 5 and 4.

Amblyomma cohaerens (Donitz)
This species was recovered only from the study animals at Holetta and was not observed in the months of August and September. Its relative abundance was also low. Its predilection site was regions 3 and 4 (Figure 5).

Marked variation in tick burdens was recorded in the observations conducted regarding host resistance. Boran, Barka and Horro indigenous breeds harbored low tick burdens throughout the year at both sites (Figure 6 and 7). Of the crossbred animals low numbers of ticks were recovered from the Jersey x Zebu, slightly higher in Freisian x Zebu and a high load in the Simmental x Zebu (Figure 6 and 7). The mean tick burden ratio for indigenous breeds, Jersey x Zebu, Freisian x Zebu and Simmental x Zebu was: 1:4:10:30 respectively (Fig 8).

Simultaneous observations carried on behavior of ticks on groups of different breeds confirmed that the weight of engorged female ticks recovered from indigenous breeds was low compared to those collected from the Zebu x Simmental crosses.

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![Figure 7: Mean tick burden in different breeds at Adami Tulu](image-url)

No. of ticks

- Zebu x Jersey
- Zebu x Friesian
- Zebu x Simmental
- Local

- F1
- F2 & F3
- 3/4 & 7/8
Discussion

In this study two important tick species namely *Boophilus decoloratus* and *Amblyomma variegatum* known for exerting great influence on cattle breeding in the tropics have been encountered. The two other tick species encountered are *Hyalomma marginatum rufipes* and *Rhipicephalus evertsi evertsi*. The vectorial capacity of the former is unknown, nevertheless it is suspected of having a role in the transmission of theileriosis due to *T. annulata* (7). What-
ever the case is the diseases has not been reported in the country so far. The latter is regarded as being virtually harmless. The distribution pattern of *B. decoloratus* and *A. variegatum* characterized by abundance at Holata which is part of the wetter highlands and subhighlands and low in numbers in tropical woodland and thorn bush vegetation habitats of the rift valley such as Adami Tulu was in agreement with that reported by Pegram (8) (Figure 9 and 10).

This preliminary work in two agroecological zones of Ethiopia has also established the existence of a varying but significant degree of resistance to cattle ticks in three indigenous *Bos indicus* breeds and their crosses. The Jersey x Zebu, Freisian x Zebu and Simmental x Zebu crosses with genotype status of F1, F2, 3/4 and 7/8 in each group exhibited in varying degrees an ability of limiting adult tick populations on their body surfaces. The Jersey x Zebu excelled the two other crosses in this respect. Similar studies conducted at Aberra State Ranch comparing pure Boran breeds with Freisian x Boran crosses showed the latter to be more susceptible to tick infestation (7). Another work carried out at Bako Research station involving Boran and Horro indigenous breeds and their crosses with Simmental, Freisian and Jersey gave the following results: Boran x Simmental crosses carried 6-7 times more ticks than the indigenous Horro, pure Borans harbored intermediate tick burdens and the Jersey.

Horro-Simmental crosses carried limited adult tick populations nearly as well as *B. indicus* breeds (18). In the same observation involving Freisian-Horro, Freisian-Boran, Simmental-Horro and Simmental-Boran crosses, high resistance was shown by the Simmental-Horro crosses, but was low in the Freisian in general, and very low in the Simmental-Boran crosses (15). Elsewhere in Africa CIPE workers have also reiterated that local breeds of *Bos indicus* acquire a more effective natural resistance to tick infestations than the exotic *Bos taurus* against *R. appendiculatus, R. e. evertsi, A. habraeum* and *H. anatolicum, anatolicum* (20). In an extended work on the survival of unfed *R. appendiculatus in relation to host resistance and environmental factors in Kenya it was demonstrated that the most resistant hosts produced smaller adult ticks with the lower survival rate. Male and female ticks from highly resistant hosts had a smaller survival pattern but the females from a moderately resistant host survived significantly better than the males (21). It is evident from this work and the others conducted so far in the country that the study framework of expression of host resistance is limited only to adult tick burdens. This may suggest the inclusion of important determinants such as species of ticks, sex of the host and instar specificity in future work. Irrespective of forthcoming undertakings the knowledge base at hand underlines that hosts showing greater resistance than other hosts in terms of adult tick burdens do so to all instars and species of ticks (19). This has been confirmed to some extent in this study.

Summing up, improvements in the control of ticks by increasing the resistance of indigenous Boran, Horro and Barka by culling and selective breeding is promising. The relevance of this strategy as a basis for integrated pest management in Ethiopia becomes more meaningful in view of the fact that the tick species demanding vigilance and pertinent control measures are *Boophilus decoloratus* and *Amblyomma variegatum* as opposed to *R. appendiculatus*, which fortunately is absent from the tick fauna of the country (22) and resistance of Zebu cattle to the species is not strong (18). Increased productivity can be achieved by instituting rational breeding practices of *B. indicus x B. taurus* which in this case implies the use of Boran, Barka and Horro, crossed preferably with the Jersey. The Horro-Simmental cross breed showed considerable degrees of resistance while the Boran-Freisian and Boran-Simmental proved to be of low resistance in all the three studies. The observation on Barka-Freisian and Barka - Simmental is however limited to reach a conclusive end. As far as tick-borne diseases are concerned, losses can be minimized by adapting a strategy of non-interference with enzootic stability. Loss of udder quarters from *Amblyomma* infestations may be a problem, but can be prevented by light hand-spraying of the affected body area. Furthermore, this find-
but can be prevented by light hand-spraying of the affected body area. Furthermore, this finding can be used as basis for encouraging small scale farmers to cull their most heavily infested animals. Selection programmes for tick resistance, based on rapid visual assessment of natural tick loads can be part of an extension service education programme in livestock improvement. The ability of identifying animals with low natural resistance to ticks at the earliest opportunity is also now possible with the use of purified protein molecule from solubilised fully fed whole extract of *R. appendiculatus*. The extension of similar works to cover important ticks such as *A. variegatum* is relevant for an effective outreach programme.

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THE PREVALENCE OF CAPRINE SARCOPTIC MANGE DUE TO SARCOPTES SCABIEI VAR CAPRI IN ILE-IFE AREA OF NIGERIA, ITS CONTROL AND MANAGEMENT

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PREVALENCE DE LA GALE SARCOPTIQUE CAPRINE DUE A SARCOPTES SCABIEI VAR CAPRI DANS LA REGION DE ILE IFE AU NIGERIA ET METHODE DE LUTTE UTILISEE CONTRE CETTE MALADIE

Résumé
On a conduit une enquête sur la prévalence de la gale sarcoptique chez les chèvres naines de l'Afrique de l'Ouest dans quatre zones gouvernementales de l'État de Osun au Nigeria. Sarcoptes scabiei var capri, l'agent responsable, affectait 17.27% de l'ensemble des chèvres examinées, provoquant d'énormes lésions de gale et 25.53% de mortalité. Les éraflements de peau ont révélé la présence de Sarcoptes scabiei var capri. Il a été observé qu'une seule dose d'ivermectine (Ivomec, MSD) a permis d'obtenir une guérison clinique complète. Il a, par ailleurs, été noté que d'autres traitements tels que le nettoyage avec l'Asuntoil® (cromophores), l'application de pommade soufrée, de l'huile - moutre déjà utilisée et les herbes locales ont été efficaces à des degrés divers, mais aucun n'était aussi efficace que l'ivermectine. Les mesures de lutte sont discutées compte tenu de la prévalence saisonnière et de la réapparition de la maladie après le traitement.

Summary
The prevalence of sarcoptic mange among the West African Dwarf goats in four local government areas of Osun State of Nigeria was investigated. Sarcoptes Scabiei var capri, the causative agent, affected 17.27% of the total goats examined, causing extensive mange lesions and 25.53% deaths. The skin scraping revealed the presence of Sarcoptes scabiei var. capri. It was observed that a single dose of ivermectin (Ivomec, MSD) resulted in complete clinical recovery. It was further observed that alternative treatments such as Asuntoil® (cromophores) handwash Sulphur ointment application used engine oil and local herbs gave varying degrees of effectiveness but none was as effective as ivermectin. The control measures are discussed in view of the seasonal prevalence and reoccurrence after treatment.

Introduction
The goats occupy an important place in the Nigerian economy as a source of meat and skin. The West African Dwarf goat is adapted to the humid tropical environment of West Southern Nigeria. A density of approximately 0.5 goat per head of rural human population for the humid zone of West Africa had been reported. It had also been observed that over 70% of rural communities in villages in Southern Nigeria keep goats or sheep. These animals, inspite of their limitation are responsible for the production of most of the meat consumed in these areas.

Sarcoptic Mange and other bacterial and viral diseases had been observed to be major constraints to profitable goat rearing in Nigeria. Sarcoptic Mange caused by Sarcoptes Scabiei has been described as a dreadful dis-ease of animals especially in the tropics. The infection of goat with various types had been reported from some countries like Australia, India, Zambia; and Tanzania.

The fact that Sarcoptic Mange is a problem in animal rearing is generally known. But the extent of infection is yet to be established in Nigeria. This paper thus records the prevalence of the Sarcoptic Mange in West African Dwarf goats in four local government areas of Ile zone, of Osun State of Nigeria, along with the clinical trials of medicaments used by different farmers with a view of determining the most cost-effective methods of controlling the disease.

Materials and Methods
Four local government areas within Ile zone of Osun State of Nigeria were involved in this
study. This are Atakumosa, Ife Central, Ife North and Ife South Local Government areas, covering 14 towns and villages. The owners of the animals were interviewed to detect the history of infection. Thorough clinical examination was carried out for the presence of clinical abnormality. Special attention was paid to the skin for the presence of skin lesions and evidence of rubbing and scratching behaviour. The type and distribution of skin lesions in each of the affected animals were noted. The study covered a period of two years (Jan. 1991– Dec. 1993).

Very deep scrapings were taken with the help of scalpel blades from skin lesions of severely affected goats. The scrapings were soaked in 10% KOH aqueous solution. The scrapings were macerated or teased with a mounted needle. Later these were centrifuged at 1500 rpm for 20–30 minutes. The sediments were examined under microscope for identification of the causal agent. The mites were identified on morphological characters.

Treatment trials were carried out to evaluate clinical efficacy of the various drugs and medicaments used by different owners to control the disease. Invermectin was administered to 20 goats at the recommended dose rate of 1ml/50kg. 20 affected goats were hand-scrubbed with 0.1% coumophos (Asuntol(R)) three times at two weeks intervals. Another 20 affected goats were treated by topical application of crude local herb, Heliotropium indian link lin three times at weekly interval. The treated goats were evaluated a month later to assess and compare the clinical effectiveness of the various medicaments used.

The same animals were also examined every month after treatment to determine the recurrence of the skin lesions; and absence or presence of mites from skin scrapings.

Results

This investigation revealed that there were no major goat farms or ranches and there was an average of seven goats per house in the area of study. The prevalence of Sarcoptic Mange in goats examined is as shown in Table 1. Skin lesions were found in 17.27% of the total goats examined.

Clinically all affected goats showed mild to extensive lesions on various parts of the body, affecting mostly face, ears, neck, legs, and abdomen. (Figure 1). The characteristic rough, thickened skin with dry whitish crusts was also observed around the back, legs and the udder of the affected goats (Figure 2). Scaly materials were seen between the hair. All affected animals were observed to be rubbing their bodies against walls and poles.

Figure 1: Caprine Mange: Lesions on the face, neck and belly

Figure 2: Caprine Mange: Lesions on the udder and legs

All affected animals were in poor bodily condition. This was more pronounced in the younger animals. The disease ran a more chronic course in the adult than the younger animals. A mortality rate of 25.53% was recorded in this study (Table 1). The mortality rate was higher in the affected younger goats than their older counterparts.
The prevalence of Caprine Sarcoptic Mange due to Sarcoptes scabiei var capri in Ile Ife area of Nigeria

Table 1: The Prevalence of Sarcoptic Mange in Goats in Ile Zone of Nigeria

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Town or Village</th>
<th>Local Government Area</th>
<th>Total No. of Goats Examined</th>
<th>Animals No.</th>
<th>Infected %</th>
<th>Deaths No.</th>
<th>Deaths %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ile-Ife</td>
<td>Ile Central</td>
<td>1,000</td>
<td>200</td>
<td>20.0</td>
<td>36</td>
<td>18.0</td>
</tr>
<tr>
<td>2.</td>
<td>Eleta</td>
<td>Ile Central</td>
<td>120</td>
<td>40</td>
<td>28.0</td>
<td>9</td>
<td>22.5</td>
</tr>
<tr>
<td>3.</td>
<td>Yekemi</td>
<td>Ile Central</td>
<td>200</td>
<td>40</td>
<td>20.0</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Adagba</td>
<td>Ile Central</td>
<td>100</td>
<td>20</td>
<td>20.0</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>5.</td>
<td>Osi-Sioko</td>
<td>Ile Central</td>
<td>200</td>
<td>50</td>
<td>29.0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>6.</td>
<td>Iyanfoworogri</td>
<td>Ile Central</td>
<td>180</td>
<td>25</td>
<td>13.0</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>7.</td>
<td>Garage Olode</td>
<td>Ile South</td>
<td>500</td>
<td>90</td>
<td>18.0</td>
<td>17</td>
<td>18.87</td>
</tr>
<tr>
<td>8.</td>
<td>Idera</td>
<td>Ile South</td>
<td>250</td>
<td>60</td>
<td>24.0</td>
<td>13</td>
<td>21.67</td>
</tr>
<tr>
<td>9.</td>
<td>Bolorunduro</td>
<td>Ile South</td>
<td>180</td>
<td>30</td>
<td>16.7</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>10.</td>
<td>Fasina</td>
<td>Ile North</td>
<td>200</td>
<td>40</td>
<td>20.0</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>11.</td>
<td>Asipa</td>
<td>Ile North</td>
<td>160</td>
<td>30</td>
<td>18.75</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>12.</td>
<td>Yakoyo</td>
<td>Ile North</td>
<td>120</td>
<td>13</td>
<td>10.8</td>
<td>2</td>
<td>15.38</td>
</tr>
<tr>
<td>13.</td>
<td>Ifewara</td>
<td>Atakumosa</td>
<td>450</td>
<td>150</td>
<td>33.3</td>
<td>26</td>
<td>17.3</td>
</tr>
<tr>
<td>14.</td>
<td>Arode</td>
<td>Atakumosa</td>
<td>150</td>
<td>50</td>
<td>33.3</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td></td>
<td>3,810</td>
<td>658</td>
<td>17.27%</td>
<td>168</td>
<td>25.53%</td>
</tr>
</tbody>
</table>

The clinical signs coupled with the characteristic skin lesions suggested mange infestation. This was confirmed by positive demonstration of mites in the skin scrapings.

The disease was noticed throughout the year but the incidence was higher during the wet cold months of the year than the dry period.

Treatment trials with drugs and medicaments showed varying degrees of efficacy as shown in Table 2. Treatment with subcutaneous injection of 1ml/50kg of Ivermectin gave the most effective efficacy (98%). This was followed by Asuntol™ wash 40%; local herbs 38%. Sulphur ointment (25%) and used engine oil (15%) in descending order.

Table 2: Showing the efficacy of various medicaments

<table>
<thead>
<tr>
<th>Medicaments applied</th>
<th>No. of goats treated</th>
<th>No. cured</th>
<th>% cured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ivermectin injections 1ml/50kg (subcut.) single dose.</td>
<td>20</td>
<td>19</td>
<td>98</td>
</tr>
<tr>
<td>2. Asuntol (cromophos) 0.1% wash at 2 weekly interval for 3 times</td>
<td>20</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>3. Used Engine oil - at weekly interval (3 times)</td>
<td>20</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4. Sulphur ointment 50% at weekly interval (3 times)</td>
<td>20</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>5. Herbs (crude extract) weekly intervals (3 times)</td>
<td>20</td>
<td>7</td>
<td>38</td>
</tr>
</tbody>
</table>

The mange mites could not be demonstrated from the skin scrapings taken from goats treatment with Ivermectin a month after treatment; while few mites could be demonstrated on the other animals sometime after treatment with Asuntol 3 months; *PT used engine oil 1 month PT; Sulphur ointment 2 months PT; and crude herb 3 months PT. Even though alternative treatment against Sarcoptic Mange in goats appeared promising, Ivermectin is still the most effective drug in the treatment of caprine sarcoptic mange.

Discussion

This study has shown that Sarcoptic Mange is widespread within the area of study. The incidence was noticed throughout the year, even though a higher prevalence was recorded during the wetter and colder part of the year. These findings were in close agreement with some earlier reports. The lower mortality rate of the disease in the older goats than the infected younger goats may probably be associated with an immunological reaction as earlier reported in human infections.

*PT - Post treatment.
The rapid development of the skin lesions might be due to short life cycle of the mite which had been reported to be completed within 17 days\(^4\). The characteristic appearance and distribution of the skin lesions are in close agreement with earlier reports from other parts of Africa\(^6,7\).

Although economic losses caused by the Sarcoptic Mange in goats are not estimated, these must be certainly high judging from the poor condition of all affected animals, loss of hide and skins; loss of milk and death which was up to 25.53% of the total goats affected. It was also noted that it took some time before the treated goats could return to their normal bodily conditions after clinical recovery. These losses would be comparable for those earlier reported for cattle resulting from generalised mange infection\(^10,11\).

The result of clinical investigation and parasitological examination of skin scrapings proved that Sarcoptic Mange mite infestation was responsible for skin lesions in the cases under study. The morphological description of the mites showed that they are *Sarcoptes scabiei var capri*; and these are in agreement with those described earlier\(^4,12\).

A number of drugs and medicaments had been tried for the control of mange in all domestic animals\(^13,14\). In the present case, a single dose of subcutaneous injection of ivermectin gave a clinical recovery within 15 to 18 days of treatment. There was a complete clearance of skin lesions. No live mites were seen in the skin scrapings as from four weeks after treatment. This is in total agreement with an earlier trial treatment with the same drug\(^13\). Handwash of affected goats with 0.1% Asuntol\(^6\) 3 times at 7 days interval gave 40% efficacy as shown in Table 2. This treatment brought about marked improvement in the conditions of the treated animals. Few numbers of mite were however seen in skin scrapings as from the 8th week after treatment. Improvement seen in this case is in agreement with an earlier report of dipping affected goats with 0.1% Asuntol\(^6\) solution\(^14\).

Farmers in Nigeria had been using local herbs in the control of mange with varying degree of success. Like most herbs in Nigeria, the secrecy surrounding the actual component and dosage of such herbs had prevented further development and use of such herbs. In this case, the topical application of *Heliotropium indicum linn* juice by sponge handwash had an efficacy of 38%. There was a marked improvement of treated goats within 4 to 5 weeks after the 3rd application. Very few numbers of mites were seen three months after recovery from skin scrapings. This finding is an important one particularly as it may reduce the cost of goat production in Nigeria. As of now, ivermectin costs about 2,000 (two thousand) Nigeria Naira per bottle of 50ml.\(^{19}\), while Asuntol\(^6\) costs about 1,800 (one thousand eight hundred) Naira per litre. At a time when there is a general economic depression, the local herb which costs nothing to the farmers will surely be a ready made substitute for the expensive conventional drugs. Further work is however going on, on the active ingredients and dosage range and how the efficacy can be improved.

The application of used-engine oil gave 15% efficacy. This brought about the improvement in the condition of recovery goats; but few mites were seen from skin scrapings as from four weeks thereafter. The mode of action of the used engine oil may be likened to the action of Salvo Shampoo in dissolving keratin and removing the crust formed by the mites\(^15\). This type of treatment must be combined with others that will eliminate the mites.

Sulphur ointment application gave 25% efficacy. Mites were seen in the scraping eight weeks thereafter.

In conclusion, it appears that Sarcoptic Mange is widespread in the humid southern part of Nigeria. Apart from the normal conventional drugs used for the treatment of this disease, the local herb may be a good alternative in making sure that goat rearing and disease control becomes a profitable venture even under a depressed economy. Further work, which is presently going on, must be concluded before a definite recommendation is made as to the mode of use and success rate of the local herb.
The prevalence of Caprine Sarcoptic Mange due to Sarcoptes scabiei var capri in Ile Ife area of Nigeria

References


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In conclusion, it appears that Resveratrol, a compound found in the skin of grapes, may have promising properties for cancer treatment. Further research is needed to confirm these findings and determine the optimal dosage and application method. The potential therapeutic applications of Resveratrol suggest a promising area for future investigation in the field of oncology.
EFFECTS OF EXPERIMENTAL FASCIOLA HEPATICA INFECTION AND NUTRITION IN MENZ SHEEP

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EFFETS DE L’INFECTION EXPERIMENTALE AVEC FASCIOLA HEPATICA
ET DE L’ALIMENTATION CHEZ LES OVINS MENZ

Résumé
Cent quarante sept agnelles Menz âgées de 3–3 1/2 mois, sevrées, ont été réparties en quatre groupes et soumises à un traitement : groupe infecté et complémenté (IC), groupe non-infecté et complémenté (NC), groupe infecté et non-complémenté (IN) et groupe non-infecté et non-complémenté (NN), en vue d’étudier les effets de l’infection expérimentale avec Fasciola hepatica et de l’alimentation pendant une période de 24 semaines. Les pertes dues à la mortalité observées chez les groupes infecté et non-complémenté, non-infecté et non-complémenté étaient peut-être provoquées par l’insuffisance alimentaire et la distomatose aiguë. A part le niveau d’alimentation et d’infection, le taux de survie était influencé par les poids vifs initiaux et variait entre 6,9–99,9% pour les poids vifs de 5–16,5 kg respectivement. Les groupes infecté et complémenté, non-infecté et complémenté ont mieux survécu au cours de l’expérience. L’hématocrite prélevé chaque quinzaine montrait en moyenne des différences significatives (P < 0,01) entre le groupe infecté et le groupe non-infecté huit semaines après l’infection, ce qui était un délai beaucoup plus court par rapport à la période prépatente du parasite de 10–12 semaines. On a observé des différences entre le poids vif mensuel moyen et la conformation mensuelle moyenne seize semaines après l’infection lorsque la distomatose chronique s’est développée. Au terme de l’expérience, il y avait une différence de 1,9 kg entre le groupe infecté, complémenté et le groupe non-infecté, complémenté.

Summary
One hundred and forty seven, 3–3 1/2 months old, weaned, female lambs of the Menz breed were divided into 4 treatment groups of infected and supplemented (IS), non-infected and supplemented (NS), infected and non-supplemented (IN) and non-infected and non-supplemented (NN) to study the effects of experimental Fasciola hepatica infection and nutrition over a period of 24 weeks. Mortality losses observed in infected and non-supplemented and non-infected and non-supplemented groups were possibly due to inadequate nutrition and acute fascioliasis. Apart from the level of nutrition and infection, survivability was influenced by initial body weights; and varied from 6.9–99.9% for body weights of 5–16.5 kg, respectively. Both infected and supplemented and non-infected and supplemented groups survived better during the study. Mean fortnightly packed cell volume (PCV) showed significant (P < 0.01) differences between infected and non-infected groups 8 weeks after infection, much earlier than the parasite’s prepatent period of 10–12 weeks. Differences in their mean monthly body weight and mean monthly body condition score were observed 16 weeks postinfection when chronic fascioliasis developed. There was a 1.9 kg body weight difference between infected, supplemented and noninfected, supplemented groups at the end of the study.

Introduction
The Menz sheep is the main breed type in the Ethiopian highlands where 2/3 of the country’s 23 million sheep are found. It is one of the few African wool variety sheep with a thick and coarse hair cover(1). Fascioliasis, caused by Fasciola hepatica, is the major health constraint affecting sheep production in the country. It occurs mainly in the dry season, from October to February with a peak transmission in November. Snail host populations are available in massive numbers during the wet season (June to September) for infection, multiplication of asexual stages and release of cercariae onto pastures(2,3,4).

The effects of clinical and subclinical infections of fascioliasis include retarded growth,
weight loss, reduced wool growth, anaemia and mortality\(^5\). Anaemia is related to intrahepatic haemorrhage and reduced erythropoietic capacity\(^5\). Twenty-eight percent of the mortality losses in sheep are due to fascioliasis in the Ethiopian highlands\(^7\). Further economic losses occur due to condemnation of cirrhotic liver during meat inspection. Ngategize et al\(^8\) estimated that annual economic losses in sheep due to fascioliasis in the Ethiopian highlands totalled 50 million Ethiopian Birr (US$ 16 million).

There is an interaction between the level of nutrition and the effects of helminth infection. In *F. hepatica* infection, sheep on a low plane of nutrition developed rapid anaemia, hypoalbuminaemia, weight loss and death faster than sheep on a high plane of nutrition\(^9\). The resistance to gastrointestinal nematodes is also influenced by the level of nutrition\(^10\). This study was undertaken to determine the effects of nutrition and experimental *F. hepatica* infection on packed cell volume, growth and survivability of Menz sheep from weaning to 9 months of age.

**Materials and Methods**

**Experimental animals and design**

This study was performed from 15th November 1991 to 1st May 1992 at Debre Berhan, the International Livestock Centre for Africa, sheep station. One hundred and forty-seven, 3–3 ½ months old, weaned, female lambs were blocked by weight and then randomly allocated into 4 treatment groups: (1) 37 lambs, infected and supplemented (IS) (2) 36 lambs, noninfected and supplemented (NS), (3) 37 lambs, infected and nonsupplemented (IN) and (4) 37 lambs, noninfected and nonsupplemented (NN). These lambs were raised in the station. The mean body weight (plus ranges) for groups 1, 2, 3 and 4 was 9.8 (5-14), 10.1 (6-15), 10.2 (5-16.5) and 9.9 (5-16.5) kg, respectively while the overall mean for all was 10.0 (5-16.5) kg at the beginning of the study. Lambs were maintained in clean adjacent pens receiving hay and water *ad libitum*. Groups 1 and 2 were supplemented with a concentrate mixture of 300 g wheat bran, 150 g oil seed cake and 3 g lime daily. The feed composition of the hay was 3.5% crude protein, 9.8 MJ per kilogramme (MJ/kg) dry matter digestible energy and 38.0% acid detergent fibre; respective values for the concentrate were 22.3%, 11.6 MJ/kg and 17.8%. All sheep were drenched with 5 mg/kg body weight of fenbendazole (Panacur\(^a\)), Hoechst) and 10 mg/kg body weight with triclabendazole (Fasinex\(^b\), Ciba-Geigy) against gastrointestinal nematodes and fascioliasis respectively, and vaccinated against Pasteurella and clostridial infection at the beginning of an adaptation period of 15 days. Faecal examinations were negative for nematodes, trematodes and cestodes after treatment.

**Metacercariae and experimental infection**

Metacercariae of *F. hepatica* were acquired from Baldwin Aquatic Inc. Monmouth, Oregon. They were received wrapped in moist Whatman filter papers contained in small vials. Their viability was checked by observing the characteristic ring form appearance of the cysts under the microscope. The Whatman filter paper carrying metacercariae was inserted into a gelatin capsule and given as a bolus with a bailing gun to lambs in groups 1 and 3.

Lambs were orally infected with 500 viable metacercariae, 250 of which were given on 15 November 1991 and the rest as weekly doses of 50 metacercariae.

**Sampling, data collection and analysis**

Body weight and body condition scores (0–5)\(^11,12\) were recorded every month; faecal and blood samples were collected fortnightly to determine eggs per gram (EPG) counts and packed cell volume (PCV) respectively. EPG of nematodes and trematodes were determined using the modified McMaster and zinc sulphate flotation techniques, respectively\(^13\). Differences in wool growth were compared by fleece weight between groups at the end. Liver flukes were recovered and counted from lambs which died during the study and from six infected and supplemented lambs slaughtered at the end of the study. The liver was dissected by cutting through the bile ducts and its tissues into small pieces of 10 mm thickness to recover and count flukes.
Mean daily hay intake of lambs in each group was measured by weighing the hay provided and left over within 24 hours every 15 days.

Data were analysed for the supplemented and nonsupplemented groups separately since 21 of 74 lambs died within the first 12 weeks from the infected, nonsupplemented and noninfected, nonsupplemented groups (3 and 4); the sampling of these groups was discontinued at 12 weeks and infected lambs were treated. Sampling from the infected and supplemented and noninfected and supplemented groups continued for 24 weeks without mortality except for one noninfected and supplemented lamb which died due to ruminal impaction.

Data were analysed using Student's T-Test to compare mean body weight, mean body condition score, mean PCV at each sampling and mean fleece weight at the end. The onset of trematode egg shedding revealed the prepatent period of *F. hepatica* infection. The causes of lamb mortality were determined by post mortem examination. The effects of group treatment and initial body weight on survivability of nonsupplemented lambs were analysed with logistic models using the program Genstat[4].

**Results**

In the first 12 weeks, 21 of 74 lambs died from the infected, nonsupplemented and noninfected, nonsupplemented groups (3 and 4) due to acute fascioliasis (8 lambs), inadequate nutrition (8 lambs) and other causes (5 lambs) (Table 1). Mean daily hay intake of these groups varied from 407.7–637.9 g and 428.6–593.7 g for groups 3 and 4, respectively.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mortality by groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
</tr>
<tr>
<td>Enterosis</td>
<td>-</td>
</tr>
<tr>
<td>Fascioliasis</td>
<td>-</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>-</td>
</tr>
<tr>
<td>Ruminal impaction</td>
<td>-</td>
</tr>
<tr>
<td>Undetermined</td>
<td>-</td>
</tr>
<tr>
<td>Not examined</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
</tr>
</tbody>
</table>

The logistic regression of survival on treatment and initial body weight showed survivability to be significantly (*P* < 0.01) affected by body weight but not group treatment. The equation for initial body weight effect was:

Logit (*P*) = -6.96 + 0.872 * x* body weight

This is shown by the regression curve in Figure 1.

**Figure 1:** Relationship between initial body weight and survivability in infected, nonsupplemented and noninfected, nonsupplemented lambs

![Graph showing relationship between initial body weight and survivability](image-url)
Mean monthly body weight for infected, supplemented and noninfected, supplemented groups (1 and 2) is shown in Figure 2. Body weight was significantly (P < 0.01) different between the two groups starting from 16 weeks postinfection. Mean daily body weight gain per lamb was 11.4 and 20.9 g for groups 1 and 2, respectively during the study. Differences on body condition score were also observed after 16 weeks of infection (Figure 3). Mean fleece weights were 315.4 and 363.1 g for groups 1 and 2, respectively but were not significantly (P > 0.05) different. Mean fortnightly PCV values were significantly (P < 0.01) different at 8 weeks postinfection (Figure 4).

Figure 2: Mean monthly body weight in infected, supplemented (IS) and noninfected, supplemented (NS) lambs

Figure 3: Mean monthly body condition score in infected, supplemented (IS) and noninfected, supplemented (NS) lambs
Mean monthly body weights and mean monthly body condition scores were not significantly (P > 0.05) different between infected, nonsupplemented and noninfected, nonsupplemented groups (3 and 4) until their sampling was discontinued at 12 weeks after onset due to mortality. Mortality losses were attributed to infection and low plane of nutrition especially among those with low initial body weight. PCV showed significant (P < 0.05) differences between the two groups starting at 10 weeks postinfection (Figure 5). Daily body weight gain per lamb, up to 12 weeks, was 4.1 and 2.0 g for groups 3 and 4, respectively.

Infected lambs started shedding trematode eggs at 10 weeks of infection (Table 2). The frequency of lambs passing trematode eggs and their mean EPG counts increased progressively (Tables 2 and 3). One noninfected lamb from group 2 also passed very low trematode eggs at 10, 12, 16 and 20 weeks of sampling while another one from group 4 passed trematode eggs at 12 week (Table 3). There was one lamb each from groups 1, 2 and 4 shedding very low nematode eggs at 24, 24 and 10 weeks of sampling, respectively. A few Paramphistomum ova were also shed by a few lambs from all groups.
There were 0, 1, 120, and 65 immature flukes at post mortem in the liver of lambs which died from the infected, nonsupplemented group on 26/01/92, 28/01/92, 28/01/92 and 31/01/92, respectively. Fluke recoveries from 6 lambs slaughtered from the infected, supplemented group at the end of the experiment varied from 4.6-10.8% of the number of metacercariae given.

Table 2: Frequency of lambs shedding trematode eggs in infected groups

<table>
<thead>
<tr>
<th>Weeks after infection</th>
<th>Group 1</th>
<th>Group 3*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
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</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
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<td>0</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>43.2</td>
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<td>12</td>
<td>31</td>
<td>83.4</td>
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<tr>
<td>16</td>
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<td>18</td>
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<td>20</td>
<td>37</td>
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<td>22</td>
<td>37</td>
<td>100.0</td>
</tr>
<tr>
<td>24</td>
<td>35</td>
<td>94.5</td>
</tr>
</tbody>
</table>

*Discontinued after 12 weeks

Table 3: Mean trematode per gram counts by groups

<table>
<thead>
<tr>
<th>Weeks after infection</th>
<th>Mean eggs per gram counts by groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>40.5</td>
</tr>
<tr>
<td>12</td>
<td>247.3</td>
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<tr>
<td>14</td>
<td>441.7</td>
</tr>
<tr>
<td>16</td>
<td>448.7</td>
</tr>
<tr>
<td>18</td>
<td>498.7</td>
</tr>
<tr>
<td>20</td>
<td>521.6</td>
</tr>
<tr>
<td>22</td>
<td>486.5</td>
</tr>
<tr>
<td>24</td>
<td>525.7</td>
</tr>
</tbody>
</table>

*Discontinued after 12 weeks

Discussion

The mortality in the nonsupplemented groups 3 and 4 compared with the supplemented groups 1 and 2 possibly indicate that nutrition could help in the resistance to *F. hepatica* infection which agreed with the findings of Berry and Dargie(9). It was similarly observed in the infected and noninfected lambs especially in those with low initial body weight. The survivability of lambs with initial body weight ranging from 5-16.5 kg varied from 6.9-99.9% in the infected, nonsupplemented and noninfected, nonsupplemented groups.

Mean body weight, mean body condition score and mean fleece weight of noninfected and supplemented lambs were higher than their corresponding infected and supplemented lambs. Such differences were observed in late infection when chronic fascioliasis had been established in the infected group. There was a 1.9 kg body weight difference between infected and supplemented as compared with noninfected and supplemented lambs at the end of the study. In contrast to the last manifestation of productivity parameters, differences in mean PCV between infected and noninfected lambs were observed beginning at 8 weeks postinfection. Such PCV differences were observed 2-4 weeks before the prepatent period. Low PCV is an indication of anaemia in *F. hepatica* infection which occurs due to intrahepatic haemorrhage by migrating young flukes and also reduction of erythropoiesis associated with reduced dietary protein and iron intake(6).

The frequency of lambs shedding trematode eggs and their EPG counts increased after 14 weeks of infection showing that more flukes matured with age and started shedding eggs. The low number of nematode and trematode eggs passed by noninfected lambs was attributed to infection originating from improperly dried hay. *Paramphistomum* ova were from infections likely acquired from hay and/or were infections carried over from before the study started, since these endoparasite are prevalent in the region(7).

Most flukes recovered from the lambs that
died during the experimental period were young flukes associated with acute damage to liver tissues during the parenchymal migration phase. Flukes recovered from slaughtered sheep were adults found lodged in the bile ducts and were associated with some degree of hyperplasia of the wall of the ducts. The low number of flukes recovered from infected group may have been due to low infectivity of metacercaiae or possibly due to the ability of Menz sheep to resist repeated *F. hepatica* infections[15,16].

**Acknowledgements**

Acknowledgements are due to the Ethiopian Pharmaceutical Manufacturing (EPHARM) for supplying gelatin capsules and to Solomon Zewdie of the Computers and Biometric Section at the International Livestock Centre for Africa for data analysis.

**References**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean egg per gram</th>
<th>Mean egg per gram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>5</td>
<td>Group 2</td>
</tr>
<tr>
<td>Group 2</td>
<td>10</td>
<td>Group 3</td>
</tr>
<tr>
<td>Group 3</td>
<td>15</td>
<td>Group 4</td>
</tr>
<tr>
<td>Group 4</td>
<td>20</td>
<td>Group 5</td>
</tr>
<tr>
<td>Group 5</td>
<td>25</td>
<td>Group 6</td>
</tr>
</tbody>
</table>

The frequency of lambs shedding trematode eggs and their EPG counts increased after 14 weeks of infection showing that more foetal membranes entered and started shedding eggs. The low number of nematode and trematode eggs passed by noninfected lambs was attributed to infection originating from improperly drenched hay. Paramphistomum ovale from infections likely acquired from hay positive were intensities carried over from before the study started, since these endoparasites are prevalent in the region(7).
THERAPEUTIC EFFICACY OF LAMSTREPTOCIDÉ® IN THE TREATMENT OF CATTLE NATURALLY INFECTED WITH DEMATOPHILUS CONGOLENSIS

R.O.A. AROWOLO and E.O. AWE
Department of Veterinary Physiology and Pharmacology, University of Ibadan, Nigeria

EFFICACITE THERAPEUTIQUE DU LAMSTREPTOCIDÉ® POUR LE TRAITEMENT DES BOVINS INFECTES NATURELLEMENT AVEC DEMATOPHILUS CONGOLENSIS

Résumé
L’efficacité du Lamstreptocidé®, un nouveau médicament produit par l’Institut National de Recherche de Vom au Nigeria a été testée chez les bovins White Fulani infectés naturellement avec Dermatophilus congolensis à la ferme de recherche et de formation de l’Université d’Ibadan, entre mars et septembre 1993. Le médicament est appliqué deux fois par semaine pendant une période de quatre à huit semaines pour obtenir une guérison complète. Lamstreptocidé® s’est donc avéré efficace. Sur 8 bovins traités, 6 (75%) étaient complètement guéris, tandis que 2 (25%) qui étaient chroniquement infectés étaient chimiorésistants. La saison et le mode d’élevage avaient des effets sur l’efficacité du médicament. Une guérison plus rapide a été observée chez les bovins infectés mis à l’étable comparé à ceux en libre parcours. Il n’y a pas eu de cas de rechute cinq mois après l’expérience.

Summary
The efficacy of Lamstreptocidé® a new drug from National Research Institute, Vom, Nigeria, was studied in White Fulani Cattle naturally infected with Dermatophilus congolensis in the Teaching and Research Farm of the University of Ibadan between March and September, 1993. The drug was applied twice per week for a period of four to eight weeks before complete cure was noticed. Lamstreptocidé® was found to be effective. Out of eight cattle treated, six (75%) were completely cured while two (25%) which were chronically infected were resistant to chemotherapy. Season and method of management seemed to influence the efficacy of the product. A faster cure rate was observed in housed infected cattle as compared with outdoor ones. There was no evidence of relapse up to five months after the termination of the study.

Introduction
Dermatophilus infection in cattle (Bovine streptothricosis) is characterized by an acute or chronic local or progressive and sometimes fatal exudative dermatitis. It is a debilitating disease of worldwide distribution and serious economic importance in tropical and subtropical countries(4). The aetiologic bacterium, Dermatophilus congolensis(3) multiplies on the skin surface under favourable conditions to produce filaments (hyphae) which penetrate and proliferate within the living epidermis(4). The disease starts as a serious exudation which later dries to form a characteristic matting of the hair (paint brush-like lesions) and progresses to scab and crust formation. Occasionally skin scabs may have a laminated appearance(5).

A review of the major chemotherapeutic agents used in the treatment of dermatophilosis showed that numerous trials have been carried out in this respect(6). Topical application of galenical compounds such as sulphur in oil, iodine solution or arsenical proved ineffective(7). Certain parasiticides were found to inhibit the proliferation of D. congolensis on the skin as well as reducing the attacks by the vectors(8). The gamma isomer of benzene hexachloride appears to be particularly active against both the vectors and the organism but probably fails to penetrate large lesions(9). Systemic treatment using long-acting oxytetracycline, has also had limited success because it does not completely cure chronically infected cattle(10,11,12).

Lamstreptocidé® is a mixture of Lamstreptocide A(LA) and Lamstreptocide B(LB). Lamstreptocide A(LA) was prepared from oil extracted from seeds of a timber tree belonging to the family Khaya(13). LB was prepared from
a ferruginous clay\textsuperscript{(14)}. Preliminary analysis of the oil (LA) shows that it contains palmitic, stearic, oleic and linolenic acids while LB contains iron as the major component. Other trace elements present include manganese, zinc, copper, magnesium, cobalt, sodium, potassium, phosphorus and calcium.

In trials conducted in the Northern States of Nigeria, Lamstreptocide\textsuperscript{R} was reported to perform better than previous agents used in the treatment of streptothricosis\textsuperscript{(15)}. However, it had been pointed out that the response of infected cattle to therapy is dependent on the location of streptothricosis lesions\textsuperscript{(16)}. Lesions on the dorsal aspects of cattle as commonly found in the Northern Nigeria being more amenable to therapy than those in the extremities of animals which are commoner in the Southern parts of Nigeria. The objective of this study was thus to investigate the efficacy of Lamstreptocide\textsuperscript{R} against dermatophilosis in a Southern Nigeria environment. The study involved cattle in the Teaching and Research Farm of the University of Ibadan, Oyo State.

**Materials and methods**

**Experimental analysis**

Eight naturally infected cattle suffering from dermatophilosis were used for this study. The age of these animals ranged between 9 months and two years. Two of these animals were housed while others were allowed to graze freely and later gathered in the paddock.

Both groups of animals were fed mainly on grass but housed animals were also fed with concentrate supplements. Water was given \textit{ad libitum}.

**Collection and Examination of Specimens**

Skin scabs and scrappings were obtained for laboratory examinations. The skin scrappings were digested with 10% potassium hydroxide solution and examined for ectoparasites, arthrospores of dermatophytes to establish if there were mixed infections. Smears were made from the underside of fresh moist scabs and stained with Giemsa.

Materials for culture on blood agar were prepared\textsuperscript{(17)}. Smears from the culture on blood agar were made and stained with Giemsa and Gram Stains for identification of the organism.

**Treatment of the Affected Animals**

The animals were treated by applying Lamstreptocide\textsuperscript{R} preparation liberally on all affected areas of the skin with a paint-brush twice per week for a maximum period of eight weeks. The animals were kept under observation and healing was monitored.

**Results**

The lesions found on the affected animals before treatment were distributed everywhere on the skin surface including the dorsal aspect, axilla, groin and extremities (Plate 1). Scabs were evident and on being removed revealed irregular concave lesions characteristic of dermatophilosis\textsuperscript{(18)}. Direct microscopic examination of the digested scabs and skin scrappings did not reveal any ectoparasites or mycotic infection. Giemsa stained smears of materials from fresh raw surface of scabs showed branching hyphae with transverse and vertical septa forming rows of two or four coccoid cells typical of \textit{Dermatophilus congolensis}. Colonial characteristics of the organisms and the growth were either moist and smooth with grayish-white to yellow colour or were yellow to orange, rough with prominent ridges which when viewed with magnification appeared as corals. The agar was depressed at the edges of large colonies which were haemolytic on blood agar. Smears from the cultures stained with Giemsa presented a typical micromorphology of \textit{D. congolensis}.

Out of eight cattle with clinical dermatophilosis that were treated with Lamstreptocide\textsuperscript{R}, six (75%) were completely cured. At least one litre of Lamstreptocide\textsuperscript{R} was used per week per treated animal, depending on the severity and distribution of the streptothricosis lesions. Two (25%) chronically affected showed no appreciable response to chemotherapy. Table 1 shows the summary of the severity, distribution of the lesions and the outcome after treatment.
Table 1: Details of the lesions and response to therapy of cattle naturally infected with streptothricosis

<table>
<thead>
<tr>
<th>Animal number</th>
<th>Age of animal</th>
<th>Sex</th>
<th>Streptothricosis Lesions</th>
<th>Stage</th>
<th>Severity</th>
<th>Distribution</th>
<th>Treatment Duration</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>9 months</td>
<td>Female</td>
<td>Acute</td>
<td>Mild</td>
<td>Leg, back</td>
<td>Generalized</td>
<td>4*</td>
<td>Fully cured</td>
</tr>
<tr>
<td>2.</td>
<td>1½ years</td>
<td>Male</td>
<td>Chronic</td>
<td>Severe</td>
<td>Generalized</td>
<td>Haphazard</td>
<td>8+</td>
<td>Not appreciable</td>
</tr>
<tr>
<td>3.</td>
<td>1½ years</td>
<td>Male</td>
<td>Acute</td>
<td>Mild</td>
<td>Haphazard</td>
<td>8+</td>
<td>Fully cured</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>1 year</td>
<td>Female</td>
<td>Acute</td>
<td>Moderate</td>
<td>Extremities</td>
<td>8+</td>
<td>Fully cured</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>2 years</td>
<td>Male</td>
<td>Acute</td>
<td>Moderate</td>
<td>Extremities</td>
<td>8+</td>
<td>Fully cured</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>2 years</td>
<td>Female</td>
<td>Chronic</td>
<td>Severe</td>
<td>Generalized</td>
<td>8+</td>
<td>Not appreciable</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>1 year</td>
<td>Male</td>
<td>Acute</td>
<td>Mild</td>
<td>Neck, dewlap</td>
<td>4*</td>
<td>Fully cured</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>1½ years</td>
<td>Female</td>
<td>Acute</td>
<td>Moderate</td>
<td>Haphazard</td>
<td>8+</td>
<td>Fully cured</td>
<td></td>
</tr>
</tbody>
</table>

* Housed animals
+ Outdoor animals

Plate 1: A white Fulani cow showing typical lesions characteristic of dermatophilosis before treatment with Lamstreptocide®

Plate 2: Photograph of the white Fulani cattle in P1 showing complete recovery and regrowth of hairs after 8 weeks of topical treatment with Lamstreptocide®

There was a marked difference in the efficacy of Lamstreptocide® observed between the outdoor and housed animals as complete cure was observed four weeks after treatment in housed cattle compared to eight weeks in outdoor animals. The scabs began to fall off two weeks after treatment with healing of lesions being appreciably noticed four weeks after treatment with growth of new hair as well. Plates 1 and 2 show a representative animal before and after treatment.

Discussion

In this study, Lamstreptocide® produced complete healing and normal regrowth of hairs at the site of lesions in cattle naturally infected with *Dermatophilus congolensis*. This complete healing was obtained with a long period of treatment (two applications per week for eight weeks) and only noticed in animals with the acute stage of infection. Those chronically infected were resistant to chemotherapy. This may be as a result of dermal penetration of the organism in chronic condition as there is a limit to which the drug can penetrate deep into the skin. However, the lesions in the perineal and groin regions showed remarkably slow response to therapy presumably due to frequent faecal contamination and difficult accessibility to the groin region during treatment. The response of housed infected cattle during treatment was fast. After two weekly applications for 4 weeks, complete cure was observed as compared with those outdoor in which complete cure was
observed after 8 weeks of two weekly applications. This response might be due to a decrease in the number of flies and fewer bites on housed infected animals. Housing also prevented the washing away of the drug when it rained therefore having a longer period of effect on skin lesions. This also facilitated the subsequent softening of the scabs enough for them to fall off thus allowing fast healing of the skin lesions.

The main disadvantage of Lamstreptocide® appeared to be the method of application which is laborious and time consuming. From this study it can be inferred that the drug is effective against the acute stage of dermatophilosis.

Acknowledgements

The authors are grateful to the National Research Institute, Vom, Nigeria for the provision of Lamstreptocide® for this study. They also wish to thank Mr. Bello, the supervisor at the University of Ibadan Teaching and Research farm for making sure that the animals were available during the period of the study.

References


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EFFECTS OF PROTEIN-ENERGY MALNUTRITION ON SERUM IMMUNOGLOBULIN G (IgG) RESPONSES OF BROILER CHICKENS IN UGANDA

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EFFETS DE LA MALNUTRITION DUE À LA CARENCE EN PROTEINES ET EN ENERGIE SUR L’IMMUNOGLOBULINE DU SERUM (IgG) ET REACTIONS DES POULETS DE GRIL AUX VACCINS CONTRE LA MALADIE DE NEWCASTLE EN OUGANDA

Résumé
Deux cent quarante poussins de gril Ross âgés de un jour, pesant chacun environ 50 g, ont été gardés dans une poussinière en litée permanente et répartis en 4 groupes de traitement de 30 poussins chacun (chaque groupe étant représenté deux fois). Ils étaient nourris d’aliments ordinaires (Fs): EM/PB = 597 et de trois différents aliments commerciaux pour poulets de gril: F1 (EM/PB = 870); F2 (EM/PB = 823); F3 (EM/PB = 685) en Ouganda en 1993 et étaient sous surveillance. On évaluait leurs réactions à la souche La sota de vaccin contre la maladie de Newcastle par le biais de la production d’anticorps IgG à l’âge de 28 jours pendant 4 semaines avec la technique ELISA. Tous les poussins étaient sérénégatifs avant la vaccination. La séroconversion était notable au jour 7 (F3 et Fs) et persistait jusqu’au 14ème jour après la vaccination chez les groupes souffrant de carence en protéines et en énergie (F1 et F2). Le temps nécessaire pour atteindre les titres maximums IgG n’était pas affecté. Il y avait une séroconversion maximale de F1 (40%), F2 (66%), F3 (83%) et Fs (100%) et les titres maximums IgG de F1 (0,298), F2 (0,300), F3 (0,360) et Fs (0,430) étaient atteints 4 semaines après la vaccination. Les titres maximums IgG de F1, F2 et Fs étaient beaucoup plus faibles (P<0,05) que celui de Fs, à savoir :30,9%, 30,2% et 16,3% respectivement. Le groupe F1 était le plus affecté avec une séroconversion IgG de 0% (1ère semaine), 10% (2ème semaine), 35% (3ème semaine), 40% (4ème semaine) et 35% (5ème semaine). Tous les poulets de gril nourris avec le régime contenant une forte énergie métabolisable (14,4 kJ/g) et de faibles protéines (17,5%) avaient un énorme gain pondéral de 20,1%; en revanche, F2 a considérablement réduit (30,2%) les titres d’anticorps IgG chez la population (66%) ayant connu une séroconversion. Le pourcentage de perte d’IgG détectable était comme suit: F1 (12,5%) F2 (16,7%), F3 (7,2%) et Fs (4%). L’absence de séroconversion pour IgG était comme suit: F1 (60%), F2 (34%) et F3 (17%). Il y avait une séroconverstion chez tous les poulets de gril nourris d’aliments ordinaires.

Summary
Ross breed day-old broiler chicks, 240 in number, of each approximately 50g, housed in a deep litter system in 4 treatment groups of 30 birds each in duplicate, fed on a standard diet (Fs) of ME/CP = 597 and 3 different commercial broiler diets, F1 (ME/CP = 870), F2 (ME/CP = 823), F3 (ME/CP = 685) in Uganda in 1993, were monitored and evaluated for their responses to the La sota strain Newcastle disease vaccine through the production of IgG antibodies, from day 28 of age for 4 weeks using ELISA. All birds were seronegative before vaccination. Sero-conversion was detectable by day 7 (F3 and Fs) and delayed to day 14 post-vaccination in groups deficient in protein and/ or energy (F1 and F2). The time of attaining IgG peak titres was not affected; Maximum seroconversion of F1 (40%), F2 (66%), F3 (83%) and Fs (100%) and peak IgG titres of F1 (0.298), F2 (0.300), F3 (0.360) and Fs (0.430), were all at week 4 post-vaccination. Peak IgG titres of F1, F2 and F3 were significantly (p<0.05) lower than that of Fs by 30.9%, 30.2% and 16.3% respectively. Group F1 was most affected with 0% (week 1), 10% (week 2), 35% (week 3), 40% (week 4) and 35% (week 5) IgG sero-conversion. All broilers fed on ration F2 with high metabolizable energy (14.4 kJ/g) and low-moderate protein (17.5%) gained excess weight by 20.1% but had significantly reduced (30.2%) IgG antibody titres in the population (66%) that sero-converted. Percent loss of detectable IgG was F1 (12.5%), F2 (16.7%), F3 (7.2%) and Fs (4%). Non sero-conversion for IgG was, F1 (60%), F2 (34%) and F3 (17%). All the broilers fed on standard diet sero-converted.
Introduction

In Sub-Saharan Africa, malnutrition is a major problem affecting both the human and animal population\(^1\). Undernutrition, particularly that involving a lack of sufficient energy and protein, is commonly responsible for suboptimum production of livestock in tropical countries\(^2\). In Uganda, livestock feeding is inadequate due to inadequately managed feeding systems. Protein-energy malnutrition has been implicated in the fluctuating production of poultry meat and eggs, and in the failure of prophylactic vaccinations against diseases like Newcastle disease\(^3\) and Rinderpest\(^4\). Energy deficiencies occur when broilers are fed low energy diets (high levels of indigestible fibre). The corresponding increase in feed intake results in excess levels of fibre that surpass the capacity of the digestive system to hold sufficient feed to obtain an adequate daily amount of energy and other nutrients\(^5\). Below the lower critical limit of dietary energy deficiency (10.9 kJ/g – cool and moderate conditions, and 10.0 kJ/g – warm environment), growth is reduced, fat deposition is decreased and eventually losses in weight start\(^6\). On the other hand, excess dietary energy lowers feed consumption thereby reducing the amount of protein, minerals and vitamins ingested below the optimum for growth and production (if the feed is not nutritionally balanced) resulting in excessive carcass fat deposition in the broilers\(^7\). A protein deficiency as well as an oversupply can both have negative effects on the performance of the birds. Maynard et al.\(^8\) and Ensminger et al.\(^9\) reported the effects of protein deficiency in chickens as: lowering/stoppage of feed intake, poor feed conversion, poor growth, deformed primary wing feathers, tendency towards greater deposition of carcass and liver fat, poor/no egg production, loss of body weight, stasis of digestive tract, and death eventually. An oversupply of protein on the other hand is associated with increased maintenance energy requirements resulting from the specific dynamic effect of proteins\(^10\). There is an increase in energy demands necessary for the deamination and excretion of unused amino acids\(^11\). Evidence that cases of protein-energy malnutrition may be associated with lethargy, poor digestion, low blood protein, reduced antibody production and alterations in the cell-mediated immunity (CMI) mechanisms has been reported\(^12\). Nutritional deficiency alters immune responses in a varied manner at different times and rates depending on the individual and species in question\(^13\). Although, these effects have been studied extensively in man, precise investigations in species of veterinary importance especially in Africa have been rare. This is the focus of our current investigations. In this study, IgG sero-conversion to NCD vaccine virus was reduced in broilers fed on a diet deficient in both protein and energy, as did one with excess energy and low-moderate protein levels.

Materials and methods

Experimental birds

Day-old Ross breed broiler chicks, 240 in number, weighing approximately 50 g each, were purchased from a local distributor (Senda Farm Ltd, Kampala, Uganda) and randomly divided into 4 treatment groups of 30 birds per pen in duplicate lots and housed in a deep litter system for the entire experimental period of 8 weeks under standard management, fed on a standard diet (Table 1) and on 3 different commercial broiler diets (Table 2) purchased in Kampala. Group 1 (F1) was fed on a low (10 KJ/g) metabolizable energy (ME) and low (11.5%) protein (CP) commercial diet (F1). Group 2 (F2) was fed on moderate (17.5%) CP and high (14.4 KJ/g) ME commercial diet (F2). Group 3 (F3) was fed on optimum (20%) CP and optimum (13.7 KJ/g) ME commercial feed (F3). The fourth group (Fs) received a standard ideal diet (23.2% CP; 13.9 KJ/g ME) formulated at the Faculty of Veterinary Medicine, Makerere University (Table 1). All birds received vitamin/mineral supplements as prescribed by the manufacturer (Bremer Pharma, GMBH, West Germany). The quality of feed during the experiment was monitored by Weende analysis, and the absence of immunosuppressive diseases (Marek’s disease, Infectious bursitis and Infectious bronchitis) in the flocks was ascertained. Levels of Hemagglutination-Inhibition (HI) maternal Newcastle disease (NCD) antibody were titrated until all the broiler chicks tested negative by day 21 of age.
Table 1: Gross proximate composition of the standard diet used

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Kg%</th>
<th>Me(Kj/g)</th>
<th>Protein%</th>
<th>Ca%</th>
<th>P%</th>
<th>Fibre%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize meal</td>
<td>65.0</td>
<td>9.55</td>
<td>5.20</td>
<td>0.00</td>
<td>0.26</td>
<td>1.30</td>
</tr>
<tr>
<td>Soya meal</td>
<td>16.0</td>
<td>2.32</td>
<td>5.92</td>
<td>0.04</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Fish meal</td>
<td>9.0</td>
<td>1.13</td>
<td>5.85</td>
<td>0.45</td>
<td>0.24</td>
<td>0.00</td>
</tr>
<tr>
<td>Blood meal</td>
<td>7.0</td>
<td>0.82</td>
<td>5.60</td>
<td>0.02</td>
<td>0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>Salt (NaCl)</td>
<td>0.25</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin - mineral premix*</td>
<td>0.35</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Obtained from Nova Chemical co. Ltd., Kampala, Uganda

Vaccination
At 28 days of age, all chickens were subjected to a primary vaccination against NCD. Intraocular NCD vaccine virus (La sota strain) obtained from the Government Department of Veterinary Services in Kampala, Uganda, was stored at 0-6°C until used as directed by the manufacturer (intraocular drops of 0.05 ml per bird).

Blood and serum collection
Blood (0.5-1 ml per bird) was collected per bleeding from day 0 (day of vaccination) to day 35 post vaccination. The blood was aseptically collected from the wing vein by venipuncture into 1-2 ml plastic serum centrifuge cups (Eppendorf-Netheler-Hinz GMBH, Hamburg, Germany) using sterile syringes, and needles of diameter 0.5–0.9 mm (Henke Sass, Wolf GMBH, Tuttlingen, Germany). It was then transported in an icebox at 4°C to the laboratory and kept for 2 hours in an incubator at 37°C to enhance clot formation. The serum was separated from the clot by centrifugation in centrifuge micro testtubes of volume 1.5 ml (Eppendorf-Netheler-Hinz GMBH, Hamburg, Germany) at 150G, and then transferred into labelled cuvettes using Pasteur pipettes. The serum was then stored in 100 μl aliquotes at -20°C until used.

Standardization of the IgG ELISA
Miers et al.\(^{(13)}\) developed an ELISA for the detection of serum antibodies to NCD virus in chicken and found the most important factors to be: the type of antigen, the NaCl concentration in the ELISA diluent and wash solutions and, the pH of the coating (sensitizing) solution. In this study the ELISA was standardized using over 130 sera from nonexposed (negative) chickens obtained from chickens hatched from NCD free embryonated eggs. European NCD negative and positive sera (Central Veterinary Laboratory, Weybridge, UK) were also used as well as sera from Uganda chickens known to have been successfully vaccinated against NCD virus. The NCD virus ELISA antigen (purified B1 NCD virus strain) was obtained from Vemie Veterinari Chemie GMBH, Kempen, Germany.

The IgG ELISA
IgG antibody titres (absorbance) were measured by Indirect ELISA at a serum dilution of 1:10, NCD virus antigen dilution 1:100 and rabbit anti-chicken IgG conjugate dilution of 1:3000 obtained following standardization of the test in our laboratory. Antigen was diluted in 0.1 M NaOH sensitizing solution, adjusted to pH 13, and 50 μl was added to each plate well. After overnight incubation at 4°C, the excess antigen was removed by washing each plate three times using ELISA wash solution prepared as 0.5 M NaCl in distilled water with 0.5 ml Tween 20 per litre. The sensitized plates were sealed off, and kept at 4°C until used. Sera diluted 1:10 in ELISA diluent (5% skimmed milk in physiological saline + 100 μl Tween 20) were added to the wells in 50 μl volumes and the plate was incubated for 60 minutes at 37°C on an orbital shaker (IKA, Germany) set at 100 revolutions per minute (rpm). The plates were washed three times with ELISA wash solution to remove excess serum, flicked off and dried. A volume of 50 μl of conjugate (rabbit anti-chicken IgG conjugate, Sigma, St. Louis, U.S.A) was added to each well and the plate was incubated for 60 minutes at 37°C on the orbital shaker at 100 rpm. Excess conjugate was removed by wash-
ing the wells three times with ELISA wash solution followed by drying. A volume of 50 μl of substrate solution (prepared as 100 ml of 40 mg Ophenylene diamine dihydro chloride + 100 ml phosphate citrate buffer pH 5.0 + 40 μl of 30% hydrogen peroxide) was added and plates incubated at 37°C for 15 minutes on an orbital shaker at 100 rpm. Immediately 50 μl of stop solution (3 M sulphuric acid) was added to each well to stop over development of the yellow colour. Optical density (O.D) values were recorded using a Multiskan Plus MicroElisa reader [Flow Laboratories, UK] set at 492 nm wave length. The reader was previously blanked to single well blank. Each serum was tested in duplicate and the test done three separate times, and their mean O.D±S.E used. Each plate also contained positive and negative control sera. The O.D readings were recorded and used to determine seronegativity-seropositivity.

Results

Feed values

Table 2 illustrates the various performance characteristics of the experimental broilers and their respective diets. The mean CP and ME was lowest in commercial feed F1 (11.5%, 10 KJ/g respectively). ME in F1 was just at the minimum (10 KJ/g) critical ME requirement of broilers. ME (14.4 KJ/g) in F2 was high and above the maximum (14.2 KJ/g) critical level. ME/CP ratios of F1(870) and F2 (823) were 35.9% and 28.6% respectively, outside the optimal range (590-640). ME/CP ratio (597) of the standard diet was optimum. Mean broiler final body weight of F1 (727.2g) was significantly (p<0.05) lower than for the standard ration (2423.04g) by 70%. However, in F2 (mean broiler final body weight = 2909.6g), it was significantly (p<0.05) higher by 20.1%.

Standardization of the IgG ELISA

When titrated using IgG ELISA, the O.Ds of sera from the chicken population considered free of NCD, ranged from 0.01 to 0.400 (Figure 1). The mean O.D value (x) for the population was found to be 0.125. The positive/negative cut-off point was taken as twice (2x) the mean (0.250).

Table 2: Performance characteristics of the broiler groups during the experiment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>Fs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean broiler final body weight</td>
<td>72.7a</td>
<td>2909.6c</td>
<td>2398.0b</td>
<td>2423.04b</td>
</tr>
<tr>
<td>Peak IgG titre (Absorbance)</td>
<td>0.298a</td>
<td>0.300a</td>
<td>0.360a</td>
<td>0.430b</td>
</tr>
<tr>
<td>Mean ME/CP ratio (KJ/Kg:%CP)</td>
<td>8701</td>
<td>8231</td>
<td>6851</td>
<td>5971</td>
</tr>
<tr>
<td>Mean % crude protein (CP)</td>
<td>11.5</td>
<td>17.5</td>
<td>20.0</td>
<td>23.2</td>
</tr>
<tr>
<td>Mean ME/KJ/g</td>
<td>10</td>
<td>14.4</td>
<td>13.7</td>
<td>12.85</td>
</tr>
</tbody>
</table>

a, c = Significantly different (p<0.05) when compared with values of Fs using the standard t test for paired difference

Fs = Group fed standard feed, prepared at the Faculty of Veterinary Medicine, Makerere University
F1, F2, F3 = Groups fed commercial diets F1, F2 and F3 respectively
a = Significantly lower values from (Fsb)
b = Not significantly different values from (Fsb)
c = Significantly higher values from (Fsb)
de = Optimum range of ME/CP (KJ/Kg:%CP) is 590-640
Figure 1: Frequency distribution of titre (O.D.s) for determination of IgG ELISA negative and positive cut-off point value

Frequency of Titre

Range of Titre (Absorbance)

\[ X = 0.125 \]

\[ 2X = 0.250 = +ve/-ve \text{ cut-off point} \]
Trend and Magnitude of IgG development

IgG sero-conversion following primary vaccination was observable between day 7 and 14 in all groups (Figure 2), being detectable by day 7 in broilers fed on the standard diet F₃, and delayed until day 14 in broilers fed on commercial diets F₁ and F₂. Broilers fed on the standard feed F₃, had marked increases in the quantity of IgG beginning in the second week. Broilers fed on commercial diets F₁ and F₂ had IgG increases delayed until the third week. IgG titres were highest in birds fed on the standard diet F₃. IgG titres (Figure 2 and Table 2) of F₁ (peak titre-0.298), F₂ (peak titre-0.300) and F₃ (peak titre-0.360), when tested with the Standard T-

Test for paired difference, were significantly (p<0.05) lower than that (0.430) of the ideal diet by 30.9%, 30.2% and 16.3% respectively. All broilers fed on ration F₂ with high metabolizable energy (14.4 kJ/g) and low-moderate protein (17.5%) gained excess weight by 20.1% but had significantly reduced (30.2%) IgG antibody titres in the population (66%) that sero-converted (Figure 3). Relative to the standard feed, F₃, the loss in detectable IgG titres was 30.9% (F₁), 30.2% (F₂) and 16.3% (F₃). All groups had IgG peak titres between day 21 and 28. The peak titres remained relatively constant until day 35 (Figure 2).

Figure 2: Development of IgG antibody to NCD vaccine Antigen in broilers fed on 4 different diets under standard management

![Graph showing development of IgG antibody titres over days post vaccination for different diets](attachment:image.png)
**Time and Relative Percentages of IgG sero-conversion**

Figure 3 illustrates the levels of IgG percent sero-conversion in all groups. The degree of sero-conversion varied markedly in terms of time and number of birds sero-converting. IgG seroconversion was detectable within the first week only in groups F3 and Fs. Sero-conversion in other groups (F1 and F2) began in week 2 of the experiment. Broilers in group F1 were most affected with 0% (week 1), 10% (week 2), 35% (week 3), 40% (week 4) and 35% (week 5) sero-conversion. Maximum sero-conversion in all groups was in week 4, with standard feed Fs (100%), commercial feed F3 (83%), commercial feed F2 (66%) and commercial feed F1 (40%) of the broilers sero-converting. In the fifth week, some of the broilers that had seroconverted, lost detectable IgG (Fig. 3). The decline in IgG titres was much higher in broilers fed the poorest commercial feed F1 and which group had the lowest sero-conversion (Figure 3). Sixty percent of the broilers in group F1 completely failed to sero-convert for IgG. Non seroconversion for IgG was 34% and 17% in groups F2 and F3, respectively. All the broilers fed on the standard diet sero-converted.

**Figure 3:** Percent sero-conversion and waning of IgG antibodies in broilers fed 4 different diets and vaccinated against Newcastle disease
Discussion

The commercial poultry feeds F1 (ME/CP = 870) and F2 (ME/CP = 823) have demonstrated a very high level of protein-energy mismatch that may result in inadequate intake of nutrients (deficiencies) or excess intake of nutrients both of which lower broiler performance\(^7\). Proteins are required in the broiler diet not only as building materials for meat and other body tissues such as feathers, but also for enzymes, hormones, vitamins and immunoglobulins. Amino acids are the building units of immunoglobulins and are important for cellular responses in cell mediated immunity\(^12\). Tsiagbe et al\(^15,16\) reported that low level methionine and cysteine supplements to broiler diets enhanced the cell mediated immunity (CMI) and IgG responses. Similarly supplements of valine were observed to result in increased HI-titres to Newcastle disease virus in chicks\(^16,17\). Unlike ruminants, poultry cannot synthesize 13 essential amino acids\(^8\). Therefore, the diet should furnish the broilers with protein which upon digestion will yield sufficient quantities of these 13 essential amino acids as well as nitrogen precursors for synthesis of non-essential amino acids. The low protein supplies in feeds as may occur in feeding commercial diets F1 and F2, limit the supply of amino acids resulting in reduced synthesis and production of antibodies\(^8,10\).

Energy in the form of metabolizable energy (ME) must be available to the broilers for production of meat and for maintenance of vital functions such as respiration, transport and communication, and homeostasis including temperature regulation and antibody production\(^18\). A high concentration of energy in the feed decreases feed intake and vice versa\(^6\). Therefore the specific proportions of other nutrients in relation to energy of the diet must be maintained as they influence the amount of nutrients consumed by the bird and its maintenance requirements\(^7,14\). In view of the protein-energy mismatch exhibited, feeds F1 and F2 were considered grossly unbalanced and our findings were similar to that of Scott et al\(^7\). Unbalanced feeds particularly those associated with intake of large excesses of protein, have a high specific dynamic effect and are therefore associated with increased maintenance requirements of the birds\(^7\). This factor together with protein deficiencies may have contributed to a reduction in the utilization of nutrients for antibody synthesis in favour of the day to day maintenance of the birds particularly in broilers fed on commercial diet F1. Our results on broilers fed on diet F2, with a final mean body weight (2909.6 g) which was 20.1% higher than that observed in those fed on the standard diet (Fs), have shown a significantly (p<0.05) lower level of IgG antibody production. This observation is important in that the feed that is most attractive to the farmers (because of the high weight gains of the broilers) is associated with reduced humoral IgG antibody, both in terms of quantity and duration. Many farmers would tend to use this feed resulting in many birds on farms being IgG immunodeficient. The IgG deficiency is masked by the high performance in weight gain. This observation may explain the persistent resurgence of NCD in previously vaccinated broilers that has been reported elsewhere on farms\(^19\) and may explain apparent vaccine failures observed in Uganda. The reduced immune responses in such heavy broilers may be associated with excessive deposition of carcass fat in the tissues\(^12\). Excessive calorie intake and weight gain is said to reduce T-helper cell function affecting IgG formation\(^12\). Furthermore, the finding in this study of reduced IgG values in such heavy and good looking broilers may explain in part why such birds have been observed to be more susceptible to infection and to register higher mortality when attacked by virulent NCD field virus (Kabasa and Opuda-Asibo, unpublished observations). On the other hand, the poor broiler performance (weight gain) resulting from feeding on commercial diet F1 (Figures 2 and 3 and Table 2), may lead to many farmers opting for better quality feeds, which action has tended to downplay the effect of such poor quality feed on broiler performance. However, the effect of poor feeds such as F1 may have been permanent, resulting into immunological deficiencies and economic losses. This is because it has been established that, in the
chicken, the extent of reduction in antibody responses is influenced by the time of its encounter with the stressor\(^{20}\). These authors reported that stressors that are encountered by chicks during the first week of life (as was the case with broilers fed poor commercial diet F1) have their adverse effects persisting for at least 18 weeks.

The observation that IgG titres declined much faster in birds fed on the poorest feed (F1) and that sero-conversion was observed less in birds on the same diet (Figure 3) may be explained by the fact that in protein-energy malnourished individuals, the quantity and quality of antibody is reduced, macrophage function is impaired and antibody response to antigens that require active help of T-cells for optimum response (IgG production) is particularly affected\(^{12}\). Similar studies with BCG antigen showed tuberculin sero-conversion following BCG vaccination to be less developed in malnourished individuals\(^{12}\).

As high as 60% of birds on commercial diet F1 did not at all sero-convert for IgG. This observation is important when one considers the morbidity of NCD in a flock following introduction of the disease. A 70% sero-conversion or more is necessary if spread of the disease in a flock is to be controlled\(^{21}\). Therefore broilers fed on this commercial diet (F1) would be at risk of high NCD morbidities.

In conclusion the effectiveness of prophylactic vaccination in chickens is influenced by the quality of nutrition. IgG, the immunoglobulin of a longer protection is reduced in quality and quantity depending on the degree of malnutrition encountered by the birds.

References

**EFFECTS OF DFMO ALONE AND IN COMBINATION WITH LEVAMISOLE IN THE TREATMENT OF EXPERIMENTAL TRYPANOSOMA CONGOLENSIS INFECTION OF RATS**

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**Introduction**

A new anti-trypanosomal compound DL- & -difluoromethylornithine (eflornithine, DFMO) which is an irreversible inhibitor of polyamine biosynthesis extensive clinical trials\(^1\) offers hope as a safe and effective drug.

Its serious drawback is the protracted treatment protocols (400 mg/kg/day for 6 weeks). Efforts are now geared towards reduction of the treatment periods through attempts at enhancing the potency of the drug by combination with other agents which act synergistically, including standard trypanocides\(^{1,2}\).

Levamisole is an anthelmintic effective against many species of nematodes of domestic animals and man\(^3\). The drug is reported to enhance immune responsiveness\(^4\) and has been tested immunotherapeutically in many immunopathological conditions\(^5,6\). The drug modulates immune function at 2 to 3 mg/kg in contrast to the greater anthelmintic dosage\(^7\). The best results are obtained in immuno-deficient hosts\(^8\).

Since trypanosomiasis causes immunosuppression\(^9\) and immune response to trypanosomiasis is a necessary component of DFMO-induced cure\(^1\) as the drug is trypanostatic rather than trypanocidal, we have studied the combination of levamisole and DFMO to determine whether they can act synergistically.

Twelve adult wistar rats and a Jema's II strain of *Trypanosoma congoense*, obtained from Nigeria Institute for Trypanosomiasis Research (NITR), Vom, were used in the study. Each rat was inoculated intraperitoneally (ip) with 10\(^5\) live trypanosomes in 1 ml of diluted infected rat blood in saline. Quantification of parasitaemia was done by the rapid matching method\(^10\). The rats were equally allocated to three groups (A, B and C) with four rats per group. Each group was housed in a separate cage and given food and water *ad libitum*. On day 8 post-infection (P.I.), when parasitaemia was well established, treatment was initiated. Group A rats were treated with 2% DFMO (Merrell Dow Research Centre, U.S.A.) in drinking water for 7 days concurrently with levamisole (Ascaraject, Univet Ltd, Tullyvin Cavan) at a dosage of 2 mg/kg subcutaneously for 3 days, Group B received only 2% DFMO in drinking water for 7 days while group C served as control. Parameters for assessing therapeutic efficacy which included packed cell volume (PCV), parasitaemia and rectal temperature were determined every four days. Survival was also noted. The parasitaemia was monitored by wet smear and buffy-coat examination of tail blood.

The results of the study were statistically analysed using Minitab Statistical Software, Release 7 (1989).

The rats were parasitaemic on day 4 post-infection. The course of the infection was acute. One rat died each from group A (treated with DFMO and levamisole) and group B (treated with DFMO alone), and 2 rats died from the untreated control group (group C) by day 9 post infection (i.e. day one of treatment). The remaining 2 rats in group C died on days 11 and 12 respectively. By the 4th day of treatment (day 12 post-infection) only one rat was aparasitaemic in group A compared to 2 rats in group B, but ultimately parasite clearance in all the rats in both groups was achieved at the same time (day 16 post-infection). However, infection relapsed in all the rats 9 days after completion of treatment (day 24 post-infection). The parasitaemia was progressive till death. The terminal stage of the infection was marked by dullness, apathy, and recumbency, with a

Key Words: Chemotherapy, Trypanosoma congolense, RATS, DFMO LEVAMISOLE
Mean survival time of 9.8 ± 0.5 days post-infection for the control (group C), 25 ± 3.4 days for group B and 28 ± 6.5 days for group A.

Mean PCV for groups A, B and C before infection were 47.5 ± 2.6%, 43.5 ± 0.9% and 42.5 ± 4.3% and fell sharply to 34.5 ± 2.5%, 35.5 ± 2.9% and 29.3 ± 1.8%, respectively, by day 8 P.I. Following commencement of treatment in groups A and B, the PCV increased steadily to 47 ± 2.5% and 42 ± 1.2% respectively by the time the infection relapsed. The relapse depressed the PCV to 37.7 ± 1.2% and 31.7 ± 0.9% in groups A and B, respectively, by day 28 P.I differing highly significantly (P<0.01).

The mean temperature for the three experimental groups did not show any significant differences (P<0.05).

The present study shows that T. congolense Jema‘a II strain can produce within nine days of infection an acutely fatal disease in rats characterised by gradual loss of condition, anaemia, apathy and recumbency.

The results show that there was no synergism between DFMO and Levamisole. Administration of DFMO alone or in combination with levamisole at the dosage levels employed, resulted in initial remission of parasitaemia but the infection relapsed. The parasite clearance which was manifest from 4th day of treatment is somewhat similar to the report of other investigators. This apparently slow induction of the anti-trypanocidal action of DFMO is due to the fact that the overall effect of DFMO is trypanostatic rather than trypanocidal, requiring a competent immune system to rid the host of the parasite. In the present study, infections relapsed 9 days after treatment. This differs from the results of Karbe et al (1982) and Schillinger and Gorton (1984) in which DFMO (2%) administered for 5 days was curative for T. congolense infections in the mouse model (treatment commenced 24 hrs. post-infection). Previous reports showed that while DFMO alone could cure acute T. brucei infections, it merely could suppress but not eliminate chronic infections except in protracted treatment regimen. This suggests that the 8 days that elapsed after infections prior to the commencement of treatment in this study was sufficient for the parasites to reach the cryptic sites from where they relapsed.

Acknowledgement

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References

CATTLE, GOATS, SHEEP AND CAMEL PRODUCTION ON RANGE:
THE KENYA EXPERIENCE

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PRODUCTION BOVINE, CAPRINE, OVINE ET CAMELINE SUR LES PARCOURS:
EXPERIENCE CONDUITE AU KENYA

Résumé

Les parcours du Kenya abritant environ 76% de la population totale de bovins, de caprins, d'ovins et de camélins, qui appartiennent souvent aux nomades. En tant que principale activité dans la région, le pastoralisme subsiste grâce au troupeau local, il permet de se procurer des aliments, il permet aussi à la communauté d'honorer ses obligations sociales, en plus de l'excédent de production destiné à la vente. Les différences relatives aux caractères de productivité ont été identifiées et à cet effet, il a été proposé de caractériser les animaux des parcours selon les races ci-après: Somali, Rendille et Turkana pour les camélins; Maasai et Boran pour les bovins; Gala, Maasai et Turkana pour les caprins; Maasai, Somali et Turkana pour les ovins. Il est possible d'obtenir des coefficients de productivité et des indices de reproduction comparables à ceux des ranches commerciaux et à ceux d'autres systèmes d'élevage sous les tropiques. La faible productivité animale sur les parcours est surtout due aux conditions difficiles du milieu, à la mauvaise gestion des maigres ressources et aux facteurs socio-économiques et techniques associés au mode d'élevage. Le reboisement stratégique qui doit bénéficier du soutien et de la participation active de la population locale ainsi que le forage de puits et la complémentation en minéraux pour le bétail là où les nomades le font pâturer, sont recommandés en vue d'améliorer la productivité du bétail et des parcours. Il faudrait ajouter à cela un programme de santé rentable qui comprend les vaccinations appropriées contre les maladies courantes pour améliorer les taux de remplacement du troupeau. On a souligné la bonne gestion des jeunes troupeaux et les avantages tirés de l'élevage continu de multiples espèces animales. La vente de bétail dans les marchés des zones à forte population a été proposée afin de veiller à ce que le nombre d'animaux soit proportionnel aux ressources disponibles sur les parcours et ce, de façon permanente.

Summary

The rangelands of Kenya is home to about 76% of the total population of cattle, goats, sheep and camels owned mostly by nomads. As the main activity in the region, pastoralism, is sustainable through the indigenous stock and is capable of meeting the food and social obligations of the community besides providing surplus for sale. Differences in productivity traits were identified and it was suggested that animals of the range may be characterized into the following breeds: Somali, Rendille and Turkana for camels; Maasai and Boran for cattle; Gala, Maasai and Turkana for goats and Maasai, Somali and Turkana for sheep. Productivity coefficients and breeding indices comparable to commercial ranching and other livestock systems in the tropics are achievable in the Kenyan range. Low animal productivity from the range is mainly a result of the harsh environment, poor management of scarce resources and system-inherent socio-economic and technical factors. Strategic afforestation involving the support and active participation of local people and location of boreholes and mineral supplements along nomadic routes of grazing are recommended for improving livestock and range productivity. This should be coupled with a cost effective herd health programme that includes timely vaccinations against common diseases to improve herd replacement rates. Proper management of young stock as well as the benefits from continued keeping of multiple animal species were emphasized. Regular disposal of animals to markets in high population areas was suggested to ensure that livestock numbers matched the resources of the range in a sustainable manner.
Introduction

The rangelands of Kenya (Figure 1) are areas of marginal agricultural potential which comprise about 80% of the country's land surface\(^1,2\). Using the percentage distribution of Too et al.\(^3\) the range population of cattle, sheep, goats and camels is about 76% of the total in the country. The Maasai, Rendille, Samburu and Turkana who are the principal inhabitants of this zone, practise pastoralism as their main activity. The pastoral sector plays an important role in the national economy through provision of livestock and products to the heavily populated crop/livestock farming systems of the high potential areas. Mboyo\(^4\), LCA\(^5\) and Kerver\(^6\) have analysed and discussed meat and milk production from the Kenyan rangelands including economic indices of productivity and experiences with group ranches. Despite suggestions for improvements, productivity has remained low in the range/livestock ecosystem. In 1983 the offtake rate from pastoral lands was estimated at 12% from about 3.8 million zebu cattle\(^7\). Reasons for this include a harsh environment that is as yet little understood\(^8\) and a complicated social and cultural organization that is often sceptical of the advantages of new innovations\(^9\).

The objective of this paper is to present data which support the view that animal production in the Kenyan range is sustainable and amenable to improvements.

The range environment

The major natural vegetal cover of the area often describes the habitat of the pastoralist. Thus, northern Kenya is characterised by dwarf shrubland and *Acacia* woodland\(^2\), dwarf shrubland with annual grassland or bushland\(^8\) or semi-arid thombush savannah\(^10\). Bush and tree layers also contribute to browse and litter of leaves, flowers and fruits\(^10\). The vegetation in the Salabani area of Baringo district is an *Acacia* woodland\(^11\) while in Kajiado, the natural vegetation is a form of treeless grassland of *Acacia* and *Themeda* associations\(^12\).

The basis of both seasonal and permanent water supplies in the rangelands is precipitation which rarely exceeds 800 mm in total per annum\(^13\). Isiolo district in northern Kenya receives 510 mm; about 650–700 mm falls in Laikipia and Baringo districts and it may be as low as 100–300 mm around Marsabit\(^11,10,14,15\). Variability in the rainfall affects pasture availability between seasons and years. Estimates have ranged from as low as 500 kg forage per ha during periods of below average rainfall\(^16\) to more than 2 tonnes DM per ha per month in years with high rainfall\(^9\). Increases in animal and human populations have made the herb layer and woodlands to deteriorate due to overgrazing and wood cutting for homestead construction\(^17\).

Species of the genera *Aristida Chloris*, *Chrysopocon*, *Eragrostis*, *Sporobolus* and *Tetrapogon* are the common plant communities preferentially grazed by cattle in the rangelands around Kiboko, Isiolo and Marsabit\(^18,19\). *Chloris roxburghiana*, *Pennisetum Mezianum* and *Digitaria macroblephara* are the most grazed
grass species by cattle in Kajiado District. For camels preference was highest for *Euphorbia spp.*, *Salvadora persica*, *Maerua angolensis* and *Balanites aegyptiaca*\(^{(11)}\). In terms of nutrient content the grasses have lower levels of CP and minerals\(^{(10,16)}\) than the herbs, shrubs and tree litter. They mature and lose quality rapidly\(^{(16,20)}\) so that for most of the year, the vegetation is essentially standing hay with CP levels of about 4%\(^{(21)}\). Nutritive value data of some Kenyan range grasses and browse are represented in Table 1.

**Pastoralism as a way of life**

In pastoralism, people live on and from the products of their herds. The major livestock species include cattle, sheep, goats, camels and donkeys. Milk, blood and meat constitute between 70 and 90% of the diet\(^{(22)}\) with milk always making the greatest proportion\(^{(23)}\). Kerven\(^{(6)}\) has given the important subsistence value of milk in terms of the energy intake from pastoral diets (Table 2). Most of the milk is derived from an estimated 4.2 million head of cattle found in the range areas of Kenya\(^{(24)}\) and owned mostly by nomads. Cattle pastoralists will, however, compliment their supply by keeping small stock and camels. The Turkana milk both sheep and goats for their subsistence while the Maasai, Samburu and Boran use only goat milk\(^{(25)}\). Goats and camels can thus form an

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**Table 2: Percent intake of energy (kcal/yr) from components of a Maasai pastoral diet\(^{1}\)**

<table>
<thead>
<tr>
<th>Values as % of total (kcal/yr)</th>
<th>Milk</th>
<th>Cereals</th>
<th>Meat</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual ranchers</td>
<td>51</td>
<td>22</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Group ranchers</td>
<td>63</td>
<td>11</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>Average</td>
<td>57</td>
<td>15.5</td>
<td>9</td>
<td>17.5</td>
</tr>
</tbody>
</table>

\(^{1}\) Modified after Kerven\(^{(6)}\)

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**Production coefficients of range livestock**

The objective of a pastoral ecosystem is to support more people per unit area of land and to maximise food production per ha\(^{(14)}\). Growth aspects of Kenyan range ruminants compiled from\(^{(8,27-38)}\) are shown in Table 3.

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**Table 1: Nutritive value of Kenya range grasses and browses\(^{1}\)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Ash (%)</th>
<th>CP % DM</th>
<th>NDF (%)</th>
<th>IVDMD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cenchrus ciliaris</em></td>
<td>9.86</td>
<td>10.40</td>
<td>67.28</td>
<td>59.71</td>
</tr>
<tr>
<td><em>Digitaria milanjina</em></td>
<td>8.45</td>
<td>8.48</td>
<td>69.81</td>
<td>41.77</td>
</tr>
<tr>
<td><em>Sporobolus fimbratus</em></td>
<td>6.02</td>
<td>6.59</td>
<td>74.56</td>
<td>44.69</td>
</tr>
<tr>
<td><em>Heteropogon contortus</em></td>
<td>6.22</td>
<td>9.75</td>
<td>79.16</td>
<td>38.18</td>
</tr>
<tr>
<td><em>Cynodon spp</em></td>
<td>12.35</td>
<td>7.50</td>
<td>65.53</td>
<td>49.53</td>
</tr>
<tr>
<td><em>Aristida kenyensis</em></td>
<td>8.90</td>
<td>6.31</td>
<td>78.68</td>
<td>35.66</td>
</tr>
<tr>
<td><em>Eragrostis superba</em></td>
<td>7.50</td>
<td>7.38</td>
<td>75.65</td>
<td>44.75</td>
</tr>
<tr>
<td><em>Themeda triandra</em></td>
<td>8.98</td>
<td>8.90</td>
<td>67.10</td>
<td>56.08</td>
</tr>
<tr>
<td><em>Salvadora persica</em></td>
<td>26.39</td>
<td>17.58</td>
<td>34.56</td>
<td>67.81</td>
</tr>
<tr>
<td><em>Maerua angolensis</em></td>
<td>17.52</td>
<td>17.00</td>
<td>39.77</td>
<td>62.25</td>
</tr>
<tr>
<td><em>Balanites aegyptiaca</em></td>
<td>7.92</td>
<td>14.50</td>
<td>40.51</td>
<td>61.86</td>
</tr>
<tr>
<td><em>Euphorbia spp.</em></td>
<td>12.66</td>
<td>8.54</td>
<td>40.14</td>
<td>66.13</td>
</tr>
</tbody>
</table>

\(^{1}(21,53)\)
Table 3: Growth parameters of range livestock in Kenya

<table>
<thead>
<tr>
<th>Species/ Breed</th>
<th>System</th>
<th>Birth Wt. (kg)</th>
<th>Preweaning ADG (kg)</th>
<th>Mature Wt. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camels</td>
<td>Rendille</td>
<td>35-47</td>
<td>0.27-0.41</td>
<td>350-500</td>
</tr>
<tr>
<td></td>
<td>Turkana</td>
<td>23-32</td>
<td>0.31-0.39</td>
<td>294-400</td>
</tr>
<tr>
<td></td>
<td>Somali</td>
<td>36-41</td>
<td>0.38-0.60</td>
<td>500-700</td>
</tr>
<tr>
<td>Cattle</td>
<td>Boran</td>
<td>11-27</td>
<td>0.54-0.61</td>
<td>380-750</td>
</tr>
<tr>
<td></td>
<td>Maasai</td>
<td>11-18</td>
<td>0.12-0.19</td>
<td>195-480</td>
</tr>
<tr>
<td></td>
<td>Maasai</td>
<td>11-20</td>
<td>0.33-0.46</td>
<td>-</td>
</tr>
<tr>
<td>Goats</td>
<td>Galla</td>
<td>1.8-2.3</td>
<td>0.10-0.15</td>
<td>25-70</td>
</tr>
<tr>
<td></td>
<td>Turkana</td>
<td>1.6-2.0</td>
<td>0.03-0.06</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Maasai</td>
<td>2.0-2.5</td>
<td>0.03-0.05</td>
<td>21-47</td>
</tr>
<tr>
<td>Sheep</td>
<td>Maasai</td>
<td>2.5-3.0</td>
<td>0.05-0.06</td>
<td>25-37</td>
</tr>
<tr>
<td></td>
<td>Turkana</td>
<td>1.5-2.1</td>
<td>0.04-0.10</td>
<td>19-34</td>
</tr>
<tr>
<td></td>
<td>Somali</td>
<td>2.0-2.4</td>
<td>0.04-0.10</td>
<td>29-41</td>
</tr>
</tbody>
</table>

1(8,27,28,29,30,31,32,33,34,35,36,37,38) (-) Data not available

The table depicts the existence of high performance genes within the populations. The attainment of the upper range in output is often made difficult by the fluctuations in pasture productivity, which is the major feed source, with time. Feed shortages are, thus, periodic with drought occurring at least once every 8 to 12 years. Work by ILCA has shown a mismatch between the permissible stocking rate of the range and the size of the herd on it. There is usually overstocking until a natural calamity such as drought forces animal numbers to drop in order to allow for range recovery. In cattle, gains of 33 kg in years of favourable rainfall and net losses of 15 kg per ha in times of nutritional stress have been recorded. Therefore, herd accumulation as a survival strategy unfortunately increases the risk of stock loss. In the 1984 drought, Kajiado district lost 76% of its cattle population. The overall productivity of sheep and goats under range is equally low; in goat and sheep flocks weights of 29 and 107 g respectively are weaned per kg of flock biomass.

Unlike gains in weight, annual milk offtakes fluctuate less in the Kenyan range. Values vary from 17 kg in normal years to 10 kg per ha in drought years respectively. Semenye and de Leeuw have reported an offtake of 20-25% of total production of about 800 kg per year from Maasai pastoral systems. When the additional product of milk is also assessed, pastoral productivity has been shown to support more people from a given area than commercial ranching. The Boran pastoral system of Ethiopia produces as much animal protein as (and 56% more energy per unit area of land than) commercial ranching in Laikipia District where Boran animals are also raised (Table 4). Yields from camels are higher than those from cows and milk offtakes vary from 1000 kg to 2500 kg over a lactation period of 12 to 18 months. Wahome et al. have reported a mean lactation yield of 55.4 litres for the Small East African (Somali) goat of the semi-arid thorn-bush savana. In western Marsabit, Rendille sheep and goats produce 17.5 and 35.1 ml of milk per day respectively. Daily wet season milk yields from livestock in central Turkana are as follows: sheep, 188 ml; goats, 548 ml, and camels, 2.69 liters. Other details relating to lactating animals under range conditions were derived from and represented in Table 5. While production of animal protein and energy in pastoral systems may be high, calf growth is often slow because man and calf compete for the same milk. Average weaning weights are 65 kg for Maasai cattle.

Table 4: Some indices of productivity between pastoral and commercial ranching in comparable areas

<table>
<thead>
<tr>
<th>Ranching system</th>
<th>Offtake per year (kgAP/ha)</th>
<th>Annual rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastoral, Ethiopia</td>
<td>10.0</td>
<td>450-600</td>
</tr>
<tr>
<td>Commercial, Kenya best</td>
<td>31.9</td>
<td>690</td>
</tr>
<tr>
<td>Average</td>
<td>18.6</td>
<td>650</td>
</tr>
</tbody>
</table>

LW = Liveweight, AP = Animal Protein, 'Modified after Cossins

Table 6 with data from 6,28,29,31,32,33,34,35,36,37,38,44,45 shows that Kenyan range animals compare in
### Table 5: Lactation related parameters of range livestock in Kenya

<table>
<thead>
<tr>
<th>Species/Breed</th>
<th>System</th>
<th>Milk yield (kg/d)</th>
<th>Days in milk (d)</th>
<th>Yield/lactation (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rendille</td>
<td>Ranch</td>
<td>2.3-5.0</td>
<td>290-460</td>
<td>2961-4220</td>
</tr>
<tr>
<td>Turkana</td>
<td>Pastoral</td>
<td>1.6-3.0</td>
<td>285-500</td>
<td>627-1592</td>
</tr>
<tr>
<td>Somali</td>
<td>Ranch</td>
<td>2.4-5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boran</td>
<td>Ranch</td>
<td>-</td>
<td>274-300</td>
<td>850-890</td>
</tr>
<tr>
<td>Maasai</td>
<td>Pastoral</td>
<td>-</td>
<td>180-210</td>
<td>518-823</td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gallra</td>
<td>Pastoral</td>
<td>0.30-0.65</td>
<td>90-180</td>
<td>25-110</td>
</tr>
<tr>
<td>Turkana</td>
<td>Pastoral</td>
<td>0.05-0.45</td>
<td>60-158</td>
<td>9-80</td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maasai</td>
<td>Pastoral</td>
<td>-</td>
<td></td>
<td>20-28</td>
</tr>
<tr>
<td>Turkana</td>
<td>Pastoral</td>
<td>0.05-0.27</td>
<td>90-181</td>
<td>10-29</td>
</tr>
</tbody>
</table>

1 (8,28,29,31,32,33,34,35,38,43)  
(\(-\)) Data not available.

### Table 6: Reproductive and survival parameters of range livestock in Kenya

<table>
<thead>
<tr>
<th>Species/Breed</th>
<th>System</th>
<th>Age at 1st parturition (mo)</th>
<th>Parturition interval (d)</th>
<th>Survival rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rendille</td>
<td>Pastoral</td>
<td>54-72</td>
<td>666-852</td>
<td>73-87</td>
</tr>
<tr>
<td>Turkana</td>
<td>Pastoral</td>
<td>60-74</td>
<td>804-898</td>
<td>76-82</td>
</tr>
<tr>
<td>Somali</td>
<td>Ranch</td>
<td>-</td>
<td>418-627</td>
<td>74-93</td>
</tr>
<tr>
<td>Cattle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boran</td>
<td>Ranch</td>
<td>-</td>
<td>-</td>
<td>92-95</td>
</tr>
<tr>
<td>Maasai</td>
<td>Pastoral</td>
<td>4-5</td>
<td>489-569</td>
<td>84-99</td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gallra</td>
<td>Pastoral</td>
<td>19-25</td>
<td>350-442</td>
<td>75-94</td>
</tr>
<tr>
<td>Turkana</td>
<td>Pastoral</td>
<td>14-23</td>
<td>227-461</td>
<td>67-94</td>
</tr>
<tr>
<td>Maasai</td>
<td>Pastoral</td>
<td>13-27</td>
<td>342-400</td>
<td>55-78</td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maasai</td>
<td>Pastoral</td>
<td>13-24</td>
<td>244-358</td>
<td>81-94</td>
</tr>
<tr>
<td>Turkana</td>
<td>Pastoral</td>
<td>15-18</td>
<td>192-313</td>
<td>72-88</td>
</tr>
<tr>
<td>Somali</td>
<td>Pastoral</td>
<td>-</td>
<td>-</td>
<td>70-81</td>
</tr>
</tbody>
</table>

1(8,28,29,31,32,33,34,35,38,44,45)  
(\(-\)) Data not available

The differences in survival rates between cattle and small ruminants are difficult to explain but the lower survival of camels in the pastoral system seems to be because camels inhabit harsher part of the range with poorer feed resources than cattle. It also seems that more survival capabilities within species and systems of production but differ in reproductive parameters. Breed differences seem apparent in these traits. In the pastoral systems the Rendille camel offers higher scope for improvement in fertility traits than the Turkana.
attention is paid by the pastoralists to veterinary care of cattle than of camels\(^{28}\). Among the small ruminants, Turkana sheep and goats tend to have lower age at first parturition and shorter parturition intervals than the other breeds. However, on average, goats have a lower survival rate than sheep. The ability to reproduce and survive in the Kenyan pastoral system is similar to that achieved (Table 7) in Ethiopian and Australian ranches\(^{46,47}\) where management conditions are better. These estimates suggest little scope for improvement of performance of Kenyan livestock in terms of reproduction and survival rates. Evolution into ranching or improvement in management techniques may, however, result in high and frequent offtakes of milk and meat per ha.

Table 7: Comparative cattle production parameters for different systems in arid areas\(^1\)

<table>
<thead>
<tr>
<th>Production system</th>
<th>Country</th>
<th>Calving rate (%)</th>
<th>Calf survival rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maasai, pastoral</td>
<td>Kenya</td>
<td>76</td>
<td>90-92</td>
</tr>
<tr>
<td>Boraba, pastoral</td>
<td>Ethiopia</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Laikipia, Ranches</td>
<td>Kenya</td>
<td>52-83</td>
<td>76-95</td>
</tr>
<tr>
<td>Abemosa, Ranch</td>
<td>Ethiopia</td>
<td>70-78</td>
<td>95</td>
</tr>
<tr>
<td>Transhumant, Pastoral</td>
<td>Mali</td>
<td>56</td>
<td>72</td>
</tr>
<tr>
<td>Alice Springs, Ranches</td>
<td>Australia</td>
<td>72-77</td>
<td>90-95</td>
</tr>
</tbody>
</table>

\(^1\)Modified after Grandin\(^{46}\) and Cossins and Upton\(^{47}\)

**Constraints to production**

Constraints to animal productivity in the Kenyan range can be summarised as those that are environmentally determined and those that have their origins in the pastoralist’s management practices which in turn are influenced by his way of life. Kenya’s high population growth rate of 4% per annum\(^{48}\) has also resulted in increased migration of mixed farmers from arable to rangeland districts especially into the dry season grazing reserve areas\(^{46}\). Considerations of the subject are many and recent ones include those of Njania\(^{58}\), Amuyunzu\(^{17}\), Maranga\(^9\), Kayongo-Male\(^{18}\) and Carles\(^8\). Studies of production factors have also been investigated\(^{49}\) as well as an analysis of the effect of individual nutrients on productivity\(^{19}\).

When natural or improved pastures are the main sources of nutrients for livestock, season-ality in quantity and quality of available herbage has a marked influence on animal productivity\(^{20,50}\). Onset of rains causes new grass to flourish and this results in a rapid rise in milk production at almost any stage of lactation; the dry season on the other hand severely depresses milk yields\(^{41}\). Throughout the year, grazing stock hardly ingest sufficient digestible energy for maintenance\(^{20}\) so that physiological functions like lactation and growth are dependent on body reserves. Periods of nutritionally high quality forage are short because the grasses of the arid zones deposit high proportions of structural carbohydrates in the plant tissue at an early vegetational stage while CP falls to about 7% in only 8–10 weeks\(^{21}\). This explains the generally low digestibility coefficients for all plant species studied in Marsabit\(^{18}\). Close and Menko\(^{51}\) have also shown that while the CP of edible leaves of trees and shrubs can be quite high, their digestibility is often low. Even in the high potential areas of Kenya, dairy heifer performance on sown pastures is more positively related to intake of digestible rather than crude nutrients\(^{50}\). Therefore, since the efficiency of animal production is dependent on the optimum utilization of ingested nutrients, poorly digested forage would lower animal productivity in the range areas. In the driest months, cattle selectively consume forage that contains about 5% CP, a value, that is unfortunately well below the minimum levels required to ensure positive nitrogen balance\(^{52}\). According to Carles\(^8\) there is no evidence of a mineral deficiency for sheep and goats in the Integrated Project on Aridlands (IPAL) study area of Marsabit excepting Sodium. A distinction should, however, be made between wet season and dry season animal diets with regard to the minerals they contain. In the range countryside of Isiolo, wet season grasses contain adequate levels of minerals to meet the demands of grazing animals but consumption of sufficient quantities may be limited by herbage intake due to a rapid fall in CP levels with time\(^{19}\).

The influence of season is also seen in its effect on calf growth. Under the Maasai and Boran traditional systems of management the calf is dependent on the dam’s milk until naturally weaned\(^{41,32}\). Milk consumed by the house-
hold will, thus, infringe upon the calf’s nutrient requirements. During periods of nutritional stress such as in the dry season, milk offtake for human consumption, may be so high as to reduce calf growth leading to late attainment of puberty and age at first calving\(^{41}\). Low annual cow reproductive rates have also been reported because of the effects of dry season undernutrition on lactation anoestrus\(^{41}\). Among the Rendille, suckling of kids and lambs is restricted to only the morning and evening and this has caused permanent stunting during the first 4 to 6 weeks of growth\(^{6}\). This is basically a management problem which has considerable impact on productivity. Many pastoralists, perhaps for reasons of prestige, also keep too many unproductive animals including infertile females and old castrated males\(^{6}\).

Livestock need a regular and an adequate supply of water for their existence and for sustenance of productive functions and this should be consumed in a certain ratio to the DM ingested. In the arid zones of Kenya, non-availability of water is a major constraint to improved livestock production\(^{17}\). Water supply points are few and far apart\(^{2}\) so that the distance that must be travelled affects the frequency of watering as well as the amount drunk. Camels drank irregularly at 3–10 day intervals from irrigation canals or from the lake in central Baringo\(^{63}\). The limited water resources have also resulted in high grazing pressures around permanent water sources and, hence, deterioration of the rangeland.

High mortality rates have further contributed to low productivity of animals in the nomadic systems of the rangelands. Nicholson\(^{41}\) has suggested that milk restriction to the calf through home consumption may be partly responsible for the 9% mortality value observed by Semenye and de Leeuw\(^{32}\) in Maasai cattle. In Isiolo, Gachuiri\(^{49}\) reported that low forage biomass was associated with death of goats due to emaciation. Under the Turkana pastoral production system abortions were common in primiparous goats with nutritional stress being the likely cause of the observed cases\(^{38}\). High death rates due to predation in sheep and to disease outbreaks both in sheep and goats, in Kajiado District, has been reported\(^{36}\). Similarly, Carlsson\(^{8}\) found that predation accounted for the largest proportion of all diagnosed deaths in Rendille goats and sheep.

Interventions for increased animal production

In view of the vastness of the range, the usual interventions suggested for improving small scale farming in other parts of Kenya cannot apply. Neither should an attempt be made to improve pasture on a wide scale. The scarcity of inputs such as fertilizer and seed and the non-profitability of such undertakings\(^{54}\) makes such a policy untenable. Exotic livestock species suggested for adoption failed to attract the interest of pastoralists and succumbed easily to drought, parasitic infestation and disease. The incorporation of Sahiwal genes in Maasai cattle was only successful in better managed ranches in Kajiado. Consequently, there is no need under the nomadic system of the range to change the existing breed types because these are the most suited to the region of the harsh environment\(^{65}\). And although the Kenyan range livestock production system is not managed as an income generating operation, it is sustainable and capable of meeting the social obligations of the community. The recommendations below fall under three categories and are made to fit that pattern.

(a) Innovations for range improvement and utilization

The DM output of the range can be increased and the vegetation offtake by livestock improved through an afforestation programme involving local people and using high fodder yielding indigenous plant genetic material. It is relevant in this respect to note the preference for Acacia melifera and A. tortilis by cattle in Isiolo District\(^{10}\). Kassily et al.\(^{11}\) have also reported that Euphorbia spp. a planted genus, was the most preferred in the diet selected by camels in central Baringo. Trees and shrubs should be planted in areas which already support vegetation such as the routes usually taken by the pastoralists in their efforts to take advantage of new plant growth following the rains. The choice
of trees and shrubs is because in the long term it is a least cost alternative. Moreover in the dry season, herbs, dwarf shrubs, tree leaves and litter constitute the major portion of cattle diets\(^{(18)}\). In northern Kenya an average camel diet consists of about 77% shrubs and trees\(^{(28)}\) while in central Baringo about 92% of the camel diet was made up of trees and tall shrubs\(^{(63)}\). Suggestions for controlled loping of shrubs and trees have also been made as a way of supplementing poor grazing\(^{(18)}\). It is appreciated that there are difficulties in establishing trees in dry areas under communal use. But experience with irrigation schemes such as those in Baringo have shown that tree establishment is possible in the range areas\(^{(63)}\). It may be necessary that areas meant for tree and shrub planting are gazetted out of use for a period of time. The success of this will depend on the cooperation of the community and the afforestation implementing agencies.

With regard to watering facilities, there is need to protect permanent water points from high grazing pressures through provision of boreholes, shallow wells and water catchment areas. Such a strategy also ensures controlled grazing of scarce feed resources, enables larger areas to be grazed, allows conservation of dry season grazing and reduces feed requirements for trekking. The technology of the boreholes should be based on hand-operation of simple pumps that can be managed by individual herdsmen to ensure continuity of their useful existence and enhancement of their social acceptability. Amuyunzu\(^{(17)}\), has reported that, with proper water distribution, the Kenyan range can support more livestock numbers than is currently the case, without causing damage to the environment.

Keeping of a diverse herd of animals is generally accepted as the best way of utilizing range resources. Pastoralists seem aware of this as they always try to maintain a good mix of all the livestock species. As an example, the Rendille keep 40, 36 and 18% of cattle, camels and sheep and goats respectively\(^{(66)}\). Comparative studies on feeding behaviour have shown that the above species are complementary rather than competitive. The animals utilize different feed sources on the same pasture and differ in their adaptation to seasonal forage shortage and quality changes\(^{(67)}\). Some measured production parameters for Kenyan pastoral small ruminants show that sheep are heavier and have higher growth rates than goats (Table 8). Unlike sheep, however, goats were found to be aseasonal breeders\(^{(66)}\). This attribute in goats increases the chances of their recovery from drought while the high prolificacy and weight gains in sheep could contribute more to meat production under normal conditions.

Appropriate nutrient supplementation can further enhance utilization of the range. Legume pods, seeds and fruits from other trees and shrubs should be collected by the pastoralists during grazing for evening supplementation of the young, the pregnant and lactating females. Camels and donkeys can provide the draught power to carry the collected feed. Hashim\(^{(59)}\) supplemented sheep with seed pods of leguminous trees and obtained satisfactory results in the semi-arid zone of western Sudan. Field\(^{(2)}\)

<table>
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<th>Table 8: Some comparative production parameters for African goats and sheep, according to semi-arid area and ethnic group(^1)</th>
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<td><strong>Kenya, Maasai</strong></td>
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<td>Age at first parturition (mo)</td>
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<td>Parturition interval (mo)</td>
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<td>Number of young per year</td>
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<td>Daily gain to 150 days (g)</td>
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\(^1\)Modified after Wilson\(^{(3)}\).
has also recognized the feed value of *Acacia tortilis* pods to sheep and goats in Rendilleland.

Supplementation with minerals would benefit animal productivity in the range because responses to mineral supplements are both physiological and economic. In Kenya, several ranches offer mineral licks to their animals although there is no guarantee that all animals will consume enough of the lick at all times. For the range animal, blocks of mineral licks adequate in P, Na, Cu and Co and distributed strategically along nomadic routes of movement would help in meeting requirements. Such mineral blocks should be covered with thorny bushes when not being licked to protect them from use by game animals.

(b) Genetic improvement

Lack of seasonal differences in the productivity performance of most of the pastoral herds and flocks in Kenya is suggestive of the high environmental stress on the genetic potential of range livestock species. Opportunity for genetic improvement is difficult to exploit due to fluctuations in the environment and lack of data. In pastoral livestock, mortality and reproductive traits have high economic weights but low heritability (h²). Although data available are very few and limited to studies on ranches, h² estimates for growth traits are not low. Kegode, working with camels, reported h² values of 0.10, 0.29 and 0.31 for birth weight, weaning weight and pre-weaning average daily gain respectively. In the same study, a dam performance repeatability estimate of 0.20 was reported for birth weight. For Boran breeds, h² estimates for birth and weaning weights were 0.44 and 0.30 respectively. The h² estimates in Red Maasai X Dorper sheep were 0.15, 0.18 and 0.14 for birth weight, weaning weight and pre-weaning average daily gain respectively. These values are comparable to those reported elsewhere in the tropics for ecologically similar conditions.

Genetic improvement for growth traits is feasible where management techniques are intensified. For example, upgrading and purebreeding takes place spontaneously on established ranches. The improved Boran breed is an example of a fast growing animal developed after four decades of selection of Boran cattle on Kenyan ranches. Thus, intensification of management in range livestock production systems is a necessary condition for genetic improvement of range animal performance for meat production. For efficient range livestock utilization, such a programme should be preceded by a proper characterization of the breeds of animals on the Kenyan range. The data reviewed suggest identifiable trait differences and it is our view, that the animals of the range may be categorised under the breeds: Somali, Rendille and Turkana for camels; Maasai and Boran for cattle; Galla, Maasai and Turkana for goats and Maasai, Somali and Turkana for sheep (Tables 3, 5 and 6).

(c) Improvement of management practices

The importance of the replacement value of young stock in the range herds has been neglected through mismanagement. Security around homesteads needs, therefore, to be improved to protect the young from predation. Appropriate fencing and the use of guard dogs both at home and during grazing would reduce mortalities. For sedentary communities, live fences of, for example, *Euphorbia spp.* would be appropriate while nomadic pastoralists would need to take advantage of dry thorny bushes in making fences. Use of guard dogs is an integral part of the pastoral system. Risks from diseases such as rabies and hydatidosis can be reduced by including the dogs in the prophylactic programmes accorded the livestock. Sucking animals should be properly fed to prevent stunting. This can be effected through retention of the dams around the homesteads until after about 6 weeks when rumen development would allow the young to subsist on their own.

Continued keeping of multiple species of animals should be encouraged in all pastoralist groups. Mixed species herds increase food production, minimise risks in pastoral use systems and are less detrimental to range condition and productivity than animal monocultures. In the dry season goats and camels can sustain milk production through browse
utilization while the camel can provide milk and blood for much longer periods during drought. Following drought, small stock recover faster to provide food for the pastoralists\(^7\). For meat production, sheep are particularly recommended because they grow faster, mature earlier and have higher fertility levels than goats\(^8\). The keeping of the right proportions of the different animal species is essential. The proper species mix may be also influenced by consumer and market preferences.

Strategic mass vaccinations against common diseases and use of anthelmintics are recommended to increase animal survival rates. Benefits from vaccinations are likely to be enormous viewed against the devastating effects of some of the diseases like rinderpest. Indeed, persistent large scale use of rinderpest vaccine has made cattle production profitable in much of Africa. In central Turkana, Njanja\(^6\) observed that roundworms were the most important helminths in camels and small stock with clinical helminthosis occurring in the late dry season when the animals were also under nutritional stress. Routine vaccinations and deworming should be coupled with a bi-monthly cost-effective herd health programme for early detection and treatment of disease. The dry season is critical in this regard because herds graze in remote areas, where there are no dipping facilities and animals invariably contract high rates of diseases such as East Coast Fever (theileriosis) and anaplasmosis\(^5\). The herd owners should then be educated on the need to separate the young and productive animals from infertile females or excess old males and castrates which should periodically be culled. A market with attractive prices, will increase the elasticity of supply of saleable products and encourage the pastoralist to practice regular disposal of his animals and, thus, increase offtake rates. This should offset the long term effects of vaccination campaigns and strategic control regimen with simple drug packages on livestock populations and the consequent effects on the feed resource base. At the human level, the nomads should be advised to space their children in-order to maintain their populations at levels compatible with the productivity of the range.

References


SHORT COMMUNICATION:

AN ATTEMPT TO TREAT PARATUBERCULOSIS DIARRHOEA BY ACUPUNCTURE

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UN ESSAI DE TRAITEMENT DE LA DIARRHÉE DUE À LA PARATUBERCULOSE PAR L’ACUPUNCTURE

Résumé
L’acupuncture a été appliquée à la cicatrice ombrillacale d’un zébu des Hauts-Plateaux souffrant de diarrhée due à la paratuberculose. Elle a permis l’arrêt de la diarrhée en seize jours ainsi que l’allègement des signes cliniques. Il a été proposé que le traitement à l’acupuncture devrait faire partie des traitements à prescrire pour soigner la maladie de Johne et d’autres maladies diarrhéiques.

Summary
Needle acupuncture was applied at the umbilical scar of a Highland Zebu with diarrhoea due to paratuberculosis. The acupuncture resulted in a sixteen days cessation of diarrhoea and alleviation of clinical signs. It was suggested that acupuncture therapy could be a potential component of the treatment of Johne’s disease and other diarrhoeal diseases.

Introduction
Acupuncture, an ancient Chinese art of healing, is used to treat a wide variety of diseases. In different parts of the world, intensified research is going on to understand its mechanism of action. However, studies conducted so far indicate that acupuncture stimulates the body’s cellular and humoral defence systems\(^{(1)}\). In Ethiopia, the only documented information on the veterinary practice of acupuncture is by members of Chinese Veterinary Team who reported on a successful treatment of equine colic\(^{(2)}\) and on electric needle anaesthesia\(^{(3)}\).

Paratuberculosis or Johne’s disease is a chronic debilitating disease of ruminants caused by Mycobacterium paratuberculosis and definitive diagnosis of the disease requires fecal culturing\(^{(4)}\). Microscopic examination of suspected fecal culturing pinch biopsy after staining with Ziehl-Neelson can also be used\(^{(5,6)}\). Prospects for treatment of the disease are poor and the usual fate of the patients is destruction\(^{(6)}\). This trial was carried out to see the effect of needle acupuncture on the clinical manifestations of Johne’s disease.

Materials and Methods
Case History and Clinical Examination
A 19 years old Highland Zebu steer presented in March 1994 to the clinic of the Faculty of Veterinary Medicine, Addis Ababa University, with history of diarrhoea that lasted two years. It was emaciated and dehydrated. Rectal temperature was within the normal range. Fecal examination for parasites was negative which was due to the homestead deworming by the owner. It was nevertheless wormed with Albendazole (TAD PHARMAZEUTISCHES WERK GMBH, West Germany).

However, the animal was brought back to the clinic for incessant watery diarrhoea and further loss of condition and was this time severely dehydrated. Then Johne’s disease was suspected and fecal sample as well as rectal scrapings were taken. Ziehl-Neelson staining revealed clumps of acid fast bacteria of mycobacterial morphology in both samples. The rectal mucosa was hyperaemic and wrinkled.

Treatment
Treatment with streptomycin, the only available drug of choice, at a dose rate of 50 mg/kg daily would cost 6 Birr (= 1 USD) per day the bill was going to be more than the animal’s value and was not affordable to the owner. Even if such a regimen had been instituted, the result would have been only a transient improvement in the clinical signs\(^{(6)}\).

Therefore, instead of leaving the animal to die in due course, it was decided to intervene by stimulating an acupoint at the umbilical scar indicated for diarrhoeal cases\(^{(7)}\). Three to five 20–22 G, 0.5–1 inch hypodermic needles were used, with proper aseptic procedure, to puncture the umbilical scar. The needles were twirled and pecked in situ for 3–5 minutes and the
urachus was also stimulated. Treatment was repeated daily for four days and then after recess of 3 days for another two days. Follow up was made every two days.

Result and Discussion

After the third treatment, cessation of the diarrhoea was noticed, with change to soft faeces and treatment was discontinued after six treatments. The degree of dehydration subsequently decreased and mucosal thickening of the rectum was also grossly reduced. However, acid fast bacilli were still detectable during the remission of diarrhoea.

The diarrhoea resumed after 16 days of cessation. Then stimulation of further occupants, viz. G-1 (Dj-Chad), B-20, St-36 (Tau San-L) and ear tip venipuncture was decided and these points were stimulated puncturing to similar depths as used by these authors. Unfortunately it was not possible to continue the therapy and follow up for the animal had not been brought back as regularly as required.

The effectiveness of acupuncture could be affected by the condition of the animal, the method used (electrical, traditional, laser, magnetic, irritant chemicals etc.) and the practitioner’s experience. Besides the absence of facilities to apply the different methods of the therapy, the steer was old. The age could have a negative impact on the immune response affecting the duration of recovery from diarrhoea.

History of the animal indicated that such an interruption of diarrhoea like that observed after the acupuncture therapy, was not seen earlier. Moreover, the cessation of diarrhoea and improvements in clinical signs were noticed in a relatively short time (3 days) after the commencement of the treatment. These facts suggest that the change noticed was due to the acupuncture therapy.

We believe that acupuncture could be a potential therapy either alone or with antibacterial therapy in alleviating the clinical manifestations of paratuberculosis. Further studies, under controlled conditions and by applying different methods of acupuncture, either alone or in combination with specific therapies for various diarrhoeal cases, are recommended.

Acknowledgement

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References

SHORT COMMUNICATION:

OBSERVATIONS ON EFFICACY OF ALPHAMETHRIN AND TOXAPHENE APPLIED AS DIPS FOR CONTROL OF TICKS IN COAST REGION, TANZANIA

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The control of ticks by dipping is of vital importance to the agricultural economy of Tanzania both in building up the national herd and encouraging upgrading of cattle.

Therefore, before any new type of acaricide is considered suitable for use in spray or dipping, investigations to determine its efficiency against ticks have to be made.

In this report, results from tick control in Coast Region using alphamethrin (Dominex 100 EC) – a synthetic pyrethroid which had never been used in Tanzania; and toxaphene (Sapaxox 75 EC) – an organochlorine commonly used in Tanzania for tick control are presented.

About 800 indigenous cattle at Chamakweza – Coast region, were being treated for tick control using toxaphene in two immersion dips, A and B. Twenty-four cattle were selected randomly from six herds, ear-tagged and left for two weeks without acaricide treatment to allow for tick infestations. These animals were divided into two groups of 12 animals each. Group one was for tick count in assessing alphamethrin efficacy and group two for toxaphene.

Dip A was charged with alphamethrin at concentration of 60 ppm (0.006%, alphamethrin) and dip B was freshly charged with toxaphene at concentration of 0.3%.

A total of 350 head of cattle together with those in group one were dipped weekly in dip B.

Weekly dipping was carried on for 7 weeks for all animals without changing their daily management and the dip concentrations were maintained according to manufacturers recommendations.

The survival of ticks was determined by counting unfed and engorged adult ticks of the three predominant species of Amblyomma variegatum, Hyalomma rufipes and Phipicephalus evertsi at predilection sites from the animals in group one and two. The countings were carried out one week before the first dipping (week 1), on the dipping week just before dipping (week 0), and thereafter every week just before dipping. The results are presented in Table 1.

Alphamethrin effectively knocked down all the species of ticks within 1–2 days post treatment. Weekly dipping showed that alphamethrin prevented the attachment of the three species of ticks considerably and the process of engorgement. Very low numbers of unfed Rhipicephalus evertsi were observed on the animals on week 4 and 7 while Hyalomma rufipes were not noticed at all on the animals after the first treatment. Low infestations of unfed Amblyomma variegatum were encountered weekly.

Animals treated with toxaphene weekly were found to carry very few numbers on their bodies at the time of each counting (Table 1). This showed that toxaphene is still effective against the tick species present in the area. In some other areas in the country organochlorine resistant tick strains have already been detected (1, 2). It is not surprising that with continued use of this acaricide in Coast region and elsewhere in Tanzania, tick species hitherto susceptible to toxaphene will develop resistance. The good efficacy of alphamethrin which has shown superiority to toxaphene in this work makes it a good alternative to the latter (toxaphene) for tick control in Tanzania.
<table>
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n.r = not recorded

Acknowledgment

We wish to thank M/s. Sapa Chemical Company for funding this trial and Mr. R. Kamande for technical assistance in the field.

References

SHORT COMMUNICATION:

PORCINE CYSTICERCOSIS IN TANZANIA: PRELIMINARY FINDINGS.

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Introduction

Cysticercus cellulosae is the cystic stage of Taenia solium, an armed tapeworm parasitizing the small intestine of man with the pig and wild boar being the main intermediate hosts. Infection in the pig is acquired by swallowing human faeces with the eggs of the worm which later develop in the animal into cysts with a predilection for the cardiac and skeletal muscles\(^1\). Humans get infected upon eating raw or under-cooked infected (measly) pork. Man may also act as an intermediate host by being infected with cysticerci of T. solium following ingestion of eggs in contaminated food or hands, with serious pathological consequences at times\(^1\). The cysticerci also cause considerable loss to the meat industry due to carcass devaluation and condemnation.

Pig farming in Tanzania is a growing practice as a way of satisfying nutrient requirements and as a source of income. While there is a degree of proper management in some government, parastatal and private farms, for the majority, the management is, by and large, poor. Thus with the intensification of pig industry coupled with poor husbandry practices, helminths and other parasitic infections are likely to become the major drawback to many farmers.

Little has been reported on the prevalence of pig helminths in Tanzania with the exception of some reports on Ascaris spp.\(^2,3,4,5\). In early November, 1987, it was learnt that some pigs from Mbulu District exported to Kenya showed generalised cysticercosis during meat inspection. It was therefore decided to investigate the disease situation in Northern Tanzania, which was until then, not widely reported.

In early December, 1987, regional and district meat inspectors were reminded by correspondence about the condition and asked to perform thorough inspections of all pigs originating from Mbulu District. They were also requested to furnish information about past and recent inspection records indicating the number of positive cases observed in their districts and where possible, pin-point the origin of the animals. A special trip was made to Mbulu District to observe the pig husbandry and management practices there.

A meat inspection report on Arusha Urban reported the first 3 incidences in November 1987. The cases were generalised in cyst distribution and were burnt. In January 1988 alone, 9 (1.34%) cases out of 670 pigs were observed. All the positive pigs were alleged to have been from Mbulu District. The report did not indicate positive cases for the previous years.

From Kilimanjaro region a report revealed that 50% of pigs slaughtered in the region originated from Mbulu District and that those which showed measly pork were among them.

In 1985, 5(0.04%) positive cases out of 13,514 carcasses were recorded while in 1986 and 1987, 15(0.11%) out of 13,280 and 18(0.13%) out of 13,646 positive cases respectively were observed. During the first quarter of 1988, 55(1.8%) pigs out of 3,127 carcasses inspected were positive in Moshi District alone. The report did not indicate cases before 1985.

The implicated Mbulu District in its report revealed only 2(0.41%) pigs out of 492 and another 2(0.24%) out of 840 positive for the condition in 1985 and 1987 respectively. In the first quarter of 1988 alone, 11 (5%) cases out of 225 were recorded in the district. The report did not indicate cases before 1985 nor for 1986.

*Veterinary Investigation Centre, P.O. Box 290, Iringa, Tanzania
**Veterinary Investigation Centre, P.O. Box 186, Tanzania
A trip to Mbulu District revealed very poor pig management and husbandry practices. Animals were left free to roam and scavenge.

The erratic data from the districts show how the condition has largely been overlooked. It clearly appears that the magnitude of the condition which is of importance in pig husbandry and health is probably more considerable than currently appreciated. For it is hard to explain why there are no data for any year before 1987 for Arusha Urban, before 1985 for Kilimanjaro region and before 1985 nor for 1986 for Mbulu District, while positive cases suddenly appeared in all reports in the first quarter of 1988 after corresponding with meat inspectors. Maybe the inspectors were ignorant of the condition or they were not recording and reporting or they were not inspecting the carcasses or a combination of any of these. Whatever the reasons the figures indicate that there may be a major problem.

The overall percentages of the positive cases seem to be quite low but that can be misleading in that by simple summation of pigs slaughtered, positive cases from certain endemic localities could be over-diluted by the number of clean pigs from other areas within the zone. Exact numbers of positive cases from exactly known areas would provide meaningful results for an epidemiological and control study.

The presence of cysticercosis in parts of Northern Tanzania signifies low standards of pig husbandry, hygiene and sanitation. In Mbulu, pigs were seen roaming and scavenging freely while the use of toilets by some local people was by and large unsatisfactory.

While further investigations on the epidemiological pattern of the problem in Northern Tanzania is required, principally the control of the problem is a matter of education, improved hygiene and proper meat inspection. The parasite is consequently rare in countries where such measures are practised and frequent where they are not. With the popularity of pork on the increase in Northern Tanzania, it is imperative that the public is made aware of the danger.

References
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RECOMMANDATIONS AUX AUTEURS

Objet

Présentation des articles
Deux exemplaires des articles doivent être adressés à Monsieur le Rédacteur en Chef, Bulletin de la Santé et de la Production Animales en Afrique, Organisation de l’Unité Africaine/Bureau interafricain des Ressources animales, P.O. Box 30786, Nairobi, Kenya.


Un article ne peut être soumis pour publication que s’il n’a pas encore été proposé ailleurs; il fera l’objet de quelques modifications par le Comité de Rédaction.

Genres d’articles publiés dans le Bulletin
— des communications originales
— des brèves communications
— analyse des articles proposées par le Rédacteur
— des éditoriaux
— le courrier des lecteurs
— analyse d’ouvrages
— informations et annonces

Format des articles
Les manuscrits doivent respecter les conditions suivantes:

Le titre doit être concis et ne pas dépasser plus de 15 mots, il est suivi du (des) nom(s) de l’auteur (ou des auteurs) et des établissements où le travail a été effectué, ainsi que de l’adresse pour les correspondances si elle n’est pas la même.

Le résumé ne doit pas excéder 200 mots. Son texte bref et concis comprendra les principaux résultats et les (les) conclusion(s) de l’étude.

L’introduction expose le but de la recherche.

Le matériel et les méthodes utilisés.

Les résultats présentés brièvement.

Un débat sur l’importance de l’article.

Remerciements éventuels.

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Le nom du pays, l’année faisant l’objet du rapport, puis le nom du service ou de l’organisation, le numéro de la première page.

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