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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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Introduction stating the purpose of the work.

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Results presented concisely.

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THE IDENTITY OF COENURI FROM SUDANESE SHEEP AND GOATS

E.E. ELOMWNI(1), M.T. ABU-SAMRA(1), K.E.E. IBRAHIM(1) and K.I. HASSAN(2)

(1)Faculty of Veterinary Science and (2)Faculty of Agriculture, University of Khartoum, P.O. Box 32, Khartoum-North, Sudan.

IDENTIFICATION DES LARVES DE COENURUS CHEZ LES OVINS ET LES CAPRINS AU SOUDAN

Résumé

On a essayé de déterminer l'identité des larves de coenurus responsables de l'infection cérébrale, intrabdominale et sous-cutanée chez trois moutons du Soudan ainsi que l'identité des larves responsables de l'infection cérébrale chez une chèvre, à l'aide des dimensions et de la morphologie des ventouses de la rostelle utilisées comme critères pour les identifier ou les distinguer. Les métacystodes cérébraux furent reconnus comme étant des Coenurus cerebralis et les larves intrabdominales et sous-cutanées étaient des Coenurus gaigeri. Les points de vue divergent concernant l'unité ou la dualité de Taenia multiceps et Taenia gaigeri. Selon les résultats obtenus, ces ténias sont des espèces différentes. Les comparaisons des ventouses ont permis de constater des différences quantitatives, mais les variations des diverses mesures étaient considérables. Les critères que nous avons utilisés ne sont donc pas des critères fiables pour distinguer les espèces.

Summary

Attempts were made to determine the identity of cerebral, intrabdominal and subcutaneous coenuri from three Sudanese sheep and a cerebral coenurus from a goat using the dimensions and morphology of the rostellar hooks as criteria for identification/differentiation. The cerebral metacestodes were assigned to Coenurus cerebralis and the intrabdominal and subcutaneous larvae to Coenurus gaigeri. There are conflicting views regarding the unity or duality of Taenia multiceps and Taenia gaigeri. The results support the opinion that they are distinct species. Comparisons of hook dimensions showed quantitative differences but the ranges of various measurements overlapped considerably. This criterion therefore cannot be used reliably for the differentiation between species.

INTRODUCTION

Several authors reported the occurrence of coenurus infections in sheep and goats in the Sudan. Magzoub(1) described Coenurus serialis from the intermuscular connective tissue of sheep and Elbadawi et al.(2) found Coenurus gaigeri in the central nervous system and musculature of these animals. Both Coenurus cerebralis and C. gaigeri have been diagnosed in the goat; the former being localized in the brain(3) and the latter between skeletal muscles or attached to the internal organs(4,5). Coenurosis in animals has been attributed to infection with the larvae of numerous tapeworm species of the genus "Multiceps"(6,7,8). There are conflicting views, however, regarding the unity or duality of some of these species. Clapham(6) considered M. multiceps and M. serialis as synonymous and she regarded M. gaigeri a valid species. Nagaty and Ezzat(9); on the other hand, assigned M. gaigeri to M. multiceps and they recognized the validity of M. serialis (see also Meyer(8), Esch and Self(10) and Verster and Bezuidenhout(10)). Bondareva (cited by Verster(11)), however, concluded that M. multiceps, M. gaigeri and M. serialis are distinct species. In view of this controversy, the present study was undertaken to determine the identity of cerebral and body coenuri parasitizing Sudanese sheep and goats using the dimensions and morphology of the rostellar hooks as criteria for identification/differentiation.

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* Majority of authors include Multiceps spp. in the genus Taenia.
Materials and Methods

Origin of coenuri
An adult sheep was brought to the University of Khartoum Veterinary Clinic showing large swellings on the body. The animal was slaughtered and necropsy findings revealed the presence of numerous coenurus cysts embedded in the intermuscular connective tissue in the cervical, retroscapular and gluteal regions. There were also coenurus cysts in the abdominal and thoracic cavities. The abdominal cysts were the largest of all and one of these has been selected for the examination of hooks.

Another sheep with subcutaneous cystic swellings was brought to the clinic in August, 1984. One of the cysts was removed surgically and on examination it was found to be a coenurus.

Other coenuri included in the study were brain cysts of sheep and goat origins kept as museum specimens in the Department of Parasitology.

Examination of hooks
The various coenuri, fixed in formalin, were opened separately and a random sample of 10 scoleces was taken from each coenurus. Individual scoleces were mounted in a few drops of Hoyer's solution and were pressed between slides to disrupt the tissues and spread the rostellar hooks in profile. The use of Hoyer's medium was found to have the advantage of providing intensity to hook substance and a better resolution of hook contours. Hooks from each scolex were counted and the dimensions were measured with the aid of an eye-piece micrometer fitted to a standard compound microscope. The parameters investigated were the length of the hook (A), width of the hook at the level of the guard (B), linear length marking the shorter curvature of the blade (C) and width of the guard at its base (D). A total of 1,856 measurements were made with 58 large and 58 small hooks (see below) being measured from each coenurus.

Analysis of results
The data recorded for respective dimensional characters were subjected to computer analysis using the randomized complete block design ANOVA. Significant F values were obtained in all

<table>
<thead>
<tr>
<th>Origin of coenurus</th>
<th>No. of hooks per scolex</th>
<th>Length of hook (Mean ± S.D.)</th>
<th>Width of hook (Mean ± S.D.)</th>
<th>Length of blade (Mean ± S.D.)</th>
<th>Base of guard (Mean ± S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain (sheep)</td>
<td>13-15</td>
<td>163.5 ± 2.4 (159-169)</td>
<td>59.3 ± 1.3 (55-62)</td>
<td>63.8 ± 1.3 (61-66)</td>
<td>25.2 ± 1.8 (22-29)</td>
</tr>
<tr>
<td>Brain (goat)</td>
<td>12-15</td>
<td>180.4 ± 6.1 (160-190)</td>
<td>69.4 ± 3.5 (64-84)</td>
<td>69.4 ± 2.5 (64-74)</td>
<td>28.4 ± 3.3 (23-38)</td>
</tr>
<tr>
<td>Subcutis (sheep)</td>
<td>11-14</td>
<td>173.4 ± 2.9 (168-182)</td>
<td>60.5 ± 3.1 (51-69)</td>
<td>67.8 ± 1.5 (65-71)</td>
<td>25.3 ± 2.0 (23-30)</td>
</tr>
<tr>
<td>Abdomen (sheep)</td>
<td>11-15</td>
<td>173.8 ± 5.2 (165-183)</td>
<td>62.9 ± 2.1 (57-67)</td>
<td>70.1 ± 1.6 (66-74)</td>
<td>26.4 ± 3.4 (20-37)</td>
</tr>
</tbody>
</table>

*Numbers in parenthesis, range values. Means within a column followed by different superscripts differ significantly at the 1% level of probability. Number of observations, 58 in each case.

<table>
<thead>
<tr>
<th>Origin of coenurus</th>
<th>No. of hooks per scolex</th>
<th>Length of hook (Mean ± S.D.)</th>
<th>Width of hook (Mean ± S.D.)</th>
<th>Length of blade (Mean ± S.D.)</th>
<th>Base of guard (Mean ± S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain (sheep)</td>
<td>13-15</td>
<td>119.7 ± 3.2 (109-127)</td>
<td>49.1 ± 1.8 (43-52)</td>
<td>47.4 ± 2.4 (40-53)</td>
<td>18.8 ± 2.0 (15-23)</td>
</tr>
<tr>
<td>Brain (goat)</td>
<td>13-15</td>
<td>131.2 ± 6.3 (115-143)</td>
<td>53.5 ± 3.0 (48-60)</td>
<td>52.2 ± 2.4 (45-56)</td>
<td>19.6 ± 2.3 (15-25)</td>
</tr>
<tr>
<td>Subcutis (sheep)</td>
<td>11-14</td>
<td>135.3 ± 5.4 (119-145)</td>
<td>50.6 ± 2.1 (46-56)</td>
<td>50.4 ± 1.8 (46-56)</td>
<td>20.2 ± 1.9 (18-25)</td>
</tr>
<tr>
<td>Abdomen (sheep)</td>
<td>12-15</td>
<td>131.4 ± 5.8 (120-143)</td>
<td>50.2 ± 2.0 (46-55)</td>
<td>52.9 ± 1.7 (51-59)</td>
<td>18.2 ± 1.8 (15-23)</td>
</tr>
</tbody>
</table>

*Numbers in parenthesis, range values. Means within a column followed by different superscripts differ significantly at the 1% level of probability. Number of observations, 58 in each case.
comparisons and means were tested for statistical difference by the Student-Newman-Keuls’ procedure\textsuperscript{12}.

\textbf{Inference}

Transformation of the mean and standard deviation figures in Tables 1 and 2 to coefficient of variation indices\textsuperscript{13} suggests that for both the large and small hooks the dimension A is the most constant and that D has the highest inherent variability. The transformed figures also suggest that the dimensions of the large hook are of a less variable disposition than those of the small one. Inferences were drawn on the basis of these findings.

\textbf{Results}

Scoleces, regardless of the origin of the cysts, were found to be provided with typical taenid hooks of two types, a large and a small, arranged as a double crown on the rostellum. The numbers of these hooks are given in Tables 1 and 2.

\textbf{Dimensions of hooks}

There is considerable overlapping in the range of individual measurements of hook dimensions in the various coenuri (Tables 1 and 2). Comparisons of respective pairs of means, however, showed differences which are highly significant.

\textbf{Morphology of hooks}

Hooks of the cranial coenuri in sheep and goat (Figs. 1 and 2, respectively) showed minor differences in morphology. The handle of the large hook in the goat coenurus for instance has a tendency to slightly tilt dorsally when viewed laterally. In the sheep coenurus, however, the large hook handle is straight with its long axis forming a right angle with the long axis of the guard. The guard of the large hook from the sheep coenurus is typically cordiform whereas that of the hook from the goat larva is cordiform with the distal end slightly elongated.

Hooks from the abdominal and subcutaneous coenuri in sheep (Figs 3 and 4) closely resembled each other in morphology but they are quite distinct from those of the cerebral cysts in this host and in the goat. The differences encountered are exemplified by variations in the sinuosity of the small hook handle, shape of the guard of the large hook, orientation of the guard of the small hook and mode of blade curvature in both the large and small hooks.

\textbf{Discussion}

Coenurid larvae are difficult to identify\textsuperscript{8,14} and specific diagnosis has commonly been based upon the species of the parasitized host, gross morphology of the cysts and/or the site of location of these cysts in the host. Using material from various species of \textit{Multiceps}, Clapham\textsuperscript{15} found that the rostellar hook reaches the full adult size in the coenurus stage. She proposed that the hook, being a chitinuous structure, is subject to less variability than most other characters and could therefore be used for the differentiation between coenuri\textsuperscript{16}. Comparisons of the measurements of hooks from the various coenuri (Tables 1
and 2) suggest that there are different taeniid populations responsible for cerebral and body coenurosis in sheep and goats in the Sudan. The finding that there are also differences in the morphology of hooks from these coenuri suggests the existence of distinct species. The various hooks examined are on the average longer than those of *Coenurus serialis* \(^{15,18,16}\) and those of the small series specifically lack the characteristic rounded ventral elevation described by Nagaty and Ezzat \(^{17}\) on the posterior of the guard of the small hook of this parasite. Generally, *C. serialis* parasitizes lagomorphs \(^{18}\) and the records of this metacestode from sheep and goats have been considered by Hall \(^{17,18}\) and Graber \(^{19}\) as errors.

There is ambiguity regarding the distin-
guishing morphological features of hooks of *Taenia multiceps* and the figures recorded for the length of hooks of this tapeworm varied considerably between investigations. Basing her findings on analysis of hook dimensions, Clapham incorporated eight supposedly distinct species into "*M. multiceps*" which she regarded as a "comprehensive species". The general concept is that the larva of this tapeworm (*Coenurus cerebralis*) develops only completely in the central nervous system. The hosts are ungulates, especially sheep. The length of hooks from the brain coenuri of sheep and goat falls within the range of *T. multiceps*. We propose that the differences between hooks of the two larvae in morphology (Figs 1 and 2) and size (Tables 1 and 2) represent the normal variations in the characteristics of hooks of this species.

The first record of *Coenurus gaigeri* was from a goat in India. The larva develops in the central nervous system and other sites including the liver, spleen, intermuscular connective tissue and subcutaneous tissue. Hooks from the abdominal cyst of sheep resemble those of *Taenia gaigeri* in morphology (Hall's Fig. 1) and they fall in the range of size recorded for this species. One of the characteristic features of hooks of this tapeworm is the "very obtuse" angle formed by the guard and handle of the small hook. The hooks of the subcutaneous cyst are also identifiable with *T. gaigeri*. The two larvae, the abdominal and subcutaneous, are indistinguishable by the length of their large hooks (presumably the most constant parameter) and the ranges of the lengths of their small hooks are almost identical. The size of both the large and small hooks excludes the two larvae from being *Taenia skirjabini* of which the coenurus parasitizes sheep and preferentially localizes in the subcutaneous tissue and in the abdominal and thoracic cavities.

We conclude from this study that there are at least two distinct species, *T. multiceps* and *T. gaigeri*, responsible for coenurosis of sheep and goats in the Sudan. The larvae of the two worms can be differentiated by the morphology of...
their rostellar hooks. Comparisons of hook dimensions showed quantitative differences but the ranges of various measurements overlapped considerably. This criterion therefore cannot be used reliably for the differentiation between species.

Addendum

Our attention was drawn to a paper by Yang et al.\(^{(24)}\) in which it has been shown that \emph{T. multiceps} would form mature coenuri in the brain and muscles of experimentally infected goats but occurred only in the brain of experimentally infected sheep. A coenurus therefore found in the subcutaneous tissue or the abdominal cavity of sheep would be expected to be the larva of a tapeworm other than \emph{T. multiceps}. According to Herbert et al.\(^{(25)}\), sheep experimentally infected with \emph{T. multiceps} develop live coenuri in the brain. Migrating oncospheres reaching other organs, however, become trapped, they are “overcome by host inflammatory responses”\(^{(26)}\) and are terminated as “abortive infections”\(^{(25)}\).

References


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INTESTINAL PATHOLOGY ASSOCIATED WITH SALMONELLA IN APPARENTLY HEALTHY ANIMALS

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PATHOLOGIE INTESTINALE DUE A SALMONELLA CHEZ DES ANIMAUX APPAREMMENT EN BONNE SANTE

Résumé
L'état des porteurs de Salmonella et la pathologie y associée chez les bovins et les caprins apparemment en bonne santé ont fait l'objet d'études lors de l'abattage de 306 bovins et de 215 caprins. Les taux d'animaux porteurs étaient respectivement de 12,1 et 7,4% pour les bovins et les caprins. Il n'y avait pas d'évidence de changements morphologiques ou cellulaires dus à Salmonella chez plusieurs animaux porteurs; en revanche, il y a eu chez d'autres des changements microscopiques sans pathologie apparente. Les changements microscopiques observés étaient la nécrose épithéiale, la desquamation, l'oedème et l'infiltration lymphoïde. Les variants sérologiques: S. diisburg, S. cubana, S. anatum, S. adelaiade, S. shomolu et S. canada étaient isolés pour la première fois au Nigéria, soit des animaux, soit de l'homme.

Summary
Salmonella carrier status and the concomitant pathology in apparently healthy cattle and goats was investigated at slaughter in 306 cattle and 215 goats. The carrier rates were 12.1 and 7.4 per cent for cattle and goats respectively. There was no evidence of gross or cellular changes due to Salmonella in several carrier animals but others showed microscopic changes and no gross pathology. Microscopic changes observed were epithelial necrosis, desquamation, oedema and lymphoid infiltration. Serovars S. diisburg, S. cubana, S. anatum, S. adelaiade, S. shomolu and S. canada were isolated for the first time in Nigeria either from animals or man.

INTRODUCTION
Isolation of Salmonella serovars from livestock, man and other sources has been carried out by several workers in Nigeria(1,2,3,4,5,6,7,8). Some of these workers isolated Salmonella from clinically sick animals(9,10,11) while others from apparently healthy animals at slaughter or from meat or other animal products(5,7). This paper encompasses the results of isolation of Salmonella from intestinal tract (GIT) of apparently healthy cattle and goats and the concomitant cellular changes observed in the ileum.

Materials and Methods
Specimens were collected from apparently healthy 306 cattle & 215 goats with no signs of diarrhoea and randomly selected at slaughter in the Nsukka abattoir (Eastern Nigeria) over a period of 30 months. Five-inch long distal section of ileum was cut for bacterial isolation and another from next adjacent length for histological study. It was cut open and washed to examine for evidence of gross pathology and later scraped through to collect mucus for bacterial isolation. Standard procedure as described elsewhere(12) was adopted to isolate and identify Salmonella.

Representative isolates from various "O" groups were serotyped at the International Salmonella Reference Centre, Paris.

Faecal matter/ingesta from each specimen was examined for helminth and protozoan parasites employing floatation technique(13). Histopathologic examination was done employing standard technique(14) on specimens, which, after microbial and parasitologic screening showed no helminthic or protozoal infestation but were positive for Salmonella and a few others from which Salmonella could not be isolated.
Results and Discussion

Salmonella serovars were isolated from 37 cattle (12.1%) and 16 goats (7.4%). In all 13 serovars were isolated, of which S. dublin, S. anatun, S. adelaidie, S. shomolu and S. agona were recovered from cattle only. Two isolates of monophasic variety were also from cattle and two rough Salmonella which were identified on the basis of cultural and biochemical characteristics were from goats. Details are shown in Table 1.

S. agama was the commonest serovar followed by S. dublin and S. typhimurium. The latter two are of greater public health significance and known, world-over, for livestock salmonellosis. S. agama is widely prevalent in Nigeria and lizards (Agama agama) are considered to be its natural host. We did not isolate S. enteritidis which was a predominant serovar in an earlier study in Nigeria.27 Serovars S. dublin, S. cubana, S. anatun, S. adelaidie, S. shomolu and S. canada have been isolated from animals for the first time in Nigeria.

The representative isolate of each serotype has been deposited with the International Salmonella Reference Centre, Institute Pasteur, Rue du Dr. Roux, Paris and the respective accession numbers are S. dublin 2881; S. dublin 2882; S. agama 2883; Salmonella 13, 23, i (monophasic) 2884; Salmonella rough 2885 & 2894; S. saint-paul 2886; S. cubana 2888; S. johannesburg 2889; S. anatun 2890; S. canada 2891; S. typhimurium 2892; S. adelaidie 2893; S. agona 2897 and S. shomolu 2899.

There were no gross pathological lesions in the intestines of the animals examined. Gross evidence of mild enteritis was noted in five cattle and two goats of which only one cow was infected with S. adelaidie while the rest were free from salmonella.

Histopathological changes consisting both proliferative and degenerative types observed in several carrier and non carrier cattle and goats were suggestive of acute salmonellosis of GIT described by other investigators.21,22,23 But our observations defy objective pathological explanation because some of these animals were not positive for either Salmonella or intestinal parasites. Thus we can not conclude that carrier state induces pathological changes in GIT. Our findings agree with the suggestion that a variety of factors both intrinsic and environmental has a role in precipitating clinical salmonellosis from the niches where salmonellae hide in carrier animals but breach in epithelial lining is not considered an important prerequisite21,17,18,19,20.

Table 1: Details of Isolation

<table>
<thead>
<tr>
<th>Isolate</th>
<th>Number From Cattle</th>
<th>Number From Goat</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. dublin</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>S. dublin</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>S. agama</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>S. 13, 23, i (monophasic)*</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>S. saint-paul</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Salmonella (rough)</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>S. cubana+</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>S. johannesburg+</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>S. anatun</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>S. typhimurium</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>S. adelaidie</td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>S. shomolu</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>S. canada</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>S. agona</td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

*Variant of S. idikan/S. jukестown or S. kedougou.
+One goat concurrently infected with both of these serotypes.
Acknowledgement
We thank Prof. L. LeMinor of International Salmonella Reference Centre for
detail serological identification of our isolates.

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cattle, sheep, dogs, cats and from other organs
Salmonella enteritidis infection causing septic
98:133.
associated with Salmonella typhimurium in
Salmonella typhimurium infection in calves.

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SOME OBSERVATIONS ON THE PATHOGENICITY OF BLACKLEG DISEASE

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QUELQUES REMARQUES SUR LA PATHOGENICITE DU CHARBON SYMPTOMATIQUE

Résumé

Selon les résultats de nos enquêtes, la présence des spores de *C. chauvoei* dans les muscles des veaux ne les affecte pas. Un facteur prédisposant est nécessaire pour réduire la tension dans les muscles et, par conséquent, retarder la germination des spores et le début de la maladie. Ce facteur pourrait provenir d’une affection interne des muscles due au dépôt d’un agent débilitant (par exemple, l’acide lactique). Les enzymes ou les blessures à la suite d’une hémorragie interne pourraient également servir de facteurs de prédisposition à la maladie.

Summary

Our results suggested that, presence of the spores of *C. chauvoei* alone in the muscles of calves does not harm the animals. A predisposing factor is required to reduce the oxygen tension in the muscles, and consequently germination of the spores and onset of the disease. Such a factor may be brought about by internal muscle damage which results from accumulation of a debilitating agent e.g. (lactic acid). Internal haemorrhages traumas or enzymes may also act as predisposing factors for the onset of the disease.

INTRODUCTION

ANAEROBIC infections are those caused by organisms requiring low redoxpotential in their environment in order to multiply\(^{(1)}\). The best known of these anaerobes are the Clostridis species.

*Clostridium chauvoei* is the main causative agent of blackleg in cattle, while *C. septicum* causes the disease in sheep\(^{(2)}\). In most cases of blackleg in cattle, infection appears to be endogenous as there are no wounds nor other breaks in the skin to explain the entrance of the organisms into the muscle masses, where infection apparently first takes place\(^{(3)}\). Circumstantial evidence indicates that the organism spreads in the faeces of carrier animals, contaminates the pasture and provides spores for the infection of other animals\(^{(4)}\).

The present study was carried out to investigate the mode of infection of cattle by the clostridia leading to blackleg disease. *C. chauvoei* CH, strain and a local sudanese Kad, strain were used in the study.

Materials and Methods

*Cattle*:
Sera from 27 local calves were tested against blackleg organisms, and these calves were found free of circulating antibodies and hence used for experimental work.

*Bacteria*:
Sporulating cultures of *C. chauvoei* CH, and Kad, strains (approximately 4.9 x 10\(^\text{8}\) C.F.U./ml and 3.8 x 10\(^\text{8}\) C.F.U./ml) respectively were used.

*Experimental design*:

*Oral route*:
Six calves were used, three calves for each strain. Each calf was given 100 ml of the sporulating *C. chauvoei* culture through the oral route using 100 ml bottles.

*Intravenous route*:
Similarly, three calves for each strain of *C. chauvoei* were used. Each calf was inoculated (i.v) in the jugular vein with 5
ml of the same culture of *C. chauvoei* spores.

**Reproduction of disease by injury:**

Experimental wounds were induced in the gluteal muscles of three calves using an old rusty knife, dipped thoroughly in the sporulating culture of *C. chauvoei* CH₃ strain. Similarly the experiment was used in other three calves using *C. chauvoei* Kad₁ strain.

**Accacia thorns:**

Long sharp accacia thorns dipped in the sporulating culture of *C. chauvoei* CH₃ were pushed into the gluteal muscles of three calves and left there. The experiment was repeated in an other batch of three calves using *C. chauvoei* Kad₁ strain.

Three calves remained as controls and each was given 10 ml normal saline i.m. All the calves were observed for any signs of blackleg disease, and the temperature was recorded regularly.

**Results**

Upon oral route administration of *C. chauvoei* CH₃ or Kad₁ spores in calves, no signs of blackleg disease were observed. Body temperature recorded was normal. Intravenous inoculation of the same spores into calves showed a moderate swelling developed at the site of inoculation. The temperature was raised by 1°-2°C. No clear signs of the disease were observed, however, the calves were restless for 3 days after which they recovered.

Calves infected with *C. chauvoei* CH₃ or Kad₁ spores using a sharp object, showed typical signs of blackleg disease. A marked swelling developed around the wound after administration of the spores. The animals were lame and unable to eat or drink. Two days after the onset of disease, the animals were recumbent and unable to rise. They showed an increased body temperature which reached 42°C. The calves died 4 days after onset of the disease. The lesions, histopathological pictures and clinical values of the dead animals which simulate typical blackleg disease. Accacia thorns dipped in *C. chauvoei* spores failed to induce the disease condition in calves.

**Discussion**

Our findings indicated that i.v. administration of *C. chauvoei* CH₃ or Kad₁ spores (4.9 x 10⁷ C.F.U./ml and 3.8 x 10⁸ C.F.U./ml) respectively did not cause any harm to the animal, apart from the local tissue reaction around the inoculation site and restlessness which disappeared after 2-3 days. Minett⁵ obtained similar results and showed that quite frequently, millions of spores have been injected into the blood without producing infection, though occasionally lesions developed in the subcutaneous tissues around the inoculation site. This was illustrated by the fact that, the organism may be phagocytosed and die in the blood⁶. Vascular endothelium might have hampered the penetration of the organism into the connective tissue and render the organism less effective. However, the local tissue reaction which occurred, might have been brought about when the organism reached the connective tissue through capillary walls by penetration of organisms. The organism also reached the tissue when the latter was damaged through injection.

Results obtained from the oral administration of the organism displayed no clinical signs of blackleg disease. Green⁶ showed that oral administration of *C. chauvoei* does not harm the animal but renders it immune.

Typical signs of blackleg disease were obtained in calves experimentally infected with *C. chauvoei* spores through mechanically induced wounds. The damage of the tissue produced by using sharp objects might have been at a level to create the right milieu for the germination of spores and onset of the disease. Minett⁵ reported that the spores reside in muscle as latent infection and become activated and vegetative when the muscle is injured in some manner with a lowering of its redoxpotential. The ease with which germination of latent spores might have been set up experimentally by tissue depressants suggests that in nature ger-
mination may be brought about by tissue damage in one way or another which favours the germination of the spores and initiates the onset of the disease. A similar suggestion was made by Cooper et al (1960) who suggested that the activation of spores of C. chauvoei by calcium chloride not only caused local tissue damage favourable for multiplication but also stimulated germination of spores. Harwood (8) also showed that the irritant nature of many commonly used preparations will produce marked local tissue damage, often through the action of the vehicle in which the agent is suspended and thereby produce conditions ideal for the bacterial multiplication.

There are several factors of importance in the pathogenicity of blackleg other than the presence of the organism. The most important of these is the physical condition of the animals. Almost all outbreaks that occur are in animals on a high nutritious food and that are gaining weight. Moreover, in any group of animals in which there is an outbreak of blackleg, those affected are individuals that are in the best physical conditions (4). This relationship between physical condition and susceptibility to C. chauvoei infection is not only noticeable in naturally occurring outbreaks but has been demonstrated in animals that have been experimentally infected (9). Elevation of nutritional status of sheep by increase protein feeding increases their susceptibility to blackleg (9).

The two interesting features in blackleg infection are that injection of washed spores alone, does not set up the disease, and the subsequent inoculation of any substance which damages tissue cells stimulates the multiplication of the organisms and the development of typical blackleg lesions (10). These authors also reported that calcium chloride administered 40 days after inoculation of spores could still activate the dormant spores and development of disease.

Acknowledgements

We are grateful to Director Vet. Res. labs., Sobs for providing facilities to carry out this work and to Prof. A.M. Shommein for revising the manuscripts. Our thanks extended to the National Council for Research and the Permanent Under Secretary, Animal Resources, for their permission to publish this paper.

References


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INTRODUCTION

Leptospirosis is a major zoonotic disease which affects all domestic animals, wildlife and man\(^1\). The major reservoirs of pathogenic leptospires are thought to be rodents and domestic animals\(^2\). In a bacteriological survey of leptospirosis in Zaria, Nigeria, Diallo and Dennis\(^3\) examined 252 rodent kidneys and isolated eight strains of leptospires belonging to *australis* and *ballum* serovars and two unidentified strains. Although previous studies had shown high serological incidence of leptospirosis in man and livestock in different parts of Nigeria\(^4,5,6\), few deliberate attempts to determine the involvement of rodents in the epidemiology of the disease have been undertaken.

Kidney samples were obtained from trapped rodents and processed within one hour of collection. The two kidneys were aseptically plucked with sterile forceps and after decapsulation they were expressed into 10 ml bovine serum albumin (BSA) medium using a 5 ml syringe without needle attached. The homogenate was allowed to stand on the bench for ten minutes before three serial dilutions of 1:50, 1:500 and 1:5,000 were made in BSA medium. From each dilution, 0.1 ml was inoculated into three tubes of semi-solid modified Ellinghausen and McCullough medium (EMJH)\(^7\) containing 150 ug/ml of 5-fluorouracil (Hoffman - LeRoche Inc. N. J.) and two per cent sterile rabbit serum. All the tubes were incubated at 30°C for twelve weeks\(^8\) and examined weekly by darkfield microscopy for characteristic leptospiral growth. Suspect tubes were subcultured into fresh enriched EMJH medium and re-incubated at 30°C.

Blood samples obtained from 105 live trapped rodents were also screened for leptospiral agglutinins by the micro-

scopic agglutination test (MAT)\(^9\) using thirteen live antigens at an initial dilution of 1:100. The rodents were first properly anaesthetized and bled by heart puncture before sacrificing.

All the rodents comprising 435 brown field rats (*Arvicanthus niloticus*), 23 white-tailed rats (*Cricetomys gambianus*) and 44 house mice (*Mus musculus*) were kidney-culture negative but serological examination of 105 serum samples obtained from the brown field rats showed that 47 (44.8%) had antibody titres of 1:100 or higher to one or more of the thirteen leptospiral serovars used as antigens (Table 1). The most frequently detected serovars were *bratislava* 19 (40.4%), *pyrogenes* 8 (17.0%), *grippotyphosa* 6 (12.8%), *pomona* 5 (10.6%), *canicola* 3 (6.4%), *ballum* 2 (4.3%) and *icterohaemorrhagiae* 2 (4.3%). Antibody titres ranging from 1:400 to 1:1600 were detected in 17 (16.2%) of the rats.

Although five strains of pathogenic leptospires were earlier isolated from 252 rodents in Zaria, Nigeria\(^9\), no isolation was made in the present study. Similar attempts to isolate leptospires from 272 house mice in England was unsuccessful\(^{90}\) and they attributed their failure to the geographical location of Britain (an island) which had resulted in a house mouse population that was genetically distinct from those in other geographical regions in terms of susceptibility to leptospiro infection. This explanation cannot strictly apply in the present study because Jos Plateau is situated in an ecological zone quite different from Zaria which lies in the northern Guinea savannah zone. In another study, Ellis *et a*\(^{91}\) recovered no leptospires and detected no leptospiral antibodies in 143 mice trapped on leptospira-infected property and they concluded that rodents were not reservoir hosts for serovar *hardjo*. When
Table 1: Distribution of leptospiral antibody titres in 47 positive sera of rodents trapped in Vom, Plateau State

<table>
<thead>
<tr>
<th>Leptospiral serovar</th>
<th>Number Positive</th>
<th>Percent Positive</th>
<th>Micoscopic agglutination test (MAT) titre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1:100</td>
</tr>
<tr>
<td>bratislava</td>
<td>19</td>
<td>40.4</td>
<td>7</td>
</tr>
<tr>
<td>pyrogenes</td>
<td>8</td>
<td>17.0</td>
<td>1</td>
</tr>
<tr>
<td>grippotyphosa</td>
<td>6</td>
<td>12.8</td>
<td>1</td>
</tr>
<tr>
<td>pomona</td>
<td>5</td>
<td>10.6</td>
<td>3</td>
</tr>
<tr>
<td>canicola</td>
<td>3</td>
<td>6.4</td>
<td>0</td>
</tr>
<tr>
<td>icterohaemorrhagiae</td>
<td>2</td>
<td>4.3</td>
<td>0</td>
</tr>
<tr>
<td>ballum</td>
<td>2</td>
<td>4.3</td>
<td>0</td>
</tr>
<tr>
<td>tarassovi</td>
<td>1</td>
<td>2.1</td>
<td>1</td>
</tr>
<tr>
<td>hardjo</td>
<td>1</td>
<td>2.1</td>
<td>1</td>
</tr>
<tr>
<td>bataviae</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>autumnalis</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>celledoni</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>shermani</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>47</td>
<td>44.8</td>
<td>14</td>
</tr>
</tbody>
</table>

only three leptospires were isolated from 328 rodent kidneys using EMJH medium\(^{(10)}\), the low isolation rate was blamed on poor culture medium even though the same medium was reported suitable for the isolation of leptospires from naturally infected animals\(^{(11)}\). A similar medium was used in the present study. The detection of high leptospiral antibody titres with negative culture result in this study needs reappraisal.

Since leptospirosis in rodents and other wild mammals has occasionally been linked directly to the disease in man and domestic animals\(^{(12,13)}\), a sustained search for the prevalent serovars in domestic and wild animals in Nigeria deserves serious consideration.

Acknowledgement

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References


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VERTEBRAL BODY OSTEOMYELITIS IN A CALF

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OSTEOMYELITE DES VERTEBRES CHEZ UN VEAU

Résumé

Un veau âgé de six mois boitait des pattes de derrière. L'examen de la radiographie a révélé qu'il souffrait d'ostéomyélite de la seconde vertèbre lombaire et de la compression de la moelle épinière au-dessus de cette vertèbre. Un traitement général à l'antibiotique n'a pas permis de guérir l'animal. L'examen nécropsique a confirmé que le veau était atteint d'ostéomyélite de la seconde vertèbre lombaire. Il semblerait que l'agent causal fût l'espèce Actinomyces.

Summary

A 10-month-old calf was lame in both hindlimbs. Radiographic examination revealed osteomyelitis of the second lumbar vertebra and spinal cord compression above this vertebra. Systemic antibiotic therapy did not result in improvement. Necropsy examination confirmed osteomyelitis of the second lumbar vertebra. The causative agent was thought to be Actinomyces species.

INTRODUCTION

Osteomyelitis does not occur commonly in cattle; when it does, it usually develops from a defect or inflammation in the overlying soft tissues and, depending on location, tends to remain localized and involve one bone.

Vertebral body osteomyelitis is a rare but life-threatening condition in animals. Swine are most commonly affected. Sporadic case of vertebral body osteomyelitis have been reported in horses and in cattle. In cattle, cases of posterior paralysis may be related to vertebral abscesses resulting in spinal cord compression. Lumbar vertebrae may be more frequently involved. The lesions are more commonly seen in 0.5 to 2.5 years-old than other age groups. Other causes of pelvic limb paresis or tetraparesis in cattle include metabolic, inflammatory, degenerative, traumatic, and neoplastic lesions that compress the spinal cord. This report is concerned with osteomyelitis of the second lumbar vertebra in a 10-month-old calf. The clinicopathological and radiographical features are presented.

Case Presentation

A ten-month old female Hereford cross calf was admitted to the Veterinary Teaching Hospital with a history of pelvic limb weakness. On admission it had normal demeanour and ate and drank readily. Rectal temperature and heart and respiratory rates were normal. The calf dragged and crossed its hindlimbs during movement and sometimes knuckled and walked on the dorsal aspect of the digits. If made to walk backwards the animal fell over. A large, firm, and painful swelling was palpable over the dorsal aspect of the right fore fetlock joint and it extended distally to the paratenon joint. The calf had an arched back at the thoracolumbar junction. Deep palpation at this point resulted in severe pain. Neurological examination revealed normal cranial nerve function, normal forelimb function and bilateral hindlimb paresis. There were severe proprioceptive deficits in both hindlimbs. Pain sensation was present on the dorsal and plantar surfaces. The patellar reflexes were accentuated. The pan-
niculus reflex was absent caudal to the second lumbar vertebra (L2).

The haemogram revealed mild leukocytosis. Results of CSF analysis were normal. Radiographs of the lumbar spine showed reduced intervertebral disc spaces between L1 and L2 and L2 and L3. L2 showed several radiolucent areas within its body (bony lysis). The lateral view showed ventral displacement of L2 due to collapse and resultant compression by L1 and L3. There was upward displacement of the spinal cord at this site. Myelography showed spinal cord compression above L2 and contrast material did not progress beyond L2 (Fig 1 & 2). Osteomyelitis of L2 was diagnosed.

Radiographs of the right fore fetlock joint showed extensive soft tissue swelling and physisis of the distal metacarpal bone.

Figure 1: VD view of the thoracolumbar vertebrae showing collapsed intervertebral disc spaces between L1 and L2 and L2 and L3. L2 (white arrow) shows several radiolucent areas due to bony lysis.

Figure 2: Radiograph taken postmortem. Contrast material was injected into the lumbosacral joint space soon after the calf was euthanized. Contrast material did not progress beyond L2 (white arrow). The material seen over the thoracic vertebrae was accidentally injected.

The calf was treated with oxytetracycline (5 mg/kg 1M) for one week. The calf was euthanized after the owner was advised of the poor prognosis. At necropsy, the entire second lumbar vertebra was involved in a destructive process which had caused lysis of much of the bone. The spinal cord in this region appeared normal except for a reddened streak on the dorsal surface. There was a three-cm diameter abscess in the perithecicular tissues dorsal and lateral to the right fore fetlock joint. Bacteria were not isolated from this abscess and from the infected second lumbar vertebra. However, a decalcified section of the vertebra showed marked mononuclear cell inflammatory infiltration with loss of bone in some areas. Multinucleated giant cells and multiple "starburst" structures with
clear centres and spicules radiating outwards were present. These giant cells were often bordered by macrophages and neutrophils as well. PAS and Gram stains were not helpful in identifying the causative agent. A histopathological diagnosis of focal, chronic and severe pyogranulomatous osteomyelitis of L2 was made. On the basis of the histopathological appearance, it was thought that the possible causative agent was *Actinomyces* species. There was patchy and mild Wallerian degeneration of the section of the spinal cord overlying L2.

**Discussion**

Vertebral body abscesses or osteomyelitis in the bovine species have been reported sporadically and usually are associated with signs of spinal cord compression. The earliest clinical signs may include fever, back pain and stiffness and radiographic changes in the vertebral bodies occur two to eight weeks after the onset of signs.

Physical examination is very important if there is pelvic limb paresis in the bovine. Several differential diagnoses should be considered. These include traumatic spinal fractures, spinal infection due thromboembolic meningoencephalitis, haematogenous spread from actinomycosis, *Hypoderma bovis* which localize and establish infection near a vertebral body and nutritional muscular dystrophy seen in growing calves in selenium-deficient areas. Rabies must be considered although individuals usually are dead within a short time of onset of signs.

In older cattle, neoplastic lesions that compress the spinal cord must be considered in the differential diagnosis. Other causes of pelvic limb weakness include hypocalcaemia and hypomagnesaemia.

In the present case, the character of the inflammatory exudate and the predilection for bone make actinomycosis or fungal agents as likely causes. There did not appear to be any relationship between the abscess seen in the periarticular tissue of the fetlock joint and the vertebral osteomyelitis. It is probable that there was traumatic episode that occurred earlier and was not noticed by the owner. Infection may then have started from an adjacent wound or was haematogenously carried to affect the vertebra.

It has been hypothesized that because of the low pressure and flow rate in the vertebral venous system, there is tendency to vascular stasis. This provides the ideal conditions for the lodging of an embolus and proliferation of bacteria within it causing vertebral osteomyelitis. In man, osteomyelitis is most common in the metaphyseal area of long bones because the small end artery branches of the metaphyseal vessels turn sharply on themselves and empty into sinusoids. Bacteria are thought to be trapped in these "hairpin" loops or to precipitate out in the sinusoids where the velocity of blood decreases. The bacteria proliferate rapidly in this highly vascular area and produce an acute localized infection.

Treatment appeared to be of little value in the present case. Antibiotic treatment does not seem to be capable of reversing the changes particularly in chronic cases. In human beings antibiotic therapy ranges between three and eight months. Such prolonged treatment is not economically feasible in the bovine. Cattle with any signs of back pain, paresis, fever and leukocytosis should be evaluated for vertebral body osteomyelitis to reach an early diagnosis and save on the cost of treatment.

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**References**


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CHARACTERIZATION OF TRYpanosoma (TRYpanozoon) FROM CAMELS IN KENYA USING BOTH STARCH GEL ELECTROPHORESIS AND ISOELECTRIC FOCUSING

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*Kenya Trypanosomiasis Research Institute, P.O. Box 362, Kikuyu, Kenya

CARACTERISATION DE TRYpanosoma (TRYpanozoon) CHEZ LES DROMADAIREs AU KENYA EN UTILISANT L’ELECTROPHORESE SUR GEL D’AMIDON ET LE POINT ISOELECTRIQUE

Résumé


Summary

Eleven Trypanozoon stocks, isolated from camels in three different areas of Kenya were screened for isoenzyme patterns of two enzymes using both starch-gel electrophoresis and iso-electric focussing (IEF). The two enzymes were chosen on the basis of previous work using only starch gel electrophoresis. The results obtained compared well with those obtained earlier. The bands that occurred after IEF were very clear and confirmed the isolates to be T. evansi.

INTRODUCTION

Characterization of T. evansi by isoenzyme analysis was described in 1983[1]. It was possible to differentiate several types of T. evansi though no correlation was found between isoenzyme types of zymodemes and the symptoms of trypanosomiasis found in camels. Further work[2,3,4] carried out to compare starch-gel electrophoresis and IEF on T. parva. T. vivax and Taenia species showed IEF to be a highly discriminatory method for enzyme heterogeneity. The results obtained by isoenzyme analysis of parasites of both medical and veterinary importance have been used to solve taxonomic problems as well as explaining the epidemiological data[5]. In 1982 further work on echinococcus granulosus[6] from both human and ani-

mal hosts in Kenya using IEF showed that two enzymes: Glucose phosphate Isomerase (GPI) (EC: 5.3.1.9) and malate dehydrogenase (MDH) (EC: 1.1.1.37) could be used to identify hydatid material obtained from numerous animal hosts from Kenya. Isonzyme studies have also been used to differentiate piroplasms isolated from bovine blood infected with Theileria annulata and Theileria parva[7]. Thin layer starch gel electrophoresis was used in the study[6,7]. This technique was also recently successfully extended to the study of Haemoglobin types in various breeds of cattle and sheep[8]. The purpose of this particular study was to find out if IEF could be used to differentiate various stocks of T. evansi obtained from camels in Kenya as opposed to other methods such as Thin-layer starch gel electrophoresis[9] and fly transmission studies[10].
Materials and Methods

Trypanosomes:
Eleven trypanosome stocks were collected from camels in different parts of Kenya namely Ngare Ndare, Galana and Ngurunit. The trypanosome isolates were arranged according to their areas of origin (Table 1). The stocks collected were identified morphologically by microscopic examination of Giemsa stained blood smears and ascertained to belong to the brucei group. The stocks were passaged into rats and mice after prior preservation in the KETRI trypanosome bank. They were later isolated from rat blood on DE - 52 columns\(^{11}\). The isolated trypanosomes were lysed and centrifuged following the method previously described\(^{10}\). The lysates were kept in liquid Nitrogen in form of beads (10ul size) until used in isoenzyme work.

Electrophoresis:
Trypanosome lysates were analysed by electrophoresis: both starch-gel and isoelectric focusing\(^{6,12}\). Only two enzymes were chosen for analysis: EC 5.3.1.9, Glucose phosphate isomerase (GPI) and EC 1.1.1.37, Malate dehydrogenase (MDH).

Results

The camel trypanosome stocks examined according to the ear tag number for identification included C15, C45, C123, C4, C5, C115, C13, C22, C18, C6 and C17. Thus C4 represents trypanozoon infection obtained from a camel whose ear tag read 4. Trypanosome stocks KETRI 2708 and KETRI 2572\(^{12}\) were included for reference. The stocks examined showed very few differences in the two enzymes studied (Figs 1a, b and 2a, b) on IEF and one enzyme studied on starch-gel electrophoresis (Fig. 3.)

MDH enzyme showed similar isoenzyme bands in 11 stocks studied (Fig 2a), with slight variation occurring only in one sample (Fig 2b). GPI enzyme showed the differences between the stocks studied more distinctly (Fig 1a, b).

Starch-gel electrophoresis of the same samples for the enzyme ME showed similarities in all the samples (Fig 3).

Discussion

The T. evansi stocks used in this study were new and have not yet been documented according to the WHO\(^{12}\) in the KETRI trypanosome bank, except for two stocks KETRI 2708, T. rhodesienscere BUSOGA/64, EATRO 842/stabilate and KETRI 2572 T. gambiense MZARA SUDAN/82/stabilate.

To try and understand the taxonomic and epidemiological data of the Trypanosoma evansi parasites, isoenzyme studies using Thin-layer starch starch gel electrophoresis have been successfully used in the past for isoenzyme characterization. From the results of this study isoenzyme characterization using isoelectric focusing for T. evansi appears to be superior. This agrees with earlier work carried out on different parasites which established that IEF was a\(^{6,6}\) highly discriminating method for enzyme heterogeneity, as opposed to Thin-layer starch gel electrophoresis. The enzymes chosen in this study were those that were easily resolved and not so difficult to interpret in comparison to the nine enzymes studied by Thin-layer

<table>
<thead>
<tr>
<th>Trypanosome stock</th>
<th>Origin</th>
<th>Isoenzyme pattern</th>
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</thead>
<tbody>
<tr>
<td>C15, C45, C6</td>
<td>Ngare Ndare</td>
<td>II</td>
</tr>
<tr>
<td>C115, C17, C123</td>
<td>Galana</td>
<td>III</td>
</tr>
<tr>
<td>C4, C5, C13, C22, C18</td>
<td>Ngurunit</td>
<td>IV</td>
</tr>
<tr>
<td>KETRI2572</td>
<td>Mzara Sudan/82</td>
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<tr>
<td>KETRI2708</td>
<td>Busoga/64, EATRO 842</td>
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</tbody>
</table>
Characterization of Trypanosoma (Trypanozoon) from camels in Kenya using both starch gel electrophoresis and isoelectric focussing

Fig. 1, 2 & 3: Picture of isoenzyme patterns of two variable enzymes among Trypanozoon stocks from Kenyan Camels.

Fig. (1b, 2b, 3):
- C15
- C45
- KETRI 2572
- KETRI 2708
- C123

Fig. 1a, 2a
1: C15
2: C45
3: C123
4: C4
5: C5
6: C115
7: C13
8: C22
9: C45
10: C6
11: C17
starch-gel electrophoresis\textsuperscript{15,13}. From the results, GPI and MDH isoenzyme bands clearly show the existence of two different zymodemes of \textit{T. evansi}.

Acknowledgements

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References


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SEASONAL PATTERN OF FASCIOILA GIRANTICA AND CYSTICERCUS TENUICOLLIS INFECTIONS IN SHEEP AND GOATS IN EGYPT

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University Zagazig, Egypt

TYPE SAISONNIER D’INFECTIONS PAR FASCIOILA GIRANTICA ET CYSTICERCUS TENUICOLLIS CHEZ LES OVINS ET LES CAPRINS EN EGYPTE

Résumé
Les foies et les cavités péritonéales de 369 moutons et 240 chèvres ont été examinés à l’abattoir de Zagazig, en vue de déterminer la prévalence de Fasciola gigantica et de Cysticercus tenuicollis. L’infection par E. gigantica était plus fréquente chez les ovins que chez les caprins. La prévalence de l’infection par Fasciola était très forte en automne (septembre-novembre), tandis que celle de l’infection par Cysticercus fut très élevée à la fin de l’hiver. Le nombre d’animaux ayant des infections mixtes était plus faible que ceux atteints d’infections uniques. L’importance épidémiologique de ces résultats est discutée.

Summary
Livers and peritoneal cavities of 369 sheep and 240 goats were examined at Zagazig abattoir to assess the prevalence of Fasciola gigantica and Cysticercus tenuicollis. More sheep were infected with F. gigantica than were goats. The prevalence of Fasciola infection was highest in fall (September-November), whereas that of Cysticercus was highest in late winter. The number of animals with mixed infections was lower than those with single infections. The epidemiological significance of these findings is discussed.

INTRODUCTION
Sharkia province occupies a part of the eastern territory of the Nile Delta in Egypt. Its economy is based mainly on agriculture. This includes livestock especially small ruminants. The majority of sheep and goats are kept in free-roaming flocks in rural areas of the province. The main fodder sources are found on the banks of irrigation canals and crop residues. Guard dogs are kept among grazing flocks.

This management system enhances the risks of acquiring infections with Fasciola gigantica and Cysticercus tenuicollis, the metacestode stage of the dog tapeworm, Taenia hydatigena.

There exists controversial evidence that C. tenuicollis infections may provide some protection against fascioliasis\(^1\)\(^2\). These studies are based on laboratory experimental data and it appears appropriate to test the interrelation between C. tenuicollis and F. gigantica in a field study.

The aim of this study was to determine the seasonal pattern of the occurrence of F. gigantica and C. tenuicollis in native breeds of sheep and goats reared under the Egyptian style of management, and to determine the interaction between both parasites in naturally infected animals.

Material and Methods
Between November, 1985 and October, 1986, 369 sheep and 240 goat carcasses were examined for the presence of F. gigantica or/and C. tenuicollis at the abat-
toir of Zagazig city, Sharkia Province, Egypt. The abattoir was visited once a week during this period. Animals examined were native breeds and between one to three years of age.

After slaughter, the livers of the animals were examined and palpated in situ for evidence of liverfluke infection and for the presence of cysticerci. The livers with detectable lesions were sliced and major bile ducts, which showed gross enlargement were opened. In addition, serous membranes in the abdominal cavity, thorax and pelvis were examined for the presence of metacestodes.

The data were statistically analysed using the Whsae t-test. Climatic data were obtained from Zagazig meteorological office.

**Results**

Of 369 sheep examined, 145 (39.3%) were found to be infected with *F. gigantica* and of 240 goats, 35 (14.6%) showed evidence of infection (table 1). Seasonal prevalence rate of *Fasciola* as detected by bile duct examination is shown in Table 1 and Figure 1. The highest infection rates were seen in late summer and fall.

The predominant predilection site of cysticerci was the omentum. However, a few of them, in a small number of animals, were found on the liver surface, urinary bladder and lung. In most animals, the number of metacestodes ranged between 1-3 per animal. A few animals had 9-19 cysticerci in the abdominal cavity. These cysticerci were smaller in size and were generally seen in younger animals.

There was no significant difference between the infection rate in sheep (29.8%) and that in goats (33.3%), (Table 1).

The prevalence of *C. tenuicollis* infection was lower in summer (22.4%) than in winter (38.3%) and in spring (35.8%), (see Table 1 and Figure 1).

Of a total of 609 animals (sheep and goats) examined, 141 (23.2%), 152 (25.0%) and 39 (6.4%) had *Fasciola, Cysticercus* and a mixed infection respectively. Statistically, the percentage of animals with mixed infection was lower than those that had *Fasciola* or *Cysticercus* only (Table 2). Moreover, livers with mixed infections showed fewer macroscopic lesions as compared with those with *Fasciola* infections only.

**Discussion**

The infection rate with *F. gigantica* was higher in sheep than in goats. Similar observations were made by Schillhorn van Veen who considered grazing behavior as the major reason. Goats are browsers more than they are grazers and thereby reduce the risk of acquiring grass-borne parasites. Management can be considered as another reason. Sheep and goats are usually kept in the same flock and driven to the banks of the irrigation canals for grazing. The grazing areas are narrow places and the animals compete to drink and eat. Because sheep are stronger and larger in number they reach the water and aquatic grasses before goats. In this way, sheep are exposed more to the infection than goats are.

This study confirms that there is a seasonal variation in the infection rate with *F. gigantica* and *C. tenuicollis*. Climatic conditions in each season have an effect on the density of the intermediate host, the survival and life span of eggs and the infective stages, the animal husbandry practice and the plants cultivated in the particular time of the year.

In Egypt, *Lymnaea natalensis* is considered the only intermediate host of *F. gigantica* in the Nile Valley. The population of this water snail is affected by temperatures and the water level in irrigation canals.

To understand the complete picture of the epidemiology of *Fascioliasis* in Egypt, the bionomics of *L. natalensis* should be correlated with the incidence of *Fasciola* infection.

In winter, most of the canals and drains are dried up due to what is called winter closure and significant snail mortality occurs. Leiper has pointed out that certain snails are able to survive dry conditions by burrowing themselves in mud and migrating through the cracks and fissures in the canal beds. These surviving
Table 1: Seasonal occurrence of *F. gigantica* and *C. tenuicollis* in sheep and goats slaughtered at Zagazig abattoir

<table>
<thead>
<tr>
<th>Season of examination</th>
<th>Host</th>
<th>No. of examined animals</th>
<th>No. of infected animals (%)</th>
<th>Overall No. of infected animals (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>winter</td>
<td>sheep</td>
<td>76</td>
<td>19 (25)</td>
<td>26 (34.2)</td>
</tr>
<tr>
<td></td>
<td>goats</td>
<td>65</td>
<td>4 (6.2)</td>
<td>28 (43.1)</td>
</tr>
<tr>
<td>spring</td>
<td>sheep</td>
<td>81</td>
<td>29 (35.8)</td>
<td>26 (32.1)</td>
</tr>
<tr>
<td></td>
<td>goats</td>
<td>70</td>
<td>10 (14.3)</td>
<td>28 (40)</td>
</tr>
<tr>
<td>summer</td>
<td>sheep</td>
<td>95</td>
<td>39 (41.1)</td>
<td>25 (26.3)</td>
</tr>
<tr>
<td></td>
<td>goats</td>
<td>39</td>
<td>8 (20.5)</td>
<td>5 (12.8)</td>
</tr>
<tr>
<td>Fall</td>
<td>sheep</td>
<td>117</td>
<td>58 (49.6)</td>
<td>33 (28.2)</td>
</tr>
<tr>
<td></td>
<td>goats</td>
<td>66</td>
<td>13 (19.7)</td>
<td>20 (30.3)</td>
</tr>
<tr>
<td>Total</td>
<td>sheep</td>
<td>369</td>
<td>145 (39.3)a</td>
<td>110 (29.8)a</td>
</tr>
<tr>
<td></td>
<td>goats</td>
<td>240</td>
<td>35 (14.6)b</td>
<td>81 (33.8)a</td>
</tr>
</tbody>
</table>

*F = Fasciola*  
*C = Cysticercus*  
Figures in columns which do not share superscript letters differ significantly.

Table 2: Single and mixed infections with *F. gigantica* and *C. tenuicollis* in sheep and goats slaughtered at Zagazig abattoir

<table>
<thead>
<tr>
<th>Season of examination</th>
<th>No. of examined animals (sheep and goats)</th>
<th>F</th>
<th>No. of infected animals (%)</th>
<th>C</th>
<th>both</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter</td>
<td>141</td>
<td>20 (14.2)</td>
<td>51 (36.2)</td>
<td>3 (2.1)</td>
<td></td>
</tr>
<tr>
<td>spring</td>
<td>151</td>
<td>33 (21.9)</td>
<td>48 (31.8)</td>
<td>6 (4.0)</td>
<td></td>
</tr>
<tr>
<td>summer</td>
<td>134</td>
<td>38 (28.4)</td>
<td>21 (15.7)</td>
<td>9 (6.7)</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>183</td>
<td>50 (27.3)</td>
<td>32 (17.5)</td>
<td>21 (11.5)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>609</td>
<td>141 (23.2)a</td>
<td>152 (25.0)a</td>
<td>39 (6.4)b</td>
<td></td>
</tr>
</tbody>
</table>

*F = Fasciola*  
*C = Cysticercus*  
Figures in line which do not share superscript letters differ significantly.

% of infected animals with *F. gigantica* and *C. tenuicollis*.

Mean monthly temperatures (°C)

Snails provide a nucleus for the subsequent generation which spreads when the water level increases\(^5\).

The spring rise in *L. natalensis* population coincides with the shortage in green fodder and the beginning of hot weather and the animals are more frequently driven to the banks of the canals for grazing, drinking and wallowing. This not only provides a risk of acquiring fluke infection but also leads to the contamination of the water with *Fasciola* eggs and increases the risk of snail infection. Abdel Ghani\(^7\) recorded a high infection rate in *Lymnaea* snail during spring. The subsequent emergence of cercariae should then occur at the beginning and mid of summer. Nagaty *et al.*\(^8\) found *Fasciola* cer-
cariae in about 63% of the snails in July. In the present study, the highest percentage of livers found infected with adult Fasciola in late summer (August) and in fall substantiate the theory that the highest infection of snail occurs in the spring and the highest infection of animals with metacercariae occurs at the beginning to the middle of summer.

Prevalence of C. tenuicollis is directly linked to the survival of Taenia hydatigena eggs on the pasture. High temperature and desiccation is inimical to the survival of T. hydatigena eggs\(^9\).
Gemmell(10) found that the absence of surface moisture and or/high temperatures during storage prevented hatching. In the present study, there was, indeed, a negative correlation between environmental temperature and the infective rate with cysticerci. In summer and fall, infection rate with C. tenuicollis was lower than in winter and spring. In winter, the temperature is low and rains occur. Pathak and Gaur(11) also observed that the highest incidence of C. tenuicollis in India was during the rainy season.

Our study shows that in the field there appears to be a negative correlation between F. gigantica and C. tenuicollis. The percentage of animals with mixed infections was significantly lower than that of those infected with a single species. Whether or not this is due to interaction between F. gigantica and C. tenuicollis, whereby one parasite inhibits the infection with the other is not clear.

Experimentally, Campbell et al. (1) found that C. tenuicollis infection in sheep in Australia greatly protects them against Fasciola hepatica. Nevertheless, Hughes et al. (2) did not observe this finding in sheep in England and postulated that the use of levamisole by Campbell et al., to control nematode infection in their sheep could explain the differences in results. Genetic resistance to Fasciola infection may be a cause for the differences of the results in Australia and England since different breeds of sheep were used in these experiments(13).

In the light of our present results it is recommended to further test, experimentally, the interaction between Fasciola and C. tenuicollis in Egyptian breed of sheep using F. gigantica.

Acknowledgement

The authors wish to thank Dr. T.W. Schillhorn van Veen, Professor of Parasitology, College of Veterinary Medicine, Michigan State University, U.S.A. for revising the manuscript.

References


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IMMUNOHISTOLOGICAL CONFIRMATION OF A DIAGNOSIS OF RINDERPEST FROM A RECENT NATURAL OUTBREAK

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CONFIRMATION IMMUNOHISTOLOGIQUE D'UN DIAGNOSTIC DE LA PESTE BOVINE DANS UN FOYER NATUREL RECENT

Résumé

La méthode de la peroxydase-antiperoxidase (PAP) a été utilisée pour démontrer la présence des antigènes du virus de la peste bovine dans les tissus intestinaux et lymphoides fixés avec du formol et enrobés de paraffine, prélevés des bovins dans un foyer naturel récent du Kenya. Le virus détecté n'a pas pu être isolé auparavant dans les cultures cellulaires; par conséquent, il s'est avéré que la technique PAP est fiable pour le diagnostic de la peste bovine.

Summary

Peroxidase-antiperoxidase (PAP) method was used to demonstrate rinderpest virus antigen in formalin-fixed paraffin-embedded intestinal and lymphoid tissues from cattle in a recent natural outbreak in Kenya. The virus involved was initially impossible to isolate in cell cultures and PAP technique has proved a reliable tool for diagnosis of rinderpest.

INTRODUCTION

Immunoperoxidase staining method is a valuable diagnostic histological procedure. It is superior to immunofluorescence in that, it gives permanent results and requires an ordinary light microscope, for detection of antigen and evaluation of morphological changes associated with the antigen. Immunoperoxidase techniques have been successfully applied to demonstrate a variety of viral antigens in tissues, including, rabies, infectious bursal disease and infectious bronchitis viruses. Recently, we successfully demonstrated rinderpest virus antigens using PAP technique in formalin-fixed and paraffin-embedded tissues from experimentally infected cattle. In a recent outbreak of rinderpest in Kenya, viral antigens were demonstrated in an agar gel immunodiffusion test, but virus isolation in tissue cultures was initially unyielding (Wamwayi personal communication). This paper reports the demonstration of rinderpest virus antigens using PAP technique on material from the above reported recent disease outbreak in an attempt to further confirm the diagnosis.

Materials and Methods

Tissues examined:
Samples were obtained from autopsy material of three adult cattle that died from a recent outbreak of rinderpest in Kenya. Sections were taken from the tongue, cheek, oesophagus, small and large intestines, prescapular and mesenteric lymph nodes and the spleen. The materials were fixed in formalin and processed through paraffin. Tissues were prepared
at 5μ thickness and processed for the peroxidase-antiperoxidase technique.

Rabbit antiserum:
Rabbit antiserum was produced to rinderpest virus as previously described.[7]

Immunoperoxidase technique
The method used was PAP technique[9,10]. Sections were deparaffinized in xylene and rehydrated in a graded series of alcohol. Endogenous peroxidase was inhibited by incubating sections in 3% H₂O₂ for 40 minutes. Non-specific protein binding was blocked by incubating the tissues for 15 minutes in non-immune swine serum diluted 1:5 in 5% bovine serum albumin (BSA). Tissues were then exposed for 30 minutes to successive antibody solutions as follows; rabbit anti-rinderpest serum diluted 1:200, swine anti-rabbit serum (Dakopatt) diluted 1:20 and rabbit PAP-complex (Dakopatt) diluted 1:100. All incubations were undertaken in a moist chamber and at room temperature. Tissues were rinsed in tris buffered saline (TBS) between each incubation, except after blocking non-specific protein binding. All antibody solutions were diluted in TBS containing 1% BSA.

The reaction was visualized in a TBS solution containing 0.06% 3-3 Diaminobenzidine tetrahydrochloride (DAB) and 0.03% H₂O₂ for 4 minutes. The reaction was terminated by adding tap water and sections were thereafter counterstained in Mayer’s haematoxylin for 3 minutes, in D.P.X. dehydrated, cleared and mounted for microscopy.

Controls were prepared by substituting rabbit anti-rinderpest serum for non-immune rabbit serum and including corresponding sections from non-infected cattle. Positive control tissues from cattle experimentally infected with virulent rinderpest virus were also included.

Results
Summary of major findings is presented in Table 1. Rinderpest virus antigens occurred mainly in the cytoplasm of epithelial cells lining crypts and villi of small and large intestines (Fig. 1). Positive reaction occurred as homogeneous brown granular deposits in the cytoplasm. The reaction was spread over wide areas and appeared in most crypts and villi. To a lesser extent, macrophages and lymphocytes in the laminar propria and submucosa also contained viral antigens in the cytoplasm. The reaction in lymph nodes and the spleen was faint, indicating that infection rate in these tissues may have been low. Oral mucosa (tongue and cheeks), and oesophagus did not show any positive reaction. Tissues from control materials were negative for the antigen (Fig. II). Histopathological changes were unremarkable as only very mild necrotic changes occurred in lymph nodes, spleen and gastrointestinal mucosa. Positive control material pre-

<table>
<thead>
<tr>
<th>Tissue Examined</th>
<th>Mg 90 A</th>
<th>CASE NUMBER</th>
<th>Mg 90 B</th>
<th>Mg 90 C</th>
<th>315 A₁₇ (+ve control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small intestines</td>
<td>++ ++</td>
<td>++ ++</td>
<td>++ +</td>
<td>++ ++</td>
<td>++ ++</td>
</tr>
<tr>
<td>Large intestines</td>
<td>++ +</td>
<td>++ +</td>
<td>++ +</td>
<td>++ +</td>
<td>++ ++</td>
</tr>
<tr>
<td>Mesenteric Lymph nodes</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Prescapular Lymph nodes</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Spleen</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Tongue</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Key: +++++: Very intensive occurrence of antigen.
+++++: Intense occurrence of antigen.
++: Faint occurrence of antigen.
-: No antigen detected.
strain of low virulence and reduced capacity to infect lymphoid tissues. Positive correlation between increased virulence and increased ability to infect lymphocytes has been demonstrated in vitro. The fact that virus isolation in tissue cultures presented initial difficulties and that histopathological changes in gastrointestinal and lymphoid tissues were unremarkable, may provide further support to this suggestion. The virus may possibly have been more epitheliotropic than lymphotropic. Concentration of viral antigens in lymphoid tissues would thus have been low than in intestinal mucosa at the time of autopsy. It is clear from the results that if intestinal mucosa/contents was omitted during virus isolation, then the negative virological results would not be surprising.

We have confirmed the diagnosis of rinderpest in an outbreak from which virus isolation was initially unsuccessful. This work emphasizes the importance of immunoperoxidase-technique as a complementary reproducible diagnostic tool for rinderpest.

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References


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EFFECTIVENESS OF FLUIDS AND ANTIBIOTICS AS SUPPORTIVE THERAPY OF CANINE PARVOVIRUS-2 ENTERITIS IN PUPPIES

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EFFICACITE DES LIQUIDES ET DES ANTIBIOTIQUES UTILISES COMME TRAITEMENT D’APPOINT DE L’ENTERITE CANINE PAR PARVOVIRUS-2 CHEZ LES CHIOTS

Résumé
Après l’inoculation orale du parvovirus-2 canin, 37 chiots de diverses races, âgés de 6 à 12 semaines, ont été traités avec des liquides isotoniques et des antibiotiques à large spectre après le début des symptômes de l’entérite. 11 chiots-témoin ont été inoculés de la même manière, mais n’ont pas reçu de traitement. Le taux de mortalité, ainsi que la durée et l’incidence des symptômes étaient déterminés. On a étudié l’hématologie, la pathologie et l’immunologie des chiots. La mortalité a baissé de 28,7% après le traitement. La durée et l’incidence des signes cliniques ont légèrement augmenté. L’importance des changements hématologiques et pathologiques était variable et avait des rapports avec ceux observés chez les chiots non-traités.

Summary
Following oral inoculation with Canine Parvovirus-2 (CPV-2), thirty seven 6 to 12 week-old mixed breed puppies were treated with isotonic fluids and broad-spectrum antibiotics after onset of clinical signs of enteritis. Eleven control puppies were similarly inoculated but not treated. Mortality rate, duration and incidence of clinical signs were determined. Haematology, pathology and immunology of the puppies studied. Mortality was reduced by 28.7% following this treatment. The duration and incidence of clinical signs increased slightly. The severity of haematological and pathological changes was variable but related to those observed in untreated puppies.

INTRODUCTION

Although there is no agreement on the optimal immunoprophylaxis strategy of canine parvovirus-2 infection, the disease incidence and fatality has been reduced by vaccination(1,2,3,4,5). However, immunisation failure in puppies born to immune bitches remain the biggest challenge to dog owner and veterinarians. Persistent low maternal antibody titres in puppies inactivate the vaccine while not protecting against the wild virus(6). This has led to persistent canine parvoviral enteritis outbreaks worldwide.

Canine parvoviral enteritis is characterised by anorexia, relative pyrexia, vomiting and diarrhoea after an incubation period of between 3 and 7 days(7,8,9). While vomiting seems to be a less consistent feature of the disease(9), anorexia and diarrhoea occur in almost all the dogs infected(7,9). Diarrhoea sets in 6 24 hours after initial signs of anorexia, lethargy and pyrexia, and varies from soft fluid faeces, grayish or yellow in colour to frank haemorrhage that is foul smelling and mucoid(7,8). Dehydration and weight loss are marked and without fluid therapy, there is rapid deterioration with puppies becoming moribund 48 to 72 hours after onset of clinical signs.

Treatment of canine parvovirus enteritis is mainly supportive. It involves
replacement of fluid losses which occur through diarrhoea and vomiting, and prevention of intercurrent bacterial infection\(^\text{10,11}\). The mucosal barrier of the intestines is eroded, and intestinal peristalsis ineffective, predisposing the animal to bacteremia and septicemia\(^\text{11}\). Additionally, leucopenia and the immunosuppression predispose the animal to secondary bacterial infection\(^\text{10,11}\).

Effective fluid therapy includes replacement of animal dehydration deficit, provision of maintenance fluids and catering for contemporary (on going) losses\(^\text{12}\). Broad-spectrum antibiotics are administered parenterally since oral administration is rendered ineffective by vomiting, ineffective intestinal peristalsis and altered intestinal mucosal integrity\(^\text{11}\). Intestinal motility modifiers are not recommended as they decrease flow of ingesta which may lead to absorption of endotoxins\(^\text{10,11}\). However, adsorbents such as animal charcoal may be used to bind toxins.

There is little information on effectiveness of fluids and antibiotics as supportive therapy of CPV-2 infection. Whereas various workers have reported varying mortality rates following canine parvoviral enteritis outbreaks\(^\text{9,13,14,15}\), precise information on the number of dogs given fluids and age distribution of the affected dogs is lacking. Since the disease occurs in puppies in 6 to 12 weeks of age, which are more prone to dehydration than adult dogs\(^\text{12}\), effectiveness of fluids and antibiotics treatment, which is both expensive and time consuming requires assessment. The information obtained would provide guidelines as to the expected recovery rate following this mode of treatment in CPV-2 enteritis outbreaks. This study was designed to investigate the role and efficacy of fluids and antibiotics in minimising mortality due to CPV-2 enteritis in puppies 6 to 12 weeks old.

**Materials and Methods**

**Experimental animals**

Forty eight clinically healthy mixed-breed puppies of either sex ranging in age from 6 to 8 weeks were purchased from local dog owners. On arrival, each puppy was dewormed using a combination of pyrantel pamoate (Canex\textsuperscript{R}-Pfizer Inc. New York, USA) and praziquantel (Droncit\textsuperscript{R}-Bayer Pharma, W. Germany) and collars with identification numbers put on each. Body weight was recorded and each puppy housed in an individual chamber within a large cemented kennel. They were fed commercial dog food supplemented with milk and meat daily. Water was provided *ad libitum*.

**Experimental procedure**

Two days acclimatization period was allowed before commencement of experiments. The experimental period was 12 days. The puppies were fasted for 12 hours before oral inoculation with 20 millilitres of the viral inoculum prepared as described below. Fasting continued for a further 6 hours after inoculation. Blood for haematology and serum for CPV-2 antibody assay were collected before and after virus inoculation.

Following onset of diarrhoea and vomiting, fluids and antibiotics therapy was started in thirty-seven puppies. The remaining eleven puppies were not treated. Faecal samples were collected for bacteriology, virology and immunology. Necropsy was done on all cases that died. Puppies surviving until day 12 post-inoculation were euthanised and necropsy carried out.

**Preparation of CPV-2 inoculum**

Canine parvovirus-2 inoculum was prepared from faecal material collected from puppies showing clinical disease and confirmed using reference serum kindly obtained from Prof. L.E. Carmichael of James A. Baker Institute, U.S.A. Screening for other causes of gastroenteritis such as helminthiasis and bacterial infection was routinely done.

An equal volume of saline was added to the faecal material and thoroughly homogenised. Then it was centrifuged at 3,000 revolutions per minute (rpm) for 20 minutes to recover the supernatant. Bacteria culturing was carried out to rule out common causes of gastroenteritis in pup-
pies such as Salmonella and Campylobacter spp. Then penicillin-dihydrostreptomycin was added to the supernatant which was stored in 10 ml volumes at -20°C using screw-capped universal bottles.

A small amount of the inoculum was used to carry out haemagglutination (HA) test to determine the titre. The inoculum had a haemagglutination titre ranging between 1:512 and 1:3.36 x 10^7. Prior to inoculation, a second bacteria culturing was done. The inoculum was then diluted to an estimated titre of 1:512 using sterile, pyrogen free water (Water for injection^R-Infusion Kenya Limited, Nairobi, Kenya). Twenty millilitres of this was given orally to each puppy using a sterile syringe. Infectivity had been shown to correlate with the haemagglutination titre of the inoculum^{17}.

Clinical examination

Temperature was recorded twice a day between 8.30 and 10.00 A.M. and also between 4.00 and 5.30 P.M. throughout the experiment period. Food intake, diarrhoea and vomiting were monitored. Body weight was used to assess the hydration status^{18}.

A hospital case sheet was used for each case to record daily parameters and treatment given. Normal blood values and temperature within the experimental conditions for comparative analysis were as indicated earlier^{17}.

Treatment

An isotonic fluid solution (Hartmanns solution^R-Infusion Kenya limited, Nairobi, Kenya) was used. Amount given to a puppy depended on the weight of the puppy, estimated percent dehydration and estimated daily losses through diarrhoea and vomiting^{19}. All fluids were given intraperitoneally. The broad spectrum antibiotic (Combioticq-Pfizer Canada Inc., Montreal, Canada) used contained procaine penicillin-G (200,000 I.U. per millilitre) and dihydrostreptomycin (250 mg per millilitre). A high dose of 20 mg/kg body weight of dihydrostreptomycin and 20,000 I.U./kg body weight of procaine penicillin-G was injected intramus-cularly once a day from onset of clinical signs until death or recovery.

Results

Infected untreated control animals

(a) Clinical signs

Of the eleven puppies infected with CPV-2 but not given any supportive treatment, ten died (mortality = 90.9%) Death occurred between days 3 and 9 post-inoculation (PI) (Fig. 1). The mean duration and percent incidence of clinical signs is shown in Table 1.

The puppy that died on day 3 PI was anorexic for less than 12 hours prior to death. No diarrhoea, vomiting or pyrexia were observed. Leucocyte levels were above 10,000/ cubic millimetre (10,000/cm) of blood 24 hours before death.

The surviving puppy had pyrexia (39.4°C) on the afternoon of day 3 PI that persisted for 24 hours. Yellowish diarrhoea was noticed on days 4.5 and 6 PI during which the appetite was also reduced. No vomiting was observed.

(b) Haematology

In all the puppies (except the one that died on day 3 PI), total white blood cells and neutrophils increased slightly until day 2 PI followed by a progressive decrease (Fig. 2). Lymphocyte levels remained relatively high compared with neutrophils throughout the 8 days. Even in puppies where total leucocyte count was below 4,000/millilitres (4,000/cm) of blood, lymphocyte levels remained within the normal range in some cases, accounting for up to 90% of all leucocytes in some instances. Finding neutrophils in blood smears made from puppies having less than 1,500 leucocytes/cm of blood was difficult. Absolute lymphopenia (<1100 lymphocytes/cm of blood) was only observed in extremely leukopenic puppies.

In the surviving puppy, both total leucocyte and neutrophils decreased from day 2 to 8 PI when 10,000 and 6,000/cm respectively were recorded. A lymphocytes count of 3,700/cm of blood was recorded on day 8 PI from this puppy.
Table 1: Mean duration and percent incidence of clinical signs in puppies infected with CPV-2 that were not treated and those treated with fluids and antibiotics after onset of clinical signs

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>Untreated</th>
<th>F/A treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% cases</td>
<td>Mean duration (Days)</td>
</tr>
<tr>
<td>Anorexia</td>
<td>100</td>
<td>4.5</td>
</tr>
<tr>
<td>Fever</td>
<td>45.45</td>
<td>2.0</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>100</td>
<td>2.0</td>
</tr>
<tr>
<td>Vomiting</td>
<td>36.36</td>
<td>1.5</td>
</tr>
</tbody>
</table>

1. Untreated — means cases infected with CPV-2 but not given any supportive treatment.
2. F/A — means CPV-2 infected cases that were treated with fluids and antibiotics only.
3. Fever = Temperature ≥ 39.3°C.

Table 2: Mean values of packed cell volume, total protein, hemoglobin and mean corpuscular volume in puppies inoculated with CPV-2 and not given any treatment

<table>
<thead>
<tr>
<th>Days after oral CPV-2 inoculation</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed cell volume (%)</td>
<td>26.8</td>
<td>29.5</td>
<td>30.5</td>
<td>33.6</td>
<td>34.7</td>
<td>--</td>
</tr>
<tr>
<td>Hemoglobin (gm/100 mls)</td>
<td>9.9</td>
<td>9.9</td>
<td>10.5</td>
<td>11.2</td>
<td>11.9</td>
<td>--</td>
</tr>
<tr>
<td>Mean corpuscular volume (µm³)</td>
<td>70.5</td>
<td>72.5</td>
<td>72.9</td>
<td>71.3</td>
<td>69.5</td>
<td>--</td>
</tr>
<tr>
<td>Total proteins (gm/100 mls)</td>
<td>5.8</td>
<td>5.6</td>
<td>5.6</td>
<td>5.6</td>
<td>5.7</td>
<td>--</td>
</tr>
</tbody>
</table>

*By day 10 PI, only one puppy was alive.

All its leucocytes levels increased progressively after day 8 PI.

The packed cell volume (PCV) increased gradually (Tab. 2). An average increase of up to 7% occurred day 1 and 8 PI. There was a corresponding increase in mean haemoglobin levels, averaging 2.0 gm/100 ml of blood by day 8 PI. As high as 6.37 million erythrocytes/cmm of blood, PCV of 47% and 14 gms/100 mls of haemoglobin were recorded in a leucopenic puppy (2,900 leucocytes/cmm of blood) 12 hours prior to death. However, total plasma proteins remained within the same level throughout the disease period. The mean corpuscular volume increased between day 1 and 4, followed by a decrease.

(c) Pathology

At necropsy, the animals were emaciated and dehydrated. There were varying amounts of straw to clear fluids in the peritoneal cavity. The intestinal mucosa was severely hyperaemic with streaks of haemorrhages. Haemorrhage was more severe at the duodenum and proximal jejunum. In some puppies, the stomach was diffusely haemorrhagic, especially around the pyloric region. Numerous discrete rounded ulcers of varying diameter were scattered in the intestinal mucosa, especially at the jejunum and ileum. The colon had clear linear haemorrhages but no ulceration.

Microscopically, the epithelial lining of the intestinal mucosa and the crypt were
Table 3: Mean values of packed cell volume, total proteins, hemoglobin and mean corpuscular volume for puppies infected with CPV-2 and treated with fluids and antibiotics after onset of clinical signs

<table>
<thead>
<tr>
<th>Days after CPV-2 inoculation</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed cell volume (%)</td>
<td>29.6</td>
<td>29.9</td>
<td>29.0</td>
<td>28.3</td>
<td>31.2</td>
<td>NT</td>
<td>31.8</td>
</tr>
<tr>
<td>Hemoglobin (gm/100 mls)</td>
<td>9.7</td>
<td>9.6</td>
<td>9.7</td>
<td>9.8</td>
<td>10.3</td>
<td>NT</td>
<td>10.0</td>
</tr>
<tr>
<td>Mean corpuscular volume (μ³)</td>
<td>73.3</td>
<td>73.3</td>
<td>73.7</td>
<td>72.0</td>
<td>70.8</td>
<td>NT</td>
<td>70.3</td>
</tr>
<tr>
<td>Total protein (gm/100 mls)</td>
<td>5.4</td>
<td>5.4</td>
<td>5.2</td>
<td>5.5</td>
<td>4.9</td>
<td>NT</td>
<td>4.9</td>
</tr>
</tbody>
</table>

NT = Not taken.

![Graph showing distribution of mortality](image)

Figure 1: Distribution of mortality in puppies inoculated with CPV-2 and not treated and those treated with fluids and antibiotics after onset of clinical signs.

necrotised and sloughed over wide areas. The villi were markedly atrophied and blunt, and the lamina propria was collapsed and compact. There was slight lymphocytic and neutrophilic infiltration in the lamina propria. Intact crypts showed early regenerative compensatory hyperplasia with irregular thickening of the wall. More severely affected crypts were dilated and contained necrotic debris in the lumen.

There was marked lymphocytic depletion in the lymphoid tissues, especially in the cortical and paracortical areas of lymph nodes. Depletion of lymphocytes was also noticed at the periarterial lymphoid sheaths of splenic follicles and in the thymus. Due to this lymphocytic
depletion, thymic lobules showed cortical thinning and there was loss of demarcation between the cortex and medulla, and between the prominent epithelial and stromal tissues.

In the bone marrow, there was depletion of both mature myeloid and erythroid cells. Depletion of myeloid cells was more marked and sinusoids appeared distended by the erythroid cells which were relatively hyperplastic. There were no obvious changes in the megakaryocytic cells. In two puppies, there was mottling of the liver surface of varying intensity although no histological changes were evident. No changes were observed in the kidney, heart, brain and lungs.

\textit{(d) Immunology}

Serum antibody levels as measured by haemagglutination-inhibition increased slightly between inoculation and day 4 PI. There was a rapid increase from day 4 until day 8 PI at which time the HI titres were above 1:1100 (Fig. 3).

Faecal haemagglutination titres were as high as 1:2.6 \times 10^5. Haemagglutination-inhibition using reference serum confirmed the titres.

\textit{Puppies inoculated with CPV-2 and treated with fluids and antibiotics after onset of clinical signs.}

\textit{(a) Clinical signs}

Out of the 37 puppies treated with fluids and antibiotics after onset of clinical disease, 23 died (mortality = 62.17\%). Mortality was distributed between days 5 and 10 with the highest incidence (65.21\% of all the puppies that died) occurring between day 7 and 8 PI (Fig. 1).

Pyrexia was recorded in 29 puppies (78.38\%). It was noticed on day 3 PI and
lasted for approximately 1.8 days. Seventeen of the dead puppies and twelve of the surviving ones had no pyrexia. Twelve puppies had temperature \( \geq 40.0^\circ\text{C} \), six of which survived.

Diarrhoea, vomiting and anorexia were the most consistent clinical signs (Tab. 1). Diarrhoea, which was observed in 35 puppies (94.59%) occurred from between days 3 and 5 and lasted for an average of 5 days. All the puppies that died had bloody diarrhoea before death. Anorexia was observed in all puppies and lasted for an average period of 4.5 days. Initially, puppies had selective appetite, eating only meat but later became completely anorexic. Vomiting was less frequent, occurring in 20 (56.75%) puppies. It started between day 4 and 8 and lasted for an average period of 3 days. Thirteen of the 23 puppies that died vomited.

(b) Haematology

Total leucocytes and neutrophils increased slightly between inoculation and day 2 PI, after which both decreased rapidly until day 6 PI. Neutrophils continued to decrease until day 10 PI while total leucocyte levels remained almost the same during that period. Both total leucocyte and neutrophils increased from an average value of 6,300 and 2,900/cmm of blood at day 10 PI to 17,100 and 11,000/cmm of blood at day 12 PI respectively.

Lymphocytes decreased from a pre-inoculation value of 5,300 to 1,800/cmm of blood by day 4 PI (Fig. 4). Then there was a gradual increase, reaching a maximal value of 3,800 cells/cmm of blood by day 10 PI.

Of the puppies that died, nine had a total leucocyte value below 2,000 cell/cmm of blood prior to death. In one case,
Mean total leucocytes
Mean lymphocytes
Mean neutrophils

![Graph showing changes in leucocyte counts over days after CPV-2 inoculation](image)

**Figure 4**: Mean leucocyte changes in puppies inoculated with CPV-2 and treated with fluids and antibiotics after onset of clinical signs.

A total leucocyte count of 590/cmm was recorded from a blood sample taken few hours before death. In the leucopenic puppies, neutrophils were relatively more reduced than lymphocytes. As low as 500 neutrophils/cmm were recorded in a puppy that had a lymphocyte count of 1,200/cmm.

Surviving puppies showed a decrease of total leucocytes and neutrophils from day 2 to 10 PI, followed by a rapid increase. The lowest total leucocyte count recorded from a surviving puppy treated with fluids and antibiotics was 3,000 cells/cmm of blood at day 10 PI. In one surviving puppy, 900 neutrophils/cmm were counted on day 10 PI which increased to 9,800/cmm by day 12 PI. During the period of transient lymphopenia (day 0 to 4 PI), as low as 400 lymphocytes/cmm were counted in a surviving puppy. This level increased to 2,000 lymphocytes/cmm of blood by day 12 PI.

Mean PCV increased slightly from inoculation to day 2 and then progressively decreased until day 6 PI (Tab. 3).

In the 14 surviving puppies, PCV decreased progressively from an average of 28.9% at pre-inoculation to 27.7% at day 8 PI. The value had increased to 31.8% by day 12 PI. In the puppies that eventually died, average PCV decreased progressively from 30% at pre-inoculation to 26.4% at day 6 PI followed by an increased to 32.8% at day 8.

Changes in haemoglobin levels were variable. Generally, it increased from day 0 to 8 PI, followed by a slight decrease from then to day 12 PI. Mean corpuscular volume remained unchanged until day 4 PI and then decreased progressively. From a mean pre-inoculation value of 73.3μm³, it decreased to 70.3μm³ by day 12 PI. Changes in total plasma proteins were not uniform. The highest mean value of 5.5 gm/100 mls recorded at 6 PI decreased to 4.5 gm/100 mls by day 8 PI and was the same at day 12 PI. In the surviving pup-
pies, a total protein level of 4.4 grammes/100 millilitres (gm/100 mls) of blood at day 8 increased to 4.9 gm/100 mls by day 12 PI. Total proteins in puppies that died fluctuated throughout the experiment period.

(c) Pathology
Pathological changes were similar to those observed in puppies infected with CPV-2 but not treated. Subcutaneous oedema around the hind limbs and ventral abdomen was observed. This was probably due to the large amounts of fluids given since it occurred in those puppies that had received fluids for more than 3 days. Pale mottling of the liver was observed in 4 puppies.

In the puppies that survived until day 12 PI, only mild haemorrhagic and congestive changes were observed in the intestines. Clear rounded ulcers of varying diameters were noticed, mainly in the jejunum and ileum.

(d) Immunology
Changes in antibody levels following oral viral inoculation were similar to those observed in puppies infected with CPV-2 but not treated. An average pre-inoculation HI titre of 1:80, increased to 1:130 by day 4 and 1:1012 by day 8 PI (Fig. 3). Increase in serum antibody levels was the same for both surviving and non-surviving puppies. In a puppy that was seronegative before inoculation, the antibody titre was 1:80 at day 5 and 1:1280 by day 7 PI while in six puppies that had a pre-inoculation titre of 1:320 the titre was between 1:1280 and 1:2560 by day 6 PI. A serum sample collected few hours prior to death on day 8 PI from a comatose puppy had a HI antibody titre of 1:2560.

Faecal haemagglutination titres were between 1:64 and 1:5.2 x 10^5. Faecal samples collected at necropsy in surviving puppies and those that died after day 9 PI had low titres.

Discussion
There was a significant decrease in mortality (P<0.05) following the use of broad spectrum antibiotics and a balanced electrolyte solution as supportive treatment in canine parvoviral enteritis. Mortality was reduced by 28.7%.

The mortality of canine parvoviral enteritis reported earlier ranged from 11 to 50% \(^{13,14,15,19}\). These variations were mainly due to the age distribution of the dogs under observation in each case. Soon after the outbreak of CPV-2 in 1978, dogs of all ages developed clinical disease though morbidity and mortality were higher in younger animals \(^{14,15,19}\). In most of the above reported mortalities, the animals under observation included adult dogs that developed mild clinical disease followed by recovery, hence the low mortalities. Today, most of the adult dogs are immune by virtue of either vaccination or previous infection, and hence, outbreaks of CPV-2 occur mainly in young dogs less than three month old resulting in high mortalities. The present study was carried out on puppies between 6 and 12 weeks of age, with 80% less than 9 weeks old, resulting in the high mortality observed.

High mortality in young animals having CPV-2 enteritis is due to their susceptibility to dehydration and increased viral replication. Puppies are more prone to dehydration because of the high amount of total body water (70 to 80% of total body weight) compared with adult dogs (60% of total body weight) \(^{12}\). Also, CPV-2 replicates more extensively in young puppies, leading to more severe clinical enteritis and therefore mortality \(^{16,20,21}\). Apart from the intestinal crypt cells and the myocardium of young animal having a high mitotic index thus predisposing them to more severe diseases after CPV-2 infection \(^{20,22,23}\), their immune system and other host defences are also not fully developed \(^{24,25,26}\).

The route of fluids administration may have also played an important role in the low reduction in mortality rate observed. Due to collapse of blood vessels in severe dehydration and shock, absorption of fluids from the peritoneal cavity in to the circulatory system is poor \(^{11}\). Administration of fluids intravenously would proba-
bly have resulted in higher reduction in the mortality rate. However, the intraperitoneal route was used due to the small size of 6 to 12 weeks old mixed-breed puppies and collapse of blood vessels resulting from dehydration, making it difficult to use the intravenous route.

The increased incidence and duration of clinical signs observed in the treated puppies (Tab. 1) was probably due to early fatality of the untreated cases.

Leucopenia (<7400 leucocytes/cmm of blood) was found to be associated with poor prognosis. It was observed in over 85% of all the clinically ill puppies. Most of the cases had a total leucocyte count below 2,000/cmm prior to death. This is in agreement with earlier work\textsuperscript{[14]} where a number of the cases that died had a leucocyte count between 2,000 and 6,000/cmm of blood. Although the authors argue that leucopenic cases survived, thus dissociating leucopenia from poor prognosis, the proportion of fatal cases that were leucopenic seems significant. In another experiment, the most severe and dying cases had leucocyte counts of 2,000/cmm or less\textsuperscript{[9]}. As low as 590 leucocytes/cmm of blood were recorded from puppies a few hours prior to death in this study. Only one puppy with a leucocyte count below 2,000/cmm (1,500 leucocytes/cmm) survived following protracted fluids and antibiotics therapy.

In this study, commencement of fluid and antibiotics therapy did not seem to aid the animal in coping with decreasing levels of leucocytes. There was no significant difference (P>0.05) in total leucocyte changes compared with infected untreated cases. Despite commencement of early fluids therapy after onset of clinical signs, the leucocyte levels continued to decrease progressively up to day 10 PI in dying and recovering cases. As low as 1,500 leucocytes/cmm were recorded at day 10 PI in a recovering puppy. The decline in circulating blood leucocytes was mainly due to decreased neutrophils. Neutropenia is probably due to depletion of mature myeloid cells from the bone marrow and sequestration of neutrophils into tissues. Other workers\textsuperscript{[27]} found depletion of mature myeloid cells from the bone marrow and neutrophils infiltration in the lamina propria between infected crypt of the small intestines in experimentally infected puppies. Depletion of the mature myeloid cells in the bone marrow was one of the most consistent pathological findings in this study. Also, there was limited neutrophil infiltration between intestinal epithelial cells.

There was a relative decrease in circulating lymphocytes between day 2 and 6 PI, after which the levels were within normal ranges. These findings agree with those recorded by others\textsuperscript{[7,27]}. However, lymphocytosis reported some researchers\textsuperscript{[9]}. was not observed in this study. On the contrary, there was a relative decrease in lymphocytes from day 0 to 4 PI followed by a gradual increase to normal levels throughout the experiment period. The relatively normal or slightly decreased levels of circulating lymphocytes and marked depletion of lymphoid tissues in the lymph nodes, spleen and thymus appear contradictory.

The increased packed cell volume (PCV) observed in this study (Tab. 2 & 4) was due to dehydration. Increase in both PCV and haemoglobin levels was more marked in infected untreated puppies (Tab. 2) as compared with those treated with fluids and antibiotics (Tab. 3). However, the expected increase in total proteins was not observed. Mean total proteins remained within the same level (5.6 to 5.8 gm/100 mls) for untreated puppies and decreased significantly (from a mean of 5.4 gm/100 mls at day 0 to 4.9 gm/100 mls at day 12 PI) in cases treated with fluids and antibiotics only. Since there was an increase in serum antibodies (gammaglobulins) as shown in Fig. 3, decreased total proteins were attributed to decrease in albumin levels although the albumin-globulin ratio was not determined.

Similar reductions of total proteins in dogs having a canine parvovirus infection were reported by others\textsuperscript{[9,14]}. This was mainly due to hypoalbuminemia. Decrease in albumins commonly results from liver diseases, although circulatory disease, nephritis and nephrosis and
inadequate protein intake can lead to the same\textsuperscript{[28]}; This is because the liver is the sole site of synthesis of albumin, fibrinogen and prothrombin whereas gammaglobulins (antibodies) are formed in the reticuloendothelial system. Pale mottling of the liver described in this study is similar to that described by others\textsuperscript{[8,13]} but was less frequent. Acute centrilobular necrosis observed earlier\textsuperscript{[13]} was not evident.

Decrease in mean corpuscular volume (Tab. 2 & 4) was probably due to decreased reticulocytes in the blood circulation as a result of bone marrow depression. The pathological changes observed in cases treated with fluids and antibiotics were as described by other workers\textsuperscript{[7,27]}. Intranuclear inclusion bodies reported in intestinal epithelial cells\textsuperscript{[7]} were not observed.

Recovery from CPV-2 enteritis appears to depend on the individual animal. Important factors in recovery include the rate of lymphoid and intestinal epithelial cells turnover\textsuperscript{[20]}, duration and magnitude of viraemia and the rapidity of humoral immune responses\textsuperscript{[21]}. Supportive treatment, including parenteral fluids and antibiotics only help in stabilizing the animal, enabling it to respond to the infection. However, the importance of this treatment is supported by the significant decrease in mortality observed in this study.

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References


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FEASIBILITY AND PROGNOSIS OF LIMB AMPUTATION IN CATTLE AND A GOAT

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PRATICABILITE ET PRONOSTIC DE L’AMPUTATION D’UNE PATTE CHEZ DES BOVINS ET UNE CHEVRE

Résumé

On a pratiqué l’amputation d’une patte, soit de devant soit de derrière, chez 5 veaux âgés de 2 à 8 mois et chez une chèvre adulte. Les animaux pouvaient se tenir debout et marcher avec les trois pattes restantes. Il s’est avéré que l’amputation de la patte de derrière avait un meilleur pronostic que celle de la patte de devant. On a obtenu un meilleur pronostic pour la chèvre que pour les bovins. Le rapport fait également état d’un autre veau atteint d’une arthrite grave et, par la suite, d’une ankylose d’une patte de devant dont il ne pouvait plus se servir, en vue de simuler une amputation de la patte de devant et son pronostic.

Summary

Limb amputation involving either the front or the hind limb was performed in 5 calves ranging 2-8 months of age, and an adult goat. The animals were able to stand and to walk on the remaining 3 limbs. Hind limb amputation was found to have better prognosis than fore limb amputation. There was better prognosis for the goat than for cattle. Another one calf with severe arthritis and subsequent ankylosis in the fore limb with complete disuse of the limb is included in the report to further simulate forelimb amputation and its prognosis.

INTRODUCTION

Limb amputation in food animals is not common, but may occasionally be indicated in preference to slaughter or to allow further growth or improved condition before slaughter. Occasionally under intensive production, limb amputation may be done to prolong life and permit a valuable female pedigree to produce potentially useful offspring, or to allow a male to be used for semen donation.

Some of the indications for limb amputation are severe suppurative arthritis of fetlock joint or joints proximal to the fetlock affecting only one limb, gangrene of the limb, gaping necrotic lacerations of the limb and permanent peripheral nerve injuries\(^{1,2,3}\). A rapid loss of condition has been reported after limb amputation\(^{4}\). Observations show that it is not a practical procedure in equines\(^{4}\).

Literature is quite scarce as regards limb amputation in large animals and especially with respect to prognosis. This article therefore specifically deals with practicality and prognosis of limb amputation in cattle with reference to hind and fore limb comparison. A goat is presented for comparison with cattle on the basis of prognosis. Details of amputation procedure are not included.

Materials and Methods

Five female calves of various dairy breeds ranging between 2-4 months of age and an adult male goat were presented at different times to the Large Animal Clinic of the University of Nairobi, Kenya between 1983-1988 for either tibial or radio-ulna fracture treatment.

Examination revealed that each of these cases had an old compound comminuted fracture with gangrenous distal fragments of the limb that were insensitive to needle prick and had straw-coloured fluid oozing after deep needle puncture.
Three of the calves and the goat had tibial fractures and the other 2 calves had radio-ulna fractures. Decision was made to amputate the limb in each case.

After anaesthesia and routine surgical preparation, the standard limb amputation procedure[9] was performed. In 3 calves and the goat, the hind limb was amputated at the mid-femur and in the other 2 calves, the fore limb was amputated at mid-humerus. Surgery was completed by closure of the wounds to cover the remaining stump.

Postoperatively, the wounds were sprayed with aerosol terramycin and the animals covered prophylactically with parenteral penicillin — streptomycin mixture for 7 days. A calf that was treated for carpal joint arthritis and finally resulted to joint ankylosis was observed over 5 months and results are presented and found to simulate front limb amputation.

Results

These animals were kept in the University Large Animal Hospital for periods between 5 months and over one year after amputation during which close observation for progress was made.

All wounds were completely healed within 14 days and skin sutures removed. During the first week, the animals were assisted to stand, but soon got used to standing on their own and could walk around. The calves with front limb amputation and the one with carpal ankylosis (with complete disuse) could not walk steadily and developed severe hyperextension of the fetlock of the remaining forelimb and upward dislocation of the shoulder joint after 2 months. These had retarded growth and weight loss.

The calves with hind limb amputation walked more steadily, but eventually got hyperextension of the remaining hind limb fetlock to a lesser degree after 5 months.

In comparison, the goat had neither growth retardation, nor any of the problems observed in calves. Immediately, after surgery, it could run around without much problem and this continued on until more than one year with no notable locomotion problem.

Following amputation, the animals however preferred lying down most of the time. Four of the amputation calves and the goat were ultimately slaughtered. One amputation calf and the ankylosis calf died following prolonged recumbency and inability to feed.

Discussion

Reluctance for the calves to move and preference for lying down affected their sufficient feeding and hence retarded growth and loss of weight. This has been reported earlier[3].

Hyperextension of the fetlock joint was due to excessive weight exerted on the remaining limb. Pelvic limb amputation seems to have a better prognosis than thoracic limb amputation. This was judged by the ability of the remaining limb to support the weight of the animal during movement. We associate this difference in prognosis with the nature of the remaining weight supporting joint. The pelvic limb has a true arthrodi al articulation with the trunk i.e. sacroiliac articulation, while the thoracic limb does not form a true joint with the trunk, to which it is attached only by muscles i.e. the scapular is attached to the trunk by muscles and hence the upward dislocation of the shoulder joint of the remaining limb. This results to instability in movement and inability of the remaining thoracic limb to support the weight of the animal for long.

The goat seems to have better prognosis than cattle probably due to animal weight differences. It appears that the goat can survive for long with the three remaining limbs without any problem.

We conclude that this procedure may not be very feasible in adult cattle, but in calves it can be done as a temporary measure to improve condition of the animal and to make it more aesthetically acceptable for slaughter and human consumption instead of condemning the whole carcass.

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CLINICAL EFFICACY OF POUR-ON FORMULATION ON SARCOPTES SCABIEI INFESTATIONS IN PIGS

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EFFICACITE CLINIQUE D’UN INSECTICIDE PRESENTE SOUS FORME DE POUR-ON DANS LE TRAITEMENT DE L’INFESTATION DES PORCS PAR SARCOPTES SCABIEI

Résumé

L’efficacité clinique du phosmet (Porect), un insecticide présenté sous forme de “pour-on” dans le traitement de l’infestation des porcs par la gale sarcoptique, a été évaluée. Le traitement des porcs a permis de noter la disparition de la maladie clinique. L’efficacité clinique et l’usage simple du phosmet confirment que ce produit pourrait être le médicament approprié pour le traitement et le contrôle de la maladie.

Summary

Clinical efficacy of phosmet (Porect), a pour-on formulation on Sarcoptic mange infestations in pigs was evaluated in an infected piggery herd. Treatment of pigs resulted in disappearance of clinical disease. The clinical efficacy and ease of application indicates that phosmet could be a drug of choice for both treatment and control of the disease.

INTRODUCTION

Sarcoptic mange appears to be a cosmopolitan ectoparasitic disease affecting many pig farms in Tanzania. Varying prevalences of the disease have been reported, however, due to the unreliability of isolating mites from skin scrapings such findings could be producing minimal assessments. This suggests that diagnosis would rather be based on clinical examination. Although a number of drugs, especially those applied by either dipping or spraying, or scrubbing, have long been in use in many countries, the disease continues to be a menace to the pig industry. Phosmet is a systemically acting drug which is applied topically and it is reported to be highly effective in treating swine scabies. Since mites have been shown to develop also in ear scabs, it was suggested that pouring of the drug into ears enhances the recovery rate. The purpose of this field trial is to evaluate the clinical efficacy of phosmet on Sarcoptes scabiei infestations.

Materials and Methods

All pigs in a mixed breeding herd were clinically examined for the presence and ascertainment of the prevalence rate of mange. Confirmation of the disease was done by isolating mites from skin scrapings taken from ears using a standard method.

The two groups of pigs housed in different houses were assigned to the two treatment regimes. 75 pigs were treated with 20% phosmet at a dose rate of 20 mg/kg bodyweight. This was administered by pouring along the backs of the animals. Treatment was repeated 14 days later. The other group was left as a control. No additional treatment was done to the animals during the 10-month observation period. Preventive measure undertaken to prevent cross infection between the two animal groups was restriction of movement of animals and personell between the two animal houses. Further to this, there was no introduction of new animals from outside. Post-treatment status of the mange in the herd, during the ten months of observation, was determined on the basis of clinical examination and mite isolation.

Results

Results of clinical and parasitological assessment of treated pigs are summarised (Table 1). Prior to treatment, 85%
of the pigs were shown to have clinical evidence of the disease. Out of these, 47% were manifesting the hypersensitive form characterized by either localized or generalised ery-thematous skin papules and alopecia whereas 53% were manifesting the chronic form which was characterised by aural encrustations and occasionally found on other parts of the body. Mites were recovered from all the chronically affected ones whereas only 50% of the samples taken from those animals affected by the hypersensitive form were positive.

A month after treatment, only 7% of the pigs were still showing signs of mange and mites were isolated from 4% of the animals. One month later, all animals had clinically recovered. Clinical mange became evident again after a five month-disease free period. No mites were recovered from scrapings taken during the re-infection period. The infection rate in the control animals is as shown in Table 2.

**Table 1: Clinical and parasitological assessment of pigs following treatment of pig with 20% phosmet**

<table>
<thead>
<tr>
<th>Months after initial treatment</th>
<th>Total number of pigs with clinical signs</th>
<th>Number of mites isolated</th>
<th>Hyper-sensitive form</th>
<th>Chronic form</th>
<th>Non-affected animals</th>
<th>Prevalence</th>
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<td>Mite isolation rate</td>
<td>Number of pigs with clinical signs</td>
<td>Number of pigs from which mites were isolated</td>
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**Table 2: Clinical and parasitological assessment of the untreated (control) pigs**

<table>
<thead>
<tr>
<th>Months after initial treatment</th>
<th>Total number of pigs with clinical signs</th>
<th>Number of mites isolated</th>
<th>Hyper-sensitive form</th>
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**Discussion**

Clinical examination of animals
revealed a higher prevalence of mange infestation than when based on mite isolation. This is in agreement with earlier reports\(^2,3,4\), thereby emphasizing the value of clinical examination in the determination of the prevalence/incidence of porcine mange. This stands to be true, because recovery of mites from animals evidencing the hypsensitve form is low\(^1,2\) and, although, skin scrapings taken from chronically affected pigs yield massive numbers of mites\(^5,7,8\), the proportion of such animals in most herds is low\(^8\).

Full clinical and parasitological recovery was evident by the end of the second month after initial treatment and this indicates a high miticidal effect of phosmet against Sarcoptic mange infestations in pigs as earlier reported\(^6,7\). Mites in all developmental stages were seen in encrusted aural materials and this led to the suggestion that in order to improve the efficacy of this drug, part of the dose should poured into the ears\(^9\).

The observation made in this study shows that pouring of the drug into ears results in disappearance of scabs even by the end of the first month after treatment. This shows that phosmet is highly effective in treating both forms of mange. Because of the difficulty in the penetration of drugs into heavy scabs, pre-soaking of scab masses has sometimes been advocated. The high effectiveness of this drug in getting rid of scabs solves the problem of additional treatment measures.

Scrapings taken from pigs a month after the initial treatment yielded a few mites from 3 animals. No attempts were made to determine the viability of these mites, however, it could as well be that these were dead mites still embedded in the skin. Based on monthly post-treatment clinical and parasitological assessments, the treated pigs showed no clinical and parasitological evidence of mange for a long period (Table 1) and it is highly suggestive that the source of infection was the control animals housed nearby. Movement of personnel was difficult to monitor and this together with the movement of the few available boars needed for service may have accounted for the re-infection. Eradication of mange thus appears to be possible in farms were all pigs are treated in addition to quarantine and treatment of all incoming animals.

Acknowledgement

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References


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PREWEANING PERFORMANCE OF KIDS OF THE WEST AFRICAN DWARF (WAD) GOAT IN THEIR NATIVE ENVIRONMENT

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RENDEMENT AVANT LE SEVRAGE DES CHEVREAUx DE LA CHEVRE NAINE DE L’AFRIQUE DE L’OUEST (WAD) ELEVES EN MILIEU NATUREL

Résumé
On a entrepris deux études en vue d’examiner le rendement avant le sevrage des chevreaux WAD. Dans la première enquête, le poids à la naissance, le poids au sevrage à 90 jours et le taux de mortalité ont été analysés chez un groupe de 147 chevreaux mis bas entre 1982 et 1986. La deuxième expérience portait sur 15 chevreaux (9 femelles et 6 mâles) mis bas en 4 jours et utilisés en vue d’étudier la croissance des chevreaux WAD.

Le poids moyen à la naissance des 147 chevreaux était de 1,16±0,01 kg. Les chevreaux avaient tendance à peser plus lourd à la naissance que les chevrettes (1,20±0,02 contre 1,12±0,03 kg). Le type de portée avait des effets sur le poids à la naissance et le pourcentage d’animaux élevés; et le poids à la naissance avait un rapport négatif avec le taux d’animaux élevés.

Le poids moyen au sevrage à 90 jours était de 6±0,21 kg. Les mâles étaient plus lourds au sevrage que les femelles (6,11 contre 5,82 kg). La croissance n’était pas affectée par le sexe, et le gain pondéral maximum a été observé au cours des trois premières semaines après la mise bas. 24,56% des chevreaux sont morts avant le sevrage à 90 jours. Le taux de mortalité était plus élevé (P<0,05) pendant les 30 premiers jours qu’à un stade plus avancé.

Ces enquêtes montrent que les chevreaux WAD au Nigeria nécessitent davantage de soins, en particulier pendant les 30 premiers jours suivant la mise bas.

Summary
Two observations were undertaken in order to study the preweaning performance of kids of the WAD goat. In the first observation, the birthweight, weaning weight at 90 days and the mortality rate were studied in a group of 147 kids delivered between 1982 and 1986. The second study consisted of 15 kids (9 females and 6 males) delivered within four days and were used for a close study of the growth pattern of kids of the WAD goat.

The mean birthweight for the 147 kids was 1.16±0.01 kg. Males kids tended to be heavier at birth than female kids (1.20±0.02 vs 1.12±0.03 kg). Litter type affected birthweight and survival rate and birthweight was negatively related to survival rate.

The mean weaning weight at 90 days was 6.00±0.21 kg. Males were apparently heavier at weaning than females (6.11 kg. vs 5.82 kg). The pattern of growth was not affected by sex and the maximum weight gain was observed during the first three weeks of life. 24.56% of kids died before weaning at 90 days. Mortality was higher (P<0.05) during the first 30 days of life than at a later stage.

These observations would suggest that kids of the WAD goat in Nigeria require better management care particularly during the first 30 days of life.

INTRODUCTION

The preweaning performance of kids of some goat breeds have been studied extensively(12) and it has been observed that there are breed differences in the pattern of growth and mortality(13). The birthweight of kids is highly variable, being affected mostly by the adult weight of the breed(14). Within breed variation in birthweight is affected by the dam’s weight rather than the age of the dam. Sex influences on birthweight have also been observed(15). However, the effect of sex of kids on birthweight depends on breed and litter size while the season of birth does not appear to affect birthweight(21).
The milk yield and duration of lactation of the dam may be the major factors affecting growth of kids. However, Datta et al.\(^8\) reported that the kid’s growth rate during the first month of life is influenced by its birthweight and weight gain during the first month of life.

Wide ranges in the preweaning mortalities have been observed in goats. While Devendra.\(^7\) reported a mortality of 4% in crossbred Anglo-Nubian goats in West Malaysia, Minett\(^15\) reported 54% in Indian breeds.

Studies on the performance of kids of the WAD goat in Nigeria are limited to birthweight\(^1\) and weaning weight\(^19\). The present study was aimed at providing information on (a) the birthweight of kids of the WAD goat and the factors affecting birthweight, (b) the growth pattern of kids from birth to weaning at 90 days and (c) the phases of preweaning mortalities in kids of the WAD goat.

It is hoped that such a study will provide useful information to livestock farmers on the expectation of kid performance.

Materials and Methods

The data of 147 WAD kids delivered between 1982 and 1986 in our experimental unit were analysed for the effect of sex and litter type on birthweight and preweaning mortalities. Another 15 kids (9 females and 6 males) delivered within a period of 4 days by a group of does bred naturally following a PGF\(_2\)-alpha synchronized oestrus were used to study the growth pattern. The management of these goats had been described earlier\(^3\).

All kids were weighed within 12 h. of birth and at the time of weaning with a suspension balance. In the case of the 15 kids in the second study, weekly weight determination was carried out.

The data were subjected to Chi-square and Student’s ‘t’-test for the establishment of significance.

Results

The mean birthweight of the 147 kids was 1.16 ± 0.01 kg (0.60 - 1.60 kg). Male kids appeared to be heavier at birth than females (1.20 ± 0.02 kg vs 1.12 ± 0.03 kg; P>0.05). The litter type but not the season of birth had a significant effect (P<0.05) on birthweights (Table 1).

Kids of the WAD goat weighed 6.00 ± 0.21 kg at weaning at 90 days. There was a high and positive correlation between birthweight and weaning weight (r = 0.75; P<0.05). The sex of kids did not affect the weaning weight significantly although the males tended to be heavier at weaning than the females.

A preweaning mortality of 24.56% was observed. Table 2 summarizes the effects of birthweight, litter type, and sex of kids on the mortality rate of WAD kids. The mortality rate among kids born as singletons and twins was significantly higher (P<0.05) than kids born as triplets and quadruplets. Similarly, mortality rate was significantly more (P<0.05) during the first 30 days of life than at a later age. Neither the sex of the kids nor the birthweight had a significant effect on mortality rate.

The weekly growth rate and weight gain until weaning are depicted in Figs. 1 and 2, respectively together with the multiple regression equations of these parameters on age. The highest weight gain was attained during the first week of life although substantial growth rates were also observed during the second and third weeks of life. There were wide variations in weight gains between the fourth and tenth weeks of life. Thereafter, a gradual increase in weight was observed until weaning at 90 days.

Discussion

The birthweight of kids of the WAD goat was lower than reports in European breeds\(^16\). This is a reflection of the adult weights of these breeds. However, higher birthweights for the WAD goat in Nigeria had earlier been reported\(^1\). Within breed variations in kids’ birthweight have also been observed in other breeds of goat\(^7,8\). The observation that male kids appeared heavier at birth than female kids is consistent with earlier reports\(^1,16\). The study has further confirmed the reports of
Devendra and Burns\textsuperscript{16} and Deichert\textsuperscript{15} that individual birthweight was negatively correlated with litter size. The non significant effect of season on birthweight is in agreement with the report of Singh\textsuperscript{21} and might suggest that breeding and kidding in the WAD goat can be undertaken throughout the year.

The correlation between birthweight and weaning weight observed in this study is in consonance with the report of Datta \textit{et al.}\textsuperscript{15} and Richetti and Intrieri\textsuperscript{20}. The preweaning weight gain of kids of the WAD goat was within the range of 4.0 - 6.3 kg at 90 days compiled by McDowell and Bove\textsuperscript{14} for some breeds of goats in the dry tropics. However, Kirkpatrick and Akindele\textsuperscript{13} and Osuagwu and Akpokodje\textsuperscript{18} reported higher weight gains in the WAD goat apparently due to the higher birthweight of the kids (\(\geq 1\) kg) involved in these earlier studies. Wilson\textsuperscript{23,24} reported weaning weights of 8.2 kg and 7.8 kg for goats on a high plane of nutrition in Uganda and Sudan, respectively.

The growth pattern of the WAD goat in this study was similar to the report of Fehr\textsuperscript{10}. The maximum weight gain in this study was observed at an earlier age than earlier report in WAD goats\textsuperscript{18}. This difference might be due to the linear increase
Wide variations in mortality rates have been observed in different breeds of goat. Devendra\textsuperscript{(7)} reported a rate of 4\% in crossbred Anglo-Nubian goats while Minett\textsuperscript{(15)} observed a rate of 54\% in Indian breeds. These variations clearly indicate the severe defects in the management practices of kid rearing and highlight the need for a better knowledge of the physical and pathological conditions affecting kids. The mortality pressure on kids of low birthweight confirms earlier reports that survival rate was related to birthweight\textsuperscript{(6)}.

in milk yield of the does with advancing lactation\textsuperscript{(9)} and the rate of multiple births which could form a limitation in the milk available to each kid. The progressive rise in weight gain towards weaning could be due to the ability of the kids to utilize solid food following increased physiological maturity\textsuperscript{(4)}.

The preweaning mortality rate observed in this study was higher than the 21\% reported for the same breed in Ghana\textsuperscript{(22)} but lower than the 28\% observed earlier in the WAD in Nigeria\textsuperscript{(18)}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1}
\caption{Performance of the WAD kids as indicated by the curves of their weekly weights ($Y =$ Age of kids in weeks and $X =$ weight of kids in kg).}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2}
\caption{Performance of WAD kids as indicated by the curves of their weekly weight gain ($Y =$ Age of kids in weeks and $X =$ weekly weight gain in kg).}
\end{figure}
particularly during the first 30 days of life.

The decline in mortality rate among kids of multiple births is surprising as it appeared contradictory to the relationship between birthweight and mortality rate. This could be explained from the existence of induced artifacts\(^\dagger\). Such artifacts include the possibility of kids of multiple births obtaining milk from another dam in the same pen or in the paddock. Secondly, there was a tendency for greater management care for kids of large litters. Thirdly, it should be noted that mortality of kids in a singleton, twin, triplet and quadruplet births represented a mortality rate of 100, 50, 33.30 and 25.00% respectively.

The higher mortality rate observed among male kids cannot be explained physiologically. However, violent attacks on male kids by does teased by male kids might be the factor responsible for this. It is thus suggested that male kids should be castrated during the first two weeks of life and reared with their dams alone in order to reduce such losses.

**Conclusion**

The birthweight, growth rate and weaning weight of kids of the WAD were generally low but satisfactory when viewed against the adult weight for the breed. The milk supply of the dam appeared to sustain fast growth of kids in the first three weeks of life and hence supplementary feeding is recommended until the kids are about 10 weeks old for optimum growth. The mortality rate among kids is considered high especially during the first 30 days of life. It is suggested that males should be castrated at about two weeks. It is also recommended that individual maternity pens, suitable housing and feeding, be adopted in their management in order to reduce mortalities in the WAD goat.

**Acknowledgement**

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**References**


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A COMPARISON OF THREE TECHNIQUES FOR ESTIMATING STRAW AND FORAGE DIGESTIBILITY

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UNE COMPARAISON DE TROIS TECHNIQUES POUR EVALUER LA DIGESTIBILITE DE LA PAILLE ET DU FOURRAGE

Résumé


Pour tous les aliments expérimentés, à l’exception de la jacinthe aquatique, il y avait une concordance des techniques in vitro. L’équation de synthèse ne pouvait pas déterminer DMS de la jacinthe aquatique, probablement à cause de la faible teneur en lignine et de l’absence de silice dans cette plante. Les données sont discutées en rapport avec l’applicabilité des techniques pour la sélection d’un grand nombre d’échantillons d’aliments pour le bétail dans les pays en développement.

Summary

A total of eleven feed samples were analyzed for their fibre fractions and dry matter digestibility (DMD) using in vitro procedures. A comparison was made between in vitro DMD, DMD predicted by the summative equation of Goering and Van Soest and nylon bag degradation at 48 hours.

For all feeds other than water hyacinth, the in vitro techniques showed good agreement. The summative equation could not predict the DMD of water hyacinth presumably due to the low content of lignin and absence of silica in water hyacinth. The data are discussed in relation to the applicability of the techniques for screening large numbers of feed samples in developing countries.

INTRODUCTION

The measurement of in-vivo digestibility is often too expensive and requires large amounts of feed material. To overcome such difficulties, scientists have developed many in vitro techniques that estimate digestibility. The detergent fibre analyses(1), the two-stage technique of Tilley and Terry(2) and dacron bag method(3) are three of the techniques commonly used in the estimation of digestibility of feeds in many laboratories.

The technique involving the detergent system of Goering and van Soest(4) uses a summative system of calculation of nutritive value based on the assumption that individual chemical factors adjectively limit nutritive value. It assumes that cell contents have a true digestibility of 98% independent of the composition of the forage. The cell wall constituents, however, are known to have variable digestibilities due to the variations in the amount and composition of structural components.

The two-stage technique of Tilley and Terry(2) simulates rumen and post-rumen digestion and is therefore a useful technique for measuring the total digestibility of fibrous feedstuffs. The first stage of the procedure which uses a rumen fluid-buffer inoculum is more critical than the second stage which uses acid-pepsin and must be operated under completely standard conditions(5). The in-vitro dry
matter digestibility (IVDMD) has proven to be a useful and accurate predictor of in-vivo digestibility of forages.

The nylon bag technique has often been used to provide estimates of the rate and extent of disappearance of feed constituents from the rumen\(^5\). The technique involves the suspending of a particular feed(s) in a dacron bag inside the rumen of sheep or cattle, through a rumen cannula. The accuracy of this technique is influenced by a number of factors\(^6\); however, it provides a relatively simple means of screening feedstuffs in terms of their potential degradability.

In this study, the in vitro dry matter digestibility of eleven feed samples estimated by the Tilley and Terry technique was compared with the predicted values using the summative equations of Goering and Van Soest\(^7\). The 48 hour dry matter disappearance rates of botanical fractions of whole plant of rice straw and water hyacinth were also compared with their respective in-vitro dry matter digestibilities.

**Materials and Methods**

The dry matter, ash and crude protein content of eleven forage samples (from the Fibrous Residue Bank of the FAO/IAEA Laboratory in Seibersdorf, near Vienna), were determined according to the standard methods of AOAC\(^8\). Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and silica were determined according to the procedures described by Goering and Van Soest\(^9\). The summative equation of Goering and Van Soest was used to predict the dry matter digestibility of the feeds from analytical data.

The two stage technique of Tilley and Terry\(^2\) was used to assess in-vitro dry matter digestibility (IVDMD). A standard sample of known in-vivo digestibility was included in each run and each sample was analyzed in quadruplicate.

The rate of dry matter degradability of whole plant, leaves and stems of rice straw and water hyacinth were determined using the method described by Orskov et al\(^3\). Dacron bags containing 2 g samples were incubated in triplicate in three rumen fistulated sheep fed a standard diet of hay and concentrate. The bags were withdrawn at 18, 24, 48, 72 and 96 h after incubation, washed for 15 minutes in running cold water, slightly squeezed to remove excess water and dried to constant weight in a forced draught oven at 105°C.

In the estimate of DMD of the samples using the summative equation of Goering and Van Soest\(^1\), the metabolic losses for sheep was considered as 12.9 units of digestibility. It was also assumed that plant metabolic silica causes a decline of 3 units of DMD per 1 percent of silica in the feed.

**Results**

The chemical composition and in vitro digestibility of the feed samples are given in Table 1. The stem fraction of rice straw contained less ADF, lignin and silica compared to the leaf and panicle fractions but had the highest IVDMD. Maize stover had lower IVDMD than the hay standard. Although *E. pyramidalis* (tree leaf from Zambia) and maize stover had higher IVDMD's, they were lower in nitrogen than water hyacinth (*Eichornia crassipes*). Rye straw had the lowest nitrogen and the IVDMD.

The correlation coefficients and regression equations for estimating IVDMD from fibre fractions are shown in Table 2. ADF, hemicellulose and silica showed significant (P<0.05) correlations with IVDMD. NDF and ADF collectively gave the best estimate (P<0.01) of IVDMD ($r^2 = 68.9$; RSE = 6.7). The correlation coefficient ($r^2$) of IVDMD with DMD, estimated using the summative equation of Van Soest was 84.6 (P<0.01) when water hyacinth was excluded from the calculations. However, the correlation coefficient became 32.5 (RSE = 9.32) when water hyacinth values were included in the estimates. The difference in DMD between the two techniques for water hyacinth was 27.6%.

The rate of degradability of water hyacinth and rice straw and its fractions, determined by the nylon bag technique
A comparison of three techniques for estimating straw and forage digestibility

Table 1: The chemical composition and in vitro dry matter digestibility (IVDMD) of feed samples

<table>
<thead>
<tr>
<th>Feed sample</th>
<th>Dry matter %</th>
<th>Nitrogen %</th>
<th>Total Neutral</th>
<th>Neutral Detergent</th>
<th>Neutral Solubles</th>
<th>Acid Detergent Cellulose</th>
<th>Acid Detergent Lignin</th>
<th>Hemicellulose (%)</th>
<th>Cellulose (%)</th>
<th>Silica (%)</th>
<th>IVDMD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice straw</td>
<td>95.9</td>
<td>0.87</td>
<td>16.8</td>
<td>77.5</td>
<td>22.5</td>
<td>55.2</td>
<td>4.5</td>
<td>22.3</td>
<td>39.8</td>
<td>9.1</td>
<td>43.1</td>
</tr>
<tr>
<td>Rice straw</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– stem</td>
<td>92.9</td>
<td>0.63</td>
<td>20.2</td>
<td>72.3</td>
<td>27.7</td>
<td>48.8</td>
<td>2.0</td>
<td>23.5</td>
<td>38.8</td>
<td>8.1</td>
<td>61.1</td>
</tr>
<tr>
<td>– leaves</td>
<td>94.4</td>
<td>1.13</td>
<td>27.9</td>
<td>76.6</td>
<td>23.4</td>
<td>53.8</td>
<td>2.5</td>
<td>22.8</td>
<td>31.3</td>
<td>12.7</td>
<td>41.5</td>
</tr>
<tr>
<td>– panicle</td>
<td>94.4</td>
<td>1.03</td>
<td>15.0</td>
<td>78.5</td>
<td>21.5</td>
<td>54.9</td>
<td>4.7</td>
<td>23.6</td>
<td>38.4</td>
<td>9.2</td>
<td>40.7</td>
</tr>
<tr>
<td>Rye straw</td>
<td>93.2</td>
<td>0.74</td>
<td>20.2</td>
<td>77.5</td>
<td>22.5</td>
<td>53.7</td>
<td>3.8</td>
<td>23.8</td>
<td>35.8</td>
<td>10.8</td>
<td>36.6</td>
</tr>
<tr>
<td>Maize stover</td>
<td>92.9</td>
<td>0.42</td>
<td>5.7</td>
<td>82.8</td>
<td>17.2</td>
<td>45.4</td>
<td>4.5</td>
<td>37.4</td>
<td>37.2</td>
<td>2.3</td>
<td>60.4</td>
</tr>
<tr>
<td>Guinea grass (dried)</td>
<td>94.3</td>
<td>1.37</td>
<td>9.9</td>
<td>79.0</td>
<td>21.0</td>
<td>46.4</td>
<td>3.9</td>
<td>32.6</td>
<td>39.5</td>
<td>3.2</td>
<td>60.0</td>
</tr>
<tr>
<td>Grass hay</td>
<td>93.3</td>
<td>1.46</td>
<td>7.0</td>
<td>74.2</td>
<td>25.8</td>
<td>46.1</td>
<td>4.2</td>
<td>28.1</td>
<td>40.3</td>
<td>1.7</td>
<td>51.8</td>
</tr>
<tr>
<td><em>Echinocloa pyramidalis</em></td>
<td>93.2</td>
<td>0.99</td>
<td>9.6</td>
<td>77.5</td>
<td>22.5</td>
<td>48.5</td>
<td>3.9</td>
<td>29.0</td>
<td>41.7</td>
<td>2.9</td>
<td>59.6</td>
</tr>
<tr>
<td>Water hyacinth</td>
<td>93.8</td>
<td>1.33</td>
<td>19.1</td>
<td>67.3</td>
<td>32.7</td>
<td>44.5</td>
<td>2.7</td>
<td>22.8</td>
<td>40.7</td>
<td>0.1</td>
<td>43.1</td>
</tr>
<tr>
<td>Grass hay standard</td>
<td>92.7</td>
<td>nd</td>
<td>7.2</td>
<td>62.4</td>
<td>37.6</td>
<td>34.0</td>
<td>2.7</td>
<td>28.4</td>
<td>29.6</td>
<td>1.3</td>
<td>68.2</td>
</tr>
</tbody>
</table>

Source of feed samples: Fibrous Residue Bank, Seibersdorf laboratory, IAEA, Vienna, Austria. nd: not determined

Table 2: Regression equations and correlation coefficients for estimating IVDMD of straws and forages from analytical values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation Coefficient (r²)</th>
<th>Equation</th>
<th>RSE+</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF</td>
<td>6.5</td>
<td>87.2 – 0.47 x</td>
<td>11.0</td>
</tr>
<tr>
<td>ADF</td>
<td>57.2**</td>
<td>114.9 – 1.31 x</td>
<td>7.5</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>43.6*</td>
<td>12.3 + 1.46 x</td>
<td>8.6</td>
</tr>
<tr>
<td>Cellulose</td>
<td>0.9</td>
<td>61.1 – 0.26 x</td>
<td>11.3</td>
</tr>
<tr>
<td>ADL</td>
<td>4.3</td>
<td>60.1 – 2.39 x</td>
<td>11.1</td>
</tr>
<tr>
<td>Silica</td>
<td>34.8*</td>
<td>59.7 – 1.47 x</td>
<td>9.1</td>
</tr>
<tr>
<td>ADF, ADL</td>
<td>57.7*</td>
<td>114.3 – 1.34 x_1 (ADF) + 0.60 x_2 (ADL)</td>
<td>7.9</td>
</tr>
<tr>
<td>ADL, Silica</td>
<td>42.2*</td>
<td>69.4 – 2.68 x_1 (ADL) + 1.50 x_2 (Silica)</td>
<td>9.2</td>
</tr>
<tr>
<td>ADF, NDF</td>
<td>68.9**</td>
<td>76.3 – 1.86 x_1 (ADF) + 0.86 x_2 (NDF)</td>
<td>6.7</td>
</tr>
<tr>
<td>ADF, ADL, NDF</td>
<td>73.2**</td>
<td>61.1 – 1.95 x_1 (ADF) + 3.29 x_2 (ADL) + 1.28 x_3 (NDF)</td>
<td>6.7</td>
</tr>
</tbody>
</table>

level of significance of r: *P<0.05; **P<0.01  
+ Residual Standard Error

are shown in Figure 1. Differences were observed in the dry matter loss (DML) after 48 hours of incubation between whole rice straw and its fractions. The stem fraction showed the highest DML at 48 hours compared to all other fractions and whole straw.

An incubation period of 48 hours was considered appropriate when comparing DML values with nylon bag technique with IVDMD by Tilley and Terry method since DML values at this period are considered closest to the mean retention of low quality feedstuffs\(^{(8)}\). Although there was a tendency for IVDMD to be higher than the DML values a significant correlation existed between the two parameters (\(r^2 = 70.6\); RSE = 5.28).

Discussion

Nutritive value of straws and forages.

Recent literature shows that the feeding value of cereal straws can vary significantly between varieties. For example rice straw varieties in Sri Lanka have shown digestibilities varying from 30-45%\(^{(9,10)}\). As suggested by Pearce\(^{(11)}\) and Sannasgala and Jayasuriya\(^{(12)}\) these differences may be attributed to variations in chemical composition, together with distribution and/or digestibility of the botanical fractions. In agreement with the previous findings of Sannasgala and Jayasuriya\(^{(12)}\) stem fraction of rice straw used in these studies showed a higher nutritive value than the others. However,
in wheat and barley straws researchers have found that leaf fractions has a higher digestibility than the stem fraction\(^{13}\).

**Feed Evaluation Technique.**

Van Soest's concept attempts to partition plant material into highly digestible cell contents and partially digestible cell wall. The proportion of cell wall and of lignin in cell wall increases with maturity and varies between species\(^11\). The extent of microbial digestion of cell wall is variable; for cellulose, it depends on the degree of crystalinity and interlinking with lignin and silica and for hemicellulloses the acetylation, both of which increases with maturity.

To estimate the DMD of a feed using the Van Soest method\(^11\) complete analysis of fibre fractions (NDF, ADF, lignin and silica) are required since they all have either a weaker or a stronger relationship with digestibility. The complete detergent method of analysis is very lengthy, time consuming, costly and labour intensive. Unfortunately, the relationship between feeding value and the chemical composition of feedstuffs depend on a number of such properties. Thus, the routine use of this analytical method as a screening technique for feeds seems impractical in many developing countries, particularly in view of the difficulties in obtaining laboratory chemicals and the high cost involved. Furthermore, it appears that the method could not be applied when the feedstuff is low in silica, as observed in the case of water hyacinth.

Compared with the detergent system of feed analysis nylon bag method is simple and inexpensive. The relative degradability of straws and forages will assist in the better understanding of the potential feeding value. The very low degradability of a feed is suggestive of many constraints limiting voluntary food
intake.

The modified Tilley and Terry procedure is widely used to estimate the in vitro digestibility of feedstuffs. In evaluating grasses, legumes and hays, Alexander and McGowen\(^{(14)}\) found that in vitro results were closely related to in vivo results \(r = 0.96\). They reported that Tilley and Terry technique gave superior results compared to conventional chemical analysis. Several authors\(^{(15,16)}\) have also reported that the in vitro fermentation technique offers the best laboratory estimation of in vivo digestibility.

For reasons of convenience and cost the Tilley and Terry method has considerable application for routine forage analysis in developing countries. This technique should serve as a guide or a screening device to select forages based on their potential digestibility. The dacron bag technique will assist in further screening and also offer a simple means of grading supplements in terms of potential degradability.

**Acknowledgements**

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**References**


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PIG PRODUCTION IN SOUTH-EASTERN NIGERIA UNDER THE INTENSIVE, SEMI-INTENSIVE AND EXTENSIVE SYSTEMS

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PRODUCTION PORCINE DANS LES SYSTEMES D'EXPLOITATION INTENSIF, SEMI-INTENSIF ET EXTENSIF AU SUD-EST DU NIGERIA

Résumé

La présente étude a identifié et examiné la rentabilité relative des divers systèmes d'élevage appliqués pour la production porcine au sud-est du Nigeria. L'on a observé qu'il existe dans cette région des systèmes extensif, semi-intensif et intensif de production porcine. La plupart des éleveurs de porcs sont des hommes, ce sont des ouvriers plutôt que des éleveurs à plein temps. Ils n'ont comme éducation qu'un niveau de l'école primaire ou même moins, avec une famille nombreuse, et sont âgés de plus de 46 ans. Ces fermiers élèvent trois races porcinnes, à savoir: la race locale (L), la race exotique (E) et le croisement (L x E). Les races exotiques prédominantes sont le Landrace et le Large White. Les taux de mortalité étaient respectivement de 19,4; 8,3 et 2,2% pour les systèmes extensif, semi-intensif et intensif. Compte tenu des techniques utilisées actuellement, le système intensif est le plus rentable, suivi des systèmes semi-intensif et extensif, mais quel que soit le mode d'élevage pratiqué, la production porcine est une entreprise lucrative.

Summary

This study has identified and analyzed the relative profitability of the different management systems used in pig production in south-eastern Nigeria. It found that the extensive, semi-intensive, and the intensive systems of pig production existed. Most of the pig farmers were males; craftsmen rather than full-time farmers; had only primary school education or less; had large families; and were more than 46 years old. Three breeds of pigs were raised namely, the local, the exotic and the "local-exotic" cross. The most popular of the exotic breeds were the Landrace and the Large white. The mortality rates were 19.4%, 8.3% and 2.2% for the extensive, semi-intensive and intensive systems, respectively. Under the present levels of technologies, the intensive system was the most profitable followed by the semi-intensive and the extensive systems, but that no matter the production system used, pig production was a profitable enterprise.

INTRODUCTION

The food situation in Nigeria has reached crisis dimension particularly in animal protein food items[1]. Nigeria's Federal Livestock Department (FLD) in 1986 reported that Nigeria's livestock resources comprised 11 million cattle, 23 million goats, 9 million sheep, 40 million exotic poultry, 130 million local fowls, and 0.9 million pigs. These sources barely provided 50% of the Food and Agricultural Organisation's (FAO's) recommended target consumption of animal based proteins, considered necessary for overall good health[2]. This serious lack of meat to supply the dietary requirements of Nigeria's population (estimated at 100 million) has drawn attention to the inadequacies of Nigeria's agricultural planning and implementation policies.

Livestock resources have not been fully developed in Nigeria and this underlines the animal protein deficiency of the Nigerian diet. The basic question facing the country is how this problem of animal protein deficiency can be solved within the shortest possible time based on the country's available resources. Many scientists believe that this could be achieved
through pig sources, that is, by the development of the piggery industry and by fully exploiting its potentials. For example, Dafwang et al\(^a\), Ogunfowora, et al\(^{a4}\) and Ijere\(^a9\) have identified pig production as one of the most economically efficient livestock enterprises in Nigeria. According to Balogun\(^6\), pigs possess several advantages over the other large livestock species. They have higher prolificacy than cattle, sheep or goats and are capable of producing 2-2½ litres of an average of eight piglets per year. Also, pigs have higher fecundity and mature early, and shorter generation interval than the other red meat animals. Besides, pigs are omnivores consuming anything from forage to kitchen waste. Furthermore, the carcass yield of pigs is higher than those of cattle, sheep or goats.

However, in spite of these overwhelming advantages of pigs over the other red meat animals, its production has not matched its potentials. Some constraints to pig production include religion, people’s attitudes, consumption habits and managerial expertise.

Thus, the primary purpose of this study is to assess the profitability of pig production in south-eastern Nigeria with emphasis on Imo State. The specific objectives are:

a) to survey the socio-economic characteristics of the pig producers;
b) to identify and compare the profitability of the different pig production systems used in the state under present levels of technologies; and,
c) to derive policy implications based on findings.

\textit{Imo State}

Imo State is bounded in the east by Akwa Ibom and Cross River States, in the West by Bendel State, in the north by Anambra State and in the south by Rivers State. With a population of 5.6 million in 1980 and a land area of 12.7 km\(^2\)\(^{\text{n}}\), it is the most densely populated State in south-eastern Nigeria. Its mean daily temperature is 30°C with the highest temperature recorded between February and April. Rainfall is seasonally distributed with the amount decreasing from the south to the north. However, the mean annual rainfall ranges from 1,900 mm in the south to 2,400 mm in the north. Relative humidity ranges from about 65% in the early mornings to 95% in the afternoons during the rainy season. It drops to below 60% during the dry season. The dry season starts in November and ends in March while the rainy season starts in April and ends in October. During the ‘dry season’, there are occasional showers.

\textbf{Materials and Methods}

Three zones (Owerri, Umuahia and Orlu) were randomly selected from the five agricultural zones that make up Imo State. A list of pig farmers in the three selected zones was obtained from the Ministry of Agriculture. A total of 50 registered pig farmers, as at January, 1987 was obtained out of which 30 were sampled (60%) with 10 from each zone. The majority of the registered farmers used the intensive system of production. The 30 selected farmers, based on relative proportion of registered pig farmers, comprised 20 intensive farmers, 5 semi-intensive and 5 intensive farmers.

Preliminary visits were made to the State Ministry of Agriculture, Owerri and some pig producers. Based on the knowledge gained during these preliminary visits, a set of questionnaires was prepared for the pig producers. The questionnaire was pre-tested and administered through personal interview.

\textbf{Results and Discussion}

\textbf{Socio-Economic Characteristics of Pig Producers in Imo State Nigeria}

The socio-economic characteristics of pig farmers is shown in Table 1. This table shows that 90% of the farmers were males, 66.7% were more than 46 years old, 100% were christians, 73.3% had primary education or less, 93.3% had a family size of more than six, while the single highest category of pig producers (40%) were craftsmen.

The implications of these findings are numerous. The able-bodied and energetic age group (i.e. less than 46) were not
actively engaged in pig production. Also, all the producers were Christians and since Imo State is more than 99.9% Christians or followers of traditional religion, the moslem abhorrence of pork was not an important factor. Furthermore, since most of the producers either had no formal education (40%) or only attended primary school (33.3%), it means that the educated people have not found pig production suitable. Finally, large households engaged in pig production while craftsmen more easily combined pig production with their occupation, since both occupations tended to be rural. Only 10% of full-time farmers kept pigs.

**Pig Management Systems**

The extensive or free range, semi-intensive or partial confinement, and intensive or total confinement systems were all used to raise pigs in Imo State.

In the extensive or free range, system, the pigs are raised in threes and fours and are let loose day and night on a self-supporting feeding, breeding and management. Under this system, pigs are generally marketed according to the financial needs of the owner rather than with regard to market weight. In the semi-intensive or partial confinement system, the pigs are confined within the compound where they are allowed free movement or are kept in an elevated bamboo or other simply constructed thatch house. They receive minimum care and are provided shelter at night and, especially for farrowing. Pigs are also marketed indiscriminately depending on the urgent financial needs of the family. However, in

| Table 1: Socio-economic characteristics of pigs producers in Imo State, Nigeria |
|---------------------------------|------------------|----------|
| Socio-economic Factors          | Variables        | No.      | %       |
| Sex                             | Male             | 27       | 90.0    |
|                                 | Female           | 3        | 10.0    |
| Total                           |                  | 30       | 100.0   |
| Age                             | 26-35 years      | 3        | 10.0    |
|                                 | 36-45 years      | 7        | 23.3    |
|                                 | 46-55 years      | 15       | 50.0    |
|                                 | 56-65 years      | 5        | 16.7    |
| Total                           |                  | 30       | 100.0   |
| Religion                        | Christianity     | 30       | 100.0   |
| Education                       | No formal education | 12  | 40.0    |
|                                 | Primary School   | 10       | 33.3    |
|                                 | Secondary School | 6        | 20.0    |
|                                 | Higher Institution | 2   | 6.7    |
| Total                           |                  | 30       | 100.0   |
| Family Size                     | 1-5              | 2        | 6.7     |
|                                 | 6-10             | 18       | 60.0    |
|                                 | 11-15            | 10       | 33.0    |
| Total                           |                  | 30       | 100.0   |
| Profession                      | Full-time farmers | 3        | 10.0    |
|                                 | Civil servants   | 8        | 26.7    |
|                                 | Business men     | 7        | 23.3    |
|                                 | Craftsmen        | 12       | 40.0    |
| Total                           |                  | 30       | 100.0   |

Table 2: Size and value of operation of pig producers

<table>
<thead>
<tr>
<th>System Pig Production</th>
<th>Months Ago</th>
<th>*Current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total No. Produced</td>
<td>Estimated Value (N)</td>
</tr>
<tr>
<td>Extensive</td>
<td>30</td>
<td>1,750</td>
</tr>
<tr>
<td>Semi-Intensive</td>
<td>110</td>
<td>9,650</td>
</tr>
<tr>
<td>Intensive</td>
<td>1,640</td>
<td>446,000</td>
</tr>
</tbody>
</table>

Source: Field Survey, 1987

Table 3: Changes in pig production under the different production systems, March 1986 – March 1987, per farmers

<table>
<thead>
<tr>
<th>Item</th>
<th>Extensive</th>
<th>Semi-Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number kept currently</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>Number kept 12 months ago</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Number sold within the last 12 months</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Number consumed by the family within the last 12 months</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Number bought within the last 12 months</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of births (Piglets) within the last 12 months</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>


Table 4: Cost incurred by the average pig farmer under the different production systems (N)

<table>
<thead>
<tr>
<th>Cost Items</th>
<th>Extensive</th>
<th>Semi-Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening stock plus new purchase</td>
<td>365</td>
<td>1,950</td>
</tr>
<tr>
<td>Shelter/housing (per annum)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Equipment (per annum)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Labour</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Feed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Veterinary services</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Marketing</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Miscellaneous (water, electricity, etc.)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>369</td>
<td>1,960</td>
</tr>
</tbody>
</table>


the intensive system, pigs are totally confined and adequate housing, good and balanced feed, water and veterinary care provided. Because of the high capital investment required and the enormous operating costs that must be incurred, it is the system adopted by only the commercial producers.

Pig population according to management systems
Three ‘breeds’ of pigs exist, namely, the local breed, the exotic breed, and the local-exotic cross. The extensive farmers kept only local breeds and accounted for 30% of this breed. The average extensive farmer had 6.8 pigs. The semi-intensive farmer also kept only the local breed and accounted for 70% of this breed. The average semi-intensive farmer had 25.6 pigs. The intensive farmers kept no local breeds but had the exotic and cross-breeds. The average intensive farmer had 79.7 exotic pigs and 19.9 cross-breeds thereby making a total of 99.6 pigs. From the field work, 7.5% of the pigs were local,
74.0% were exotic while 18.5 were cross-
es. The most popular of the exotic breeds
were the Landrace and the Large White
breeds.

Table 2 shows the size and value of pigs
kept under the different production sys-
tems during a one-year period. As at
March, 1987 (when the interview was
done), the extensive farmers had
increased their flock from 30 to 34
(13.3%), the semi-intensive from 110 to
128 (16.4%), and the intensive from 1,640
to 1,992 (21.5%).

The value per pig for the extensive
farmer fell from N58 to N54 (6.9%), while
those for the semi-intensive and inten-
sive farmers rose. For the semi-intensive
farmers, average value rose from N84 to
N90 (7.1%), while that of intensive far-
defers rose from N284 to N359 (26.4%).
These reflect the relative superiority of
these management techniques in pro-
ducing higher quality market animals.
Table 2 also highlights the relative size of
the average farmer (in monetary terms)
under the different production systems.
During the one year period, March 1986
to March 1987 covered by the survey, the
pig population under the different pro-
duction system underwent several
metamorphosis shown in Table 3. The
mortality rates were 19.4%, 8.3% and

Table 5: Enterprise budget per annum for the average farmer using the extensive system of pig management

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Quantity of cost per unit (N)</th>
<th>Amount (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GROSS INCOME</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pig sales</td>
<td>(No)</td>
<td>2</td>
<td>90.00</td>
<td>180.00</td>
</tr>
<tr>
<td>Closing stock</td>
<td>&quot;</td>
<td>7</td>
<td>54.00</td>
<td>375.00</td>
</tr>
<tr>
<td>Total Gross Income</td>
<td></td>
<td></td>
<td></td>
<td>555.00</td>
</tr>
<tr>
<td>2. VARIABLE COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening stock</td>
<td>&quot;</td>
<td>6</td>
<td>58.00</td>
<td>350.00</td>
</tr>
<tr>
<td>New stock (weaner)</td>
<td>&quot;</td>
<td>1</td>
<td>15.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td>2</td>
<td>2.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Interest on variable costs</td>
<td></td>
<td></td>
<td></td>
<td>410.00</td>
</tr>
<tr>
<td>Gross Margin</td>
<td></td>
<td></td>
<td></td>
<td>145.00</td>
</tr>
</tbody>
</table>

Source: Calculated from Survey Data, 1987.

Table 6: Enterprise budget per annum for the average farmer using the semi-intensive system of pig management

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price or cost per unit (N)</th>
<th>Amount (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GROSS INCOME</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pig sales</td>
<td>(No)</td>
<td>5</td>
<td>104.00</td>
<td>522.00</td>
</tr>
<tr>
<td>No. consumed in the family</td>
<td>&quot;</td>
<td>1</td>
<td>108.00</td>
<td>108.00</td>
</tr>
<tr>
<td>Closing</td>
<td>&quot;</td>
<td>26</td>
<td>90.00</td>
<td>2,350.00</td>
</tr>
<tr>
<td>Total GROSS INCOME</td>
<td></td>
<td></td>
<td></td>
<td>2,980.00</td>
</tr>
<tr>
<td>2. VARIABLE COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening stock</td>
<td>&quot;</td>
<td>22</td>
<td>84.00</td>
<td>1,930.00</td>
</tr>
<tr>
<td>New stock (weaner)</td>
<td>&quot;</td>
<td>1</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td></td>
<td>2.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Interest on variable costs at 11%</td>
<td></td>
<td></td>
<td></td>
<td>216.00</td>
</tr>
<tr>
<td>Total variable cost</td>
<td></td>
<td></td>
<td></td>
<td>2,176.00</td>
</tr>
<tr>
<td>Gross Margin</td>
<td></td>
<td></td>
<td></td>
<td>804.00</td>
</tr>
</tbody>
</table>

Source: Calculated from Survey Data, 1987.
Table 7: Enterprise budget per annum for the average farmer using the intensive system of pig management

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit</th>
<th>cost per Quantity</th>
<th>Price or Amount unit (N)</th>
<th>(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GROSS INCOME</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pig sales</td>
<td>(No.)</td>
<td>80</td>
<td>361.00</td>
<td>28,910.00</td>
</tr>
<tr>
<td>Number consumed in the family</td>
<td></td>
<td>5</td>
<td>360.00</td>
<td>1,800.00</td>
</tr>
<tr>
<td>Number given out</td>
<td></td>
<td>1</td>
<td>350.00</td>
<td>350.00</td>
</tr>
<tr>
<td>Closing stock</td>
<td></td>
<td>100</td>
<td>359.00</td>
<td>35,900.00</td>
</tr>
<tr>
<td>Other sales made bags</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
<td>(kg)</td>
<td></td>
<td></td>
<td>650.00</td>
</tr>
<tr>
<td>Total Gross Income</td>
<td></td>
<td></td>
<td></td>
<td>50.00</td>
</tr>
</tbody>
</table>

2. VARIABLE COSTS

Opening stock                  | (No.)| 82                | 284.00                   | 23,300.00 |
Labour (feeding, watering, cleaning) | (Atten-) | 1 | 100.00 | 1,200.00 |
Feed                          |      | 1                 | 13,700.00                |      |
Veterinary services            |      |                   |                          | 1,000.00 |
Miscellaneous (water, electricity, etc.) |      |                   |                          | 150.00 |
Interest on variable at 11%    |      |                   |                          | 4,328.00 |
Total Variable Cost            |      |                   |                          | 43,678.00 |
Gross Margin                  |      |                   |                          | 23,982.00 |

3. FIXED COSTS

*Depreciation – shelter/housing |      | 1,333.00 |
Depreciation – buckets          |      | 25.00 |
Depreciation – weighing scale   |      | 80.00 |
Depreciation – wheel barrow     |      | 100.00 |
Depreciation – shovels/spades   |      | 40.00 |
Interest on fixed costs at 11%  |      | 174.00 |
Total Fixed Cost               |      | 1,752.00 |
Net Farm Income                |      | 22,230.00 |

Source: Calculated from Survey Data, 1987.

Table 8: Relative profitability of the three production systems, 1987

<table>
<thead>
<tr>
<th>Profitability Measure</th>
<th>Extensive</th>
<th>Semi-Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Break-even quantity (Pigs)</td>
<td>7.00</td>
<td>24.00</td>
</tr>
<tr>
<td>Return to capital (N)</td>
<td>0.35</td>
<td>0.37</td>
</tr>
<tr>
<td>Gross margin on variable costs (N)</td>
<td>0.35</td>
<td>0.37</td>
</tr>
<tr>
<td>Return on foundation stock (N/Pig)</td>
<td>24.7</td>
<td>36.55</td>
</tr>
</tbody>
</table>

Source: Calculated from Survey Data, 1987.

2.2% for the extensive, semi-intensive, and intensive farmers, respectively, reflecting the degree of care (management) in each system.

Costs and Returns Under the Different Production Systems

In this section, the costs and returns were worked out for the typical (average) farmer under the different production systems. The total costs of the piggery enterprised comprised the total variable costs and the total fixed costs. The variable costs included the cost of feeds, casual labour, opening stock, veterinary services and transportation while the major fixed costs were those of buildings and equipment (Table 4).

The extensive and semi-intensive farmers incurred costs in transportation to and from the market and breeding stocks only. The semi-intensive farmers provided accommodation for the pigs at night in thatched houses which are used
for other purposes during the day. The prorated cost to the piggery enterprise was negligible. They also used old, discarded buckets to supply water to the pigs. These buckets had no market values or opportunity costs.

The average intensive farmer had two shovels/spades, one wheel barrow, five buckets and one weighing scale. Their annual values are really their depreciated values, using in this case, the straight line method. Good accommodation was provided for and used solely for the piggery operation.

In terms of returns, the gross margin was used as a proxy of the profit earned by the average extensive and semi-intensive farmer since no important fixed costs were involved, while for the intensive farmer, net farm income was used because of the significant fixed costs incurred. The enterprise budgets for the three production systems are presented in tables 5, 6 and 7 for the extensive, semi-intensive and intensive farmers respectively.

Pig production was generally profitable under all the production systems. Profitability is determined by the relationship between gross revenue and total costs. Gross revenue is the product of output and its price but output is in turn affected by litter size, mortality rate, breed and feed conversion efficiency. Product and input prices are influenced by marketing efficiency.

Four profitability measures were used to analyse the relative profitability of the three production systems. These were:

a) Return to capital = Net Farm Income; 
   Total Costs

b) Gross margin on variable costs = 
   Gross Margin; 
   Total Variable Costs

c) Return on foundation stock = 
   Net Farm Income; and, 
   Opening Stock

d) Break-even quantity.

These findings are presented in Table 8. Generally, the intensive system was the most profitable, followed by the semi-intensive and the extensive systems. For example, N1.00 invested in the piggery enterprise returned N0.35 (extensive), N0.37 (semi-intensive) and N0.49 (intensive). The break-even analysis indicate the number of pigs that had to be produced under each system for the average farmer to just cover total costs, i.e. at the break-even quantity, total revenue equals total costs. Beyond the break-even quantity profit is reached.

Using the break-even analysis, the intensive farmer had the largest margin of safety (that is the amount of output by which the scale of output exceeded the break-even point). The margin of safety was 2 pigs for the average extensive farmer, 2 pigs for the average semi-intensive and 60 pigs for the intensive farmer.

These results on relative profitability of the different pig production systems, suggest that the intensive system is the most profitable under the present levels of technologies using any, or all of the profitability measures shown in Table 8. Also, no matter which method of production used, piggery is a profitable enterprise.

References


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LYSINE SUPPLEMENTATION OF COTTONSEED MEAL BASED DIET FOR BROILERS

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L'ADDITION DE LYSINE A UNE RATION A BASE DE FARINE DE GRAINE DE COTON POUR LES POULETS DE GRIL

Résumé
On a effectué deux expériences avec deux différentes souches de poulets de gril (Anac 180 et Shaver) pour évaluer l’effet du gossypol avec ou sans complément de lysine sur la performance de croissance et le rendement en carcasse des poulets de gril. Trois niveaux d’incorporation de lysine (0; 0.13 et 0.26% de L-lysine HCI) ont fait l’objet d’expériences. Les taux de lysine étaient de 1; 1.10 et 1.20% dans la ration à base de farine de graine de coton (FGC), et de 1.07% dans la ration-témoin à base de farine de soja (FS). FGC fut incorporée à raison de 14% dans les rations expérimentales, et la teneur en gossypol libre de ces rations était de 83 ppm/matière sèche (MS). Toutes les rations étaient isocaloriques et isonitrogenés.

D’après les résultats, la lysine n’améliore pas la performance de croissance et le rendement à l’abattage des poulets de gril nourris de ration à base de FGC. Il n’y avait pas de différence notable quant au rendement des poulets nourris de farine de maïs/ farine de graine de coton et ceux servis de farine de maïs/farine de soja avec ou sans complément de lysine. Cependant, on a observé une hypertrophie du foie et une accumulation de gossypol libre dans le foie des poulets nourris de FGC. Les deux souches ne réagissent pas de la même manière à la toxicité du gossypol si l’on tient compte de la consommation alimentaire, du poids du foie et du taux de gossypol libre dans le foie.

Summary
Two trials were conducted with two different strains of broilers (Anac 180 and Shaver) to measure the effect of gossypol with or without lysine supplementation on broiler’s performance and carcass yield. Three levels of added L-lysine HCI (0.00, 0.13 and 0.26% added) were investigated and lysine levels in the diets were 1.00, 1.10 and 1.20% in the cottonseed meal (CSM) diet and the control soybean meal (SBM) diet contained 1.07% lysine. CSM was incorporated at a level of 14% in the experimental diets and free gossypol in these diets were 83 ppm on a dry matter basis. All diet were isocaloric and isonitrogenous.

Results indicated that lysine did not improve broiler performance and carcass yield when fed a CSM based diet. There was no significant difference in broiler performance between birds fed a corn—SBM diet and a corn-CSM diet with or without added lysine. However, liver hypertrophy and hepatic free gossypol accumulation were found to be significant with the CSM based diet. A genetic variability of broiler lines for gossypol toxicity was observed for feed intake, liver weight and hepatic free gossypol accumulation.

INTRODUCTION

In a review article, Waldroup\(^1\) summarized the problems associated with CSM in poultry feed as the presence of the toxic compound gossypol, the deficiency of the amino acid lysine coupled with binding during the heat of processing and the presence of cyclopropenoid fatty acids. The degree of severity of these problems is highly related to the type of processing which the meal undergoes\(^2\). Early work indicated that the tolerance level varied from 160\(^2\) to 1000 ppm\(^3\) according to age, body weight, protein quality and iron level in the diet.

Most reports indicate a depression of appetite as one of the adverse effect of gossypol feeding\(^4,5,6,7\). However some authors reported that CSM could replace groundnut to the extent of 15% without any adverse effect on chick growth\(^8\), or a level up to 20% in the diet was successful for broilers.

Johnston et al.\(^9\) indicated that the depressive effect due to CSM could be overcome by increasing the protein content of the diet or by lysine supplementation. Most studies indicate that the overall amino acid digestibility of CSM is lower than that of SBM\(^10,11,12,13\). Packman et al.\(^14\) completely replaced SBM with CSM in
broiler rations and found that even with adequate supplementation of lysine and methionine, all the groups receiving CSM gave poorer performance than the SBM ration.

The effect of added amino acids on fat synthesis is not clearly defined. Pfaff and Austic\textsuperscript{(15)} reported that essential amino acid deficiency tended to increase consumption and carcass fat. Thomas \textit{et al.}\textsuperscript{(16)} observed a slight trend for the percentage total fat to decrease as lysine increased. Later work indicated that abdominal fat pad was reduced by adding non-essential amino nitrogen to the diet\textsuperscript{(17)}. Meanwhile, Rosenbrough \textit{et al.}\textsuperscript{(18)} reported that lysine increased in vitro lipogenesis from acetate. Therefore increasing the percentage of protein as lysine will increase growth but may also increase the lipid synthetic ability of the poult.

This study was undertaken to evaluate the feeding potential of CSM with or without lysine supplementation on performance, carcass yield and abdominal fat pad of 2 broiler lines (fast and slow growth) at optimum level of dietary lysine.

\textbf{Materials and Methods}

800 chicks imported (Anac 180) and 800 chicks from a local hatchery (Shaver) were used consecutively in a growing trial and fed a common starter diet (Table 1) for 3 weeks and 4 grower diets (Table 1) from 3 weeks to slaughter age. The control diet was based on corn-BSM with 3 level of added L-lysine (0.00, 0.13 and 0.26%). Each dietary treatment consisted of 3 replicates of 66 birds each, randomly distributed in floor pens of 6 square meters. Feed and water were provided \textit{ad libitum}.

Once a week, body weights and feed consumption per replicate were determined. At the end of the experiment (45 days for Anac and 56 days for Shaver) 15 randomly selected males per treatment were sacrificed and the abdominal fat pad

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|c|}
\hline
\textbf{Ingredients} & \textbf{Starter} & \textbf{1 (SBM)} & \textbf{2} & \textbf{3} & \textbf{4} \\
\hline
Yellow maize & 45.56 & 44.84 & 43.67 & 43.81 & 43.95 \\
Cottonseed meal (CSM) & – & – & – & – & – \\
Glandless CSM & 10.00 & 6.00 & 14.00 & 14.00 & 14.00 \\
Fish meal & 16.39 & 8.49 & 10.04 & 10.06 & 10.06 \\
Wheat middlings & 20.79 & 21.99 & 23.73 & 23.45 & 28.18 \\
CaCo & – & 0.45 & 0.34 & 0.34 & 0.34 \\
NaCl & 0.20 & 0.20 & 0.20 & 0.20 & 0.20 \\
Palm oil & 5.00 & 6.00 & 6.00 & 6.00 & 6.00 \\
DL-Methionine & 0.05 & 0.03 & 0.03 & 0.03 & 0.03 \\
L-Lysine & – & – & 0.13 & 0.26 & 0.26 \\
Premix\textsuperscript{1} & 2.00 & 2.00 & 2.00 & 2.00 & 2.00 \\
Feed cost (FCFA/KG) & 89.77 & 99.57 & 82.89 & 85.07 & 88.46 \\
\hline
\textbf{Calculated composition}\textsuperscript{2} (as fed basis) & & & & & \\
\textbf{Crude protein (\%)} & 22.00 & 19.8 & 19.8 & 19.8 & 19.8 \\
\textbf{ME, Kcal/kg} & 3000 & 3000 & 3000 & 3000 & 3000 \\
\textbf{Crude fiber (\%)} & 4.06 & 4.20 & 4.70 & 4.70 & 4.70 \\
\textbf{Calcium (\%)} & 1.00 & 0.90 & 0.90 & 0.90 & 0.90 \\
\textbf{Total Phosphorus (\%)} & 1.00 & 0.90 & 0.90 & 0.90 & 0.90 \\
\textbf{Lysine (\%)} & 1.23 & 1.07 & 1.00 & 1.10 & 1.20 \\
\textbf{Met + Cys (\%)} & 0.85 & 0.72 & 0.72 & 0.72 & 0.72 \\
\textbf{Free gosspol (ppm)} & Traces & Traces & 83.98 & 83.33 & 83.15 \\
\hline
\textsuperscript{1}Premix provides per Kg: Vitamine A 500,000 IU; Vit. D, 50,000 IU; Vit. E 500 mg; Vit. B, 80 mg; Vit. B, 60 mg; Vit. B, 120 mg; Vit. B, 400 mg; Folic acid 32 mg; Nicotinic acid 720 mg; Vit. B, 240 mg; Choline 4,000 mg; Vit. K, 1,000 mg; Mn 6,000 mg; Zn 4,000 mg; Fe 2400 mg; Cu 20 mg; Co 10mg; I 20 mg Flavomycin 20 mg.

\textsuperscript{2}Based on 1984 NRC.
\end{tabular}
\end{table}
Table II: Live weight, average daily gain, feed intake, feed conversion and grower feed cost per kg weight gain

<table>
<thead>
<tr>
<th></th>
<th>Broiler Line</th>
<th>Treatment(1)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liveweight (g)</td>
<td>A</td>
<td>1880.33a</td>
<td>1835.00a</td>
<td>1847.33a</td>
<td>1860.67a</td>
<td>1644.15a</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>1835.00a</td>
<td>1847.33a</td>
<td>1860.67a</td>
<td>1880.33a</td>
<td>1655.13a</td>
</tr>
<tr>
<td>Average daily gain (g/day)</td>
<td>A</td>
<td>37.55a</td>
<td>36.65a</td>
<td>36.88a</td>
<td>37.19a</td>
<td>97.22ab</td>
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<tr>
<td></td>
<td>S</td>
<td>28.72a</td>
<td>28.91a</td>
<td>28.67a</td>
<td>29.39a</td>
<td>91.10a</td>
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<tr>
<td>Feed intake (g/day)</td>
<td>A</td>
<td>97.22ab</td>
<td>93.80a</td>
<td>96.33ab</td>
<td>99.41b</td>
<td>2.59a</td>
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<tr>
<td></td>
<td>S</td>
<td>91.10a</td>
<td>93.80a</td>
<td>94.90a</td>
<td>90.30a</td>
<td>3.17a</td>
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<tr>
<td>Efficiency of feed conversion (g feed/g gain)</td>
<td>A</td>
<td>2.59a</td>
<td>2.56a</td>
<td>2.61a</td>
<td>2.67a</td>
<td>474.32</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>3.17a</td>
<td>3.24a</td>
<td>3.31a</td>
<td>3.18a</td>
<td>507.97</td>
</tr>
<tr>
<td>Grower Feed cost/kg gain (CFA)</td>
<td>A</td>
<td>474.32</td>
<td>380.98</td>
<td>404.38</td>
<td>430.90</td>
<td>90.68a</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>89.48a</td>
<td>90.50a</td>
<td>90.22a</td>
<td>90.37a</td>
<td>69.19a</td>
</tr>
<tr>
<td>Eviscerated Yield (% Live weight)</td>
<td>A</td>
<td>69.19a</td>
<td>68.15a</td>
<td>68.32a</td>
<td>68.21a</td>
<td>68.53a</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>68.53a</td>
<td>67.73a</td>
<td>67.70a</td>
<td>68.30a</td>
<td>1.06a</td>
</tr>
<tr>
<td>Abdominal fat pad (% Live weight)</td>
<td>A</td>
<td>1.96ab</td>
<td>2.03a</td>
<td>1.61ab</td>
<td>2.18b</td>
<td>1.61a</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>1.61a</td>
<td>1.51a</td>
<td>1.49a</td>
<td>1.49a</td>
<td>2.03a</td>
</tr>
<tr>
<td>Liver weight (% Live weight)</td>
<td>A</td>
<td>2.03a</td>
<td>2.40b</td>
<td>2.34b</td>
<td>2.29b</td>
<td>61.48a</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>1.88a</td>
<td>2.05a</td>
<td>2.06a</td>
<td>2.06a</td>
<td>41.8a</td>
</tr>
</tbody>
</table>

(1) Mean values for each broiler line (A = Anac 180; S = Shaver) on the same line with the same superscript are not different (P>0.05).

Table III: Carcass yield, abdominal fat pad, liver weight and gossypol level in the liver

<table>
<thead>
<tr>
<th></th>
<th>Broiler Line</th>
<th>Treatment(1)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield after bleeding and plucking (% Live weight)</td>
<td>A</td>
<td>90.68a</td>
<td>90.40a</td>
<td>91.94a</td>
<td>90.95a</td>
<td>90.48a</td>
</tr>
<tr>
<td>Eviscerated Yield (% Live weight)</td>
<td>A</td>
<td>69.19a</td>
<td>68.15a</td>
<td>68.32a</td>
<td>68.21a</td>
<td>68.53a</td>
</tr>
<tr>
<td>Abdominal fat pad (% Live weight)</td>
<td>A</td>
<td>1.96ab</td>
<td>2.03a</td>
<td>1.61ab</td>
<td>2.18b</td>
<td>1.61a</td>
</tr>
<tr>
<td>Liver weight (% Live weight)</td>
<td>A</td>
<td>2.03a</td>
<td>2.40b</td>
<td>2.34b</td>
<td>2.29b</td>
<td>61.48a</td>
</tr>
<tr>
<td>Gossypol level in the liver (ppm)</td>
<td>A</td>
<td>41.8a</td>
<td>42.86a</td>
<td>42.06a</td>
<td>42.06a</td>
<td>61.48a</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>41.8a</td>
<td>42.86a</td>
<td>42.06a</td>
<td>42.06a</td>
<td>61.48a</td>
</tr>
</tbody>
</table>

(1) Mean values for each broiler line (A = Anac 180; S = Shaver) on the same line with the same superscript are not different (P>0.05).

removed and weighed according to Kubena et al. Carcass yield were obtained after bleeding and plucking, and after eviscerating. The liver from each bird was weighed to measure hypertrophy and then dried and grounded for gossypol determination. Feed efficiency (feed/gain) and feed cost per kg gain were calculated. Data were analysed using Costat Statistical Software.

Results

The mean value for live weight, daily gain, feed intake, feed conversion and grower feed cost per kg weight gain for both broiler lines are presented in Table II. There was no difference (P>0.05) in live weight within each line due to dietary treatment. Feed intake was significantly (P<0.05) increased by lysine level for
Anac 180 but not for Shaver. All the other performance traits were not affected by dietary treatment within each broiler line. Grower feed cost per kg weight gain increased with increasing lysine level in the CSM based diet.

Mean value for carcass yield, abdominal fat pad, liver weight and gossypol level in the liver for both broiler lines are presented in Table III. Yield after bleeding and plucking and eviscerated yield were not affected by dietary regime, within each broiler line. Abdominal fat pad size was not influenced by dietary treatment. Liver hypertrophy was observed for Anac 180 with CSM based diet. A trend towards a reduction in liver weight was observed with increasing level of lysine, but these differences were not significant (P>0.05). Gossypol level in the liver was not affected by lysine level in the diets. However a genetic variability to the hepatic gossypol accumulation was observed.

**Discussion**

Within each broiler line, live weight was consistently unchanged by dietary treatment. However a variation between line was noted for live weight and average daily gain. A genetic variability was found for feed consumption as related to gossypol toxicity. CSM based diet without lysine supplementation depressed feed intake for Anac 180. This trend was not consistent with Shaver broiler line. Efficiency of feed conversion was not affected by dietary treatment within each broiler line. These results were somewhat similar to previous reports\textsuperscript{[4,5,6,7]} if we refer to the line Anac for feed intake. However, our results were conflicting with the results reported by Haydon\textsuperscript{[23]} which indicated a linear improvement in average daily gain and feed efficiency with increasing dietary lysine from .67 to .76%. This disagreement was due to marginal lysine levels used in earlier studies\textsuperscript{[23]} whereas in our studies, lysine level met the NRC\textsuperscript{[19]} requirements with 10% fish meal in the CSM based diets.

Grower feed cost per kg weight gain was in favor of CSM based diets and increased with increasing lysine level in the diets. The return from adding lysine was not worth.

Carcass yield after bleeding and plucking and eviscerated yield were consistently unaffected by dietary regime for both lines. Abdominal fat pad weight remained unchanged. Liver weight showed a genetic variability with liver hypertrophy for Anac 180 when CSM replaced SBM. A trend towards detoxification was observed with increasing dietary lysine but the differences were not significant (P>0.05). Shaver broiler line did detoxify gossypol better than Anac as no change in liver weight was observed with or without CSM for Shaver.

Lysine added to the diet based on cottonseed meal do not improve growth, nor carcass yield. The NRC\textsuperscript{[19]} lysine requirement for growing broilers is confirmed to be 1.00% under the tropics and any increase to 1.20% in the diet do not improve growth and carcass yield. The nutritive value of cottonseed meal should be evaluate in association with other ingredients in a least cost feed formula, but not as an isolated feedstuff.

This study suggests a genetic variability for gossypol detoxification. However, there was a consistent agreement with both lines for lysine meeting the NRC\textsuperscript{[19]} requirements when 10% fish meal is included in a 14% CSM diet. Meanwhile, care should be taken to ensure adequate calories (3000 kcal ME/kg) and proteins (19.8%) to optimize CSM feeding for broilers. A free gossypol level of 83 ppm has no adverse effect on broiler growth, carcass yield and abdominal fat pad weight.

**Acknowledgements**

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**References**


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BIOCHEMICAL CHARACTERISTICS OF FOLLICULAR AND OVIDUCTAL FLUIDS IN CYCLING WHITE FULANI COWS — BOS INDICUS

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Department of Animal Science, University of Nigeria, Nsukka, Nigeria

CARACTERISTIQUES BIOCHIMIQUES DES LIQUIDES DU FOLLICULE ET DE L’OVIDUCTE AU COURS DU CYCLE DE REPRODUCTION DES VACHES WHITE FULANI BOS INDICUS

Résumé
Les caractéristiques biochimiques des liquides du follicule (FF) et de l’oviducte (OV) ont été déterminées chez les vaches tropicales indigènes non gravides pendant le cycle oestral. La concentration moyenne de protéine totale dans FF était de 1,85±0,06 mg/ml, avec une différence très importante (P<0,01) observée entre les phases du cycle. Les concentrations moyennes des principaux composants minéraux (exprimés en mg/100 ml) dans FF étaient comme suit : Na⁺ : 76,52±6,63; K⁺ : 26,19±3,25; Ca²⁺ : 10,25±1,79 et Mg²⁺ : 11,47±1,36. Les variations des concentrations de chaque minéral au cours des phases du cycle oestral étaient négligeables. Le pH de FF était de 7,30±0,16.

Dans OV, la concentration moyenne de protéine totale était de 1,07±0,12 mg/ml, sans différence notable pendant les phases du cycle. Les concentrations moyennes de minéraux (mg/100 ml) dans OV étaient les suivantes : Na⁺ : 134,70±15,92; K⁺ : 143,37±23,49; Ca²⁺ : 15,63±3,01 et Mg²⁺ : 6,86±0,98. À l’exception de la concentration de magnésium, qui variait beaucoup (P<0,01), il n’y avait pas de différences notables quant aux concentrations des autres électrolytes pendant les phases du cycle. La concentration moyenne pH de OV était de 6,29±0,10. Les concentrations, les rapports et le type de variations de ces composants minéraux dans FF et OV des vaches White Fulani Bos indicus étaient comparées aux résultats obtenus dans les rapports antérieurs sur ce sujet.

Summary
Biochemical characteristics of follicular fluid (FF) and oviductal fluid (OV) were determined in non-pregnant indigenous tropical cows during the oestrous cycle. The mean total protein concentration in FF was 1.85±0.06 mg/ml, with a highly significant difference (P<0.01) occurring between phases of the cycle. Mean concentrations of the major mineral constituents expressed as mg/100 ml of FF were as follows: Na⁺ : 76.52±6.63; K⁺ : 26.19±3.25; Ca²⁺ : 10.25±1.79; and Mg²⁺ : 11.47±1.36. Variations in the concentrations of each mineral during phases of the oestrous cycle were not significant. The pH of FF was 7.30±0.16.

In OV, the mean total protein concentration was 1.07±0.12 mg/ml, with no significant difference during phases of the cycle. Average mineral concentrations (mg/100ml) in OV were: Na⁺ : 134.70±15.92; K⁺ : 143.37±23.49; Ca²⁺ : 15.63±3.01; and Mg²⁺ : 6.86±0.98. With the exception of magnesium concentration which varied significantly (P<0.01), there were no significant differences in the concentrations of the other electrolytes during phases of the cycle. Mean pH of OV was 6.29±0.10. The concentrations, interrelationships and pattern of variations of these constituents in FF and OV of this breed were compared to previous reports in literature.

INTRODUCTION
Secretions of the bovine ovarian follicles and oviducts may be important not only in providing a stable biochemical environment for the proper functioning of the support cells, but also as a source of nourishment for the ova contained in the follicles; and as a milieu necessary for the vital fertilization process within the oviduct\(^1\). To ensure these physiological roles, these fluids contain essential elements and compounds which are both organic and inorganic in nature\(^2\). Existing reports on the the general biochemical composition of FF\(^3,4,5\) and OV\(^6,7\), and specifically as related to periods of the oestrous cycle appear to be limited to Bos taurus breeds. The aim of this study was therefore to quantify the protein and major mineral constituents of these secretions in normal-cycling White Fulani

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cattle, a breed very much in use for beef and milk supply throughout the West African sub-region.

Materials and Methods

Reproductive tracts of White Fulani cows aged between 3 to 5 years and with active ovaries were collected after slaughter from the abattoir in Nsukka between May and September (wet season). Within 30 minutes of slaughter, each reproductive tract was transported to the laboratory under ice and the stage of the reproductive cycle was estimated. In a previous study, Akinpelumi and Orji\(^{20}\) classified six distinct ovarian morphological changes during the ovarian cycle of White Fulani cows and these changes could be used to estimate phases of the oestrous cycle. (Phase I, days 22 and 23 of previous cycle to day 1 of new cycle; phase II, days 2-4; phase III, days 5-10; phase IV, days 11-14; phase V, days 15-18; phase VI, days 19-21) Subsequently, only the genital tracts of twenty three cows classified according to these phases were included in this study.

Ovary: Follicular fluid (FF) was aspirated from all follicles (≥ 2mm) found on twenty-two pairs of ovaries. The pH was determined using bromothymol indicator paper while the colour and consistency of the fluids were also recorded. FF from ovaries of same cow were pooled, kept separately in glass sample bottles and respective pooled volumes recorded. The fluids were frozen at -5°C until required for analysis.

Oviduct: Each pair of oviducts was excised from the genital tract and all adhering tissues removed. Oviductal fluid (OV) was collected in a sample bottle by gently passing each oviduct between two smooth batons, once in either direction. The colour, consistency, pH and respective pooled volumes of the fluids were recorded. Oviductal fluids were also frozen at -5°C until required for analysis.

Prior to laboratory analyses, stored FF and OV were allowed to thaw at room temperature and diluted in doubly deionised water (1:50, v/v). Total protein concentration was determined by the Lowry, Rosenbrough, Farr and Randall\(^{30}\) method using PYE UNICAM SP6 — 450 UV/VIS spectrophotometer. Bovine serum albumin was used to construct the standard curve. Mineral concentrations were determined by the method of Quinn, White and Wirrick\(^{30}\). Calcium and magnesium concentrations were determined using Atomic Absorption Spectrophotometer (UNICAM SP90A Series 2). Sodium and potassium concentrations were analysed using Petracourt PF-P1 Flame Photometer.

One-way analysis of variance (ANOVA) unequal subclass\(^{10}\) was used to compare the means of all parameters over phases of the oestrous cycle.

Results

Follicular fluids: All samples of FF collected were yellow in colour and watery in consistency. The mean volume of FF per pair of ovaries was 0.84 ± 0.09 ml; range 0.03 - 2.00 ml while the pH was 7.30 ± 0.16 and ranged between 7.00 and 8.00. Mean total protein concentration during the cycle was 1.85 ± 0.06 (mg/ml) while the average mineral concentrations (mg/100ml) of Na\(^+\), K\(^+\), Ca\(^{2+}\) and Mg\(^{2+}\) in FF were 76.52 ± 6.63, 26.19 ± 3.25, 10.25 ± 1.79 and 11.47 ± 1.36 respectively.

The mean volume of FF and the mean concentrations of protein and minerals in FF during phases of the cycle are presented in Table 1. A highly significant difference (P<0.01) in the total protein concentration was detected between phases of the oestrous cycle. Protein concentrations were highest during phases V and VI (days 15-18 and 19-21 of the cycle respectively). Although considerable variations were observed in the mineral concentrations during phases of the cycle, these were however not significantly different. The Na\(^+\) to K\(^+\) ratio was about 3:1 while that of Ca\(^{2+}\) to Mg\(^{2+}\) was about 1:1 (Table 1). The correlation coefficients between biochemical parameters of FF are shown in Table 2. Highly significant positive correlations (P<0.01) were found between Na\(^+\) and K\(^+\); and between Ca\(^{2+}\) and total
Table 1: Biochemical characteristics of follicular fluid during the oestrous cycle
Phases of the cycle
(Mean±S.E.)

<table>
<thead>
<tr>
<th>Item</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Overall VI Mean±S.E.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=3)</td>
<td>(N=3)</td>
<td>(n=5)</td>
<td>(n=2)</td>
<td>(n=5)</td>
<td>(n=4)</td>
<td></td>
</tr>
<tr>
<td>Vol. of fluid</td>
<td>0.90</td>
<td>0.51</td>
<td>0.91</td>
<td>0.55</td>
<td>0.75</td>
<td>1.20</td>
<td>0.84</td>
</tr>
<tr>
<td>(ml)</td>
<td>±0.06</td>
<td>±0.05</td>
<td>±0.28</td>
<td>±0.15</td>
<td>±0.13</td>
<td>±0.27</td>
<td>±0.09</td>
</tr>
<tr>
<td>Protein</td>
<td>1.68</td>
<td>1.54</td>
<td>1.87</td>
<td>1.47</td>
<td>2.10</td>
<td>2.06</td>
<td>1.85</td>
</tr>
<tr>
<td>(mg/ml)</td>
<td>±0.08</td>
<td>±0.07</td>
<td>±0.06</td>
<td>±0.00</td>
<td>±0.06</td>
<td>±0.14</td>
<td>±0.06</td>
</tr>
<tr>
<td>Sodium</td>
<td>67.23</td>
<td>60.80</td>
<td>63.84</td>
<td>78.80</td>
<td>101.96</td>
<td>82.00</td>
<td>76.52</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±10.44</td>
<td>±14.83</td>
<td>±16.54</td>
<td>±10.90</td>
<td>±18.76</td>
<td>±5.24</td>
<td>4.80-176.40</td>
</tr>
<tr>
<td>Potassium</td>
<td>34.73</td>
<td>17.43</td>
<td>20.28</td>
<td>28.20</td>
<td>32.01</td>
<td>25.50</td>
<td>26.19</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±20.08</td>
<td>±1.25</td>
<td>±5.90</td>
<td>±7.27</td>
<td>±11.70</td>
<td>±2.17</td>
<td>±3.25</td>
</tr>
<tr>
<td>Calcium</td>
<td>10.67</td>
<td>3.87</td>
<td>12.80</td>
<td>5.15</td>
<td>15.50</td>
<td>7.50</td>
<td>10.25</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±3.61</td>
<td>±0.59</td>
<td>±3.77</td>
<td>±0.35</td>
<td>±5.71</td>
<td>±2.60</td>
<td>±1.79</td>
</tr>
<tr>
<td>Magnesium</td>
<td>13.55</td>
<td>8.24</td>
<td>16.08</td>
<td>16.08</td>
<td>6.76</td>
<td>10.14</td>
<td>11.47</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±4.45</td>
<td>±4.89</td>
<td>±1.98</td>
<td>±0.24</td>
<td>±2.01</td>
<td>±3.17</td>
<td>±1.36</td>
</tr>
</tbody>
</table>

n=number of ovary pairs used in analyses.
a, b, c, d, different letter superscripts represent different means (P<0.01).

Table II: Correlation coefficients between biochemical parameters in follicular and oviductal fluids

<table>
<thead>
<tr>
<th></th>
<th>FF</th>
<th>Protein</th>
<th>Ca²⁺</th>
<th>Mg²⁺</th>
<th>Na⁺</th>
<th>M⁺</th>
</tr>
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<tbody>
<tr>
<td>OF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>–</td>
<td>0.545**</td>
<td>–</td>
<td>–</td>
<td>0.323</td>
<td>0.110</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>0.330</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.640</td>
<td>0.124</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>–0.175</td>
<td>0.162</td>
<td>–</td>
<td>–</td>
<td>–0.389</td>
<td>–0.029</td>
</tr>
<tr>
<td>Na⁺</td>
<td>–0.006</td>
<td>0.100</td>
<td>0.593**</td>
<td>–</td>
<td>0.70**</td>
<td></td>
</tr>
<tr>
<td>K⁺</td>
<td>0.084</td>
<td>0.110</td>
<td>0.618**</td>
<td>–</td>
<td>0.936**</td>
<td></td>
</tr>
</tbody>
</table>

**=Significance (P<0.01)

Table 3: Biochemical characteristics of oviductal fluid during the oestrous cycle
Phases of the cycle
(mean ± S.E.)

<table>
<thead>
<tr>
<th>Item</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Overall VI Mean±S.E.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=3)</td>
<td>(n=3)</td>
<td>(n=5)</td>
<td>(n=3)</td>
<td>(n=5)</td>
<td>(n=4)</td>
<td></td>
</tr>
<tr>
<td>Vol. of fluid</td>
<td>0.37</td>
<td>0.27</td>
<td>0.46</td>
<td>0.37</td>
<td>0.28</td>
<td>0.45</td>
<td>0.37</td>
</tr>
<tr>
<td>(ml)</td>
<td>±0.07</td>
<td>±0.07</td>
<td>±0.10</td>
<td>±0.09</td>
<td>±0.05</td>
<td>±0.10</td>
<td>±0.04</td>
</tr>
<tr>
<td>Protein</td>
<td>0.98</td>
<td>1.26</td>
<td>1.31</td>
<td>0.81</td>
<td>0.56</td>
<td>1.54</td>
<td>1.07</td>
</tr>
<tr>
<td>(mg/ml)</td>
<td>±1.60</td>
<td>±0.44</td>
<td>±0.18</td>
<td>±0.10</td>
<td>±0.09</td>
<td>±0.46</td>
<td>±0.12</td>
</tr>
<tr>
<td>Sodium</td>
<td>254.00</td>
<td>109.33</td>
<td>142.60</td>
<td>105.00</td>
<td>91.00</td>
<td>131.25</td>
<td>134.70</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±80.62</td>
<td>±16.62</td>
<td>±23.75</td>
<td>±12.19</td>
<td>±10.83</td>
<td>±14.10</td>
<td>±15.92 77.00-360.00</td>
</tr>
<tr>
<td>Potassium</td>
<td>315.00</td>
<td>91.00</td>
<td>166.70</td>
<td>110.83</td>
<td>80.50</td>
<td>127.75</td>
<td>143.37</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±117.57</td>
<td>±24.05</td>
<td>±50.01</td>
<td>±21.25</td>
<td>±9.44</td>
<td>±35.51</td>
<td>±23.49 45.00-534.00</td>
</tr>
<tr>
<td>Calcium</td>
<td>22.17</td>
<td>15.67</td>
<td>17.70</td>
<td>3.00</td>
<td>15.40</td>
<td>15.50</td>
<td>15.63</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±8.26</td>
<td>±9.25</td>
<td>±5.07</td>
<td>±1.00</td>
<td>±8.43</td>
<td>±9.24</td>
<td>±3.01</td>
</tr>
<tr>
<td>Magnesium</td>
<td>15.15b</td>
<td>7.15a</td>
<td>7.75a</td>
<td>5.46a</td>
<td>4.51a</td>
<td>3.33a</td>
<td>6.86</td>
</tr>
<tr>
<td>(mg/100ml)</td>
<td>±0.58</td>
<td>±2.90</td>
<td>±1.76</td>
<td>±1.25</td>
<td>±0.70</td>
<td>±1.90</td>
<td>±0.98</td>
</tr>
</tbody>
</table>

n=number of oviduct pairs used in analyses.
a, b=different letter superscripts represent different means (P<0.01).
protein.

Oviductal Fluid: The colour of OV examined varied between cream and yellow and was somewhat of thick consistency. The mean volume of OV collected per oviduct pair was 0.37 ± 0.04 ml and ranged between 0.20 - 0.70 ml, while the mean pH for all samples was 6.29 ± 0.10; range 6.00 - 6.50. The mean total protein concentration was 1.07 ± 0.12 (mg/ml) while the mean mineral concentrations (mg/100ml) of OV during the cycle were Na+, 134.70 ± 15.92; K+, 143.37 ± 23.49; Ca2+, 15.63 ± 3.01; and Mg2+, 6.86 ± 0.98. The average volume of fluid obtained per oviduct and the mean concentrations of protein and electrolytes in OV during phases of the cycle are shown in Table 3. Total protein concentrations were collectively higher during phases VI, I and II (follicular phase) than during phases III, IV and V (luteal phase). Of the four electrolytes determined, only magnesium concentration showed a highly significant variation (P<0.01) between phases of the cycle. The Na+:K+ ratio was about 1:1 while that of Ca2+:Mg2+ was about 2.3:1. The coefficient of correlation between biochemical parameters in OV are presented in Table 2. Correlations between Na+ and K+; Na+ and Mg2+; and K+ and Mg2+ were highly significant (P<0.01).

Discussion

The colour and consistency of both FF and OV of White Fulani cows are consistent with previous observations on beef breeds[2,11]. Furthermore, the volume of FF collected is comparable to 0.78 ml reported for Hereford heifers[11], while the volume of OV was below the average of 2.0/ml obtained through cannulation of oviducts[6]. The pH of FF and OV obtained in this study were respectively more alkaline and slightly more acidic than the 7.10 and 6.29 reported for follicular and oviductal fluids of diary-type cows[1].

The mean total protein concentration observed in FF is far less than values earlier reported for temperate breeds[1,3,5]. The pattern of variation of total protein in FF appears to indicate that follicular pro-

tein is accumulated starting from the late luteal phase, and reaching a maximum in the early follicular phase (days 19-21 of cycle). This period coincides with the rapid growth phase of the Graafian follicle that culminates in ovulation. The concentrations of sodium and potassium in FF of White Fulani cows are below values quoted in other reports[12,11]. However the average calcium concentration is consistent with the observation of[11], while the magnesium concentration is higher than that obtained by[12]. Due to the appreciable variability in the mineral concentrations in FF during phases of the cycle, caused primarily by variations between cows within same period, no meaningful inference could be arrived at, as to whether any of the constituents was mobilized at either the luteal or follicular phase.

In OV, the amount of protein obtained is similar to values reported for Bos taurus cows[6,13]. Also the pattern of variation of protein in OV shows some degree of consistency with earlier findings[6,14]. Comparatively, the protein concentration was higher during the follicular phase than during the luteal phase. This appears to suggest that in White Fulani cows, the secretion of protein in OV may be stimulated by circulating oestrogen. With the exception of calcium, the concentrations of the other electrolytes were relatively lower than values previously reported for OV of temperate breeds[11].

The results indicate that with the exception of sodium and potassium, the concentrations of the other biochemical indices investigated were within the range of values reported for temperate breeds of cattle. However, the consistently low levels of sodium and potassium in both FF and OV of White Fulani cows may suggest a significant breed implication in providing appropriate osmotic pressure and acid-base balance in these secretions within the tropical environment.

Acknowledgements

The authors wish to thank Dr. J.O. Onyechi of the Department of Pharmaceutical Technology and Industrial
Pharmacy and Mr. C. Ovaga of the Department of Animal Science for their technical assistance.

References


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GROSS MORPHOLOGICAL AND MORPHOMETRIC CHANGES IN OVARIES OF CYCLING WHITE FULANI COWS — BOS INDICUS

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CHANGEMENTS MORPHOLOGIQUES ET MORPHOMETRIQUES DES OVAIRES AU COURS DU CYCLE DE REPRODUCTION DES VACHES WHITE FULANI (BOS INDICUS)

Résumé
Les phases du cycle ovarien ont été évaluées en tenant compte des changements morphologiques et morphométriques des ovaires des vaches White Fulani au cours de leur cycle de reproduction. On a noté six stades morphologiques distincts sur les ovaires pendant le cycle ovarien. La couleur du corps lutéal, le poids et le diamètre, ainsi que le nombre de follicules variaient au cours du cycle. Les poids moyens du corps lutéal pour les phases I à IV étaient respectivement de 1 ± 0,45 g; 0,23 ± 0,03 g; 2,84 ± 0,35 g; 1,47 ± 0,50 g; 1,33 ± 0,24 g et 0,53 ± 0,24 g; tandis que les nombres de follicules étaient en moyenne de 5,33 ± 2,11; 3 ± 1,16; 7,71 ± 1,06; 5 ± 1,62 et 5,20 ± 0,66. Une variation significative du cycle (P<0,05) était manifeste pour les poids du corps lutéal. On a pris des photos des ovaires pour mettre en relief les changements constatés durant chaque phase du cycle ovarien.

Summary
Phases of the ovarian cycle were estimated based on the gross morphological and morphometric changes observed within the ovaries of cycling White Fulani cows. Six distinct morphological stages were observed on the ovaries during the ovarian cycle. Corpora luteal colour, weight and diameter as well as follicle count were variable during the cycle. The mean corpora luteal weights for phases I to VI were 1.00 ± 0.45g, 0.23 ± 0.03g, 2.84 ± 0.35g, 1.47 ± 0.50g, 1.33 ± 0.24g and 0.53 ± 0.24g respectively; while the corresponding mean follicle numbers were 5.33 ± 2.11, 3.00 ± 1.16, 7.71 ± 1.06, 5.00 ± 1.62 and 5.20 ± 0.66. A significant cyclical variation (P<0.05) was evident for the corpora luteal weights. Photographs of the ovaries were taken to highlight the appearance of the gross changes during each phase of the ovarian cycle.

INTRODUCTION

The ovaries of Bos taurus cows are reported to be relatively larger than those of Bos indicus breeds\(^\text{1,2}\). As such, there may be differences in the nature and extent of the changes undergone by the ovaries of tropical breeds of cows during the oestrous cycle as compared to those of temperate breeds. Changes in the morphology of the corpus luteum\(^\text{3,4}\), and changes in morphology and numbers of follicles\(^\text{5,6,4}\) have been reported during the oestrous cycle of temperate breeds of cattle. However, previous investigations into the ovarian characteristics of tropical cows\(^\text{7,8}\) have rather been descriptive in nature. Therefore, this study was aimed at quantifying the morphological and morphometric changes in the ovaries of normal-cycling White Fulani cows — a predominant West African Zebu breed.

Materials and Methods

Animals:
Reproductive tracts of White Fulani cows aged between 3-5 years were collected after sacrifice from the abattoir in Nsukka. It was not possible to observe the cows for heat symptoms prior to slaughter. Genital tracts were recovered soon after killing and transported to the laboratory under ice. Of the several specimens collected, only the reproductive organs of thirty non-pregnant cows, the ovaries of
which had undergone one or more oestrous cycles and showed normal follicular and luteal development were included in this study.

**Experimental procedure:**

On arrival at the laboratory, each pair of ovaries from individual cows was examined and phase of the ovarian cycle immediately estimated using the classification guidelines established for bovine ovaries\(^{[9,4]}\). Length of the oestrous cycle was taken as 23 days\(^{[10]}\), day 1 being day of onset of oestrus. Between three to seven cows were used to classify each phase. Each ovary was excised from adhering tissues and weighed. All follicles (\(\geq 2\) mm) seen on the surface of each pair of ovaries were counted and their sizes measured. The colour and texture of each corpus luteum as well as the diameter at its greatest extremities were recorded. Each corpus luteum was subsequently excised from the ovary and weighed. Using a single reflex 35 mm camera, photographs of all the ovaries used were taken (10 cm from object) to record the gross morphological changes. Subsequently, one photograph representative of each of the phases determined, was used in the analysis.

**Statistical analysis:**

Differences in mean weights and lengths of the ovary and corpus luteum during phases of the ovarian cycle were determined using Analysis of Variance (ANOVA) technique for unequal subclasses. Significantly different means were separated using standard statistical procedure\(^{[11]}\).

**Results**

**Morphological observations:**

All the ovaries examined were oval in shape. Each ovary contained follicles while some contained corpora lutea which bulged on the surfaces of the ovaries. Plate 1 (a)-(f) shows the representative gross appearance of the ovary during each phase of the ovarian cycle.

**Phase 1:**- Late follicular phase (days 21, 22 of previous cycle — day 1 of new cycle). This phase was characterized by the presence of one very large, fluid filled and translucent preovulatory follicle (\(\geq 6\) mm) that appeared like a blister on the ovarian surface. The large follicle has a visible network of blood vessels and would easily depress to the touch. Degenerating corpus luteum (corpus albicans) of the previous cycle was usually present and was cream in colour, although in two ovaries the colour remained yellowish. (Plate 1a).

**Phase II:**- Ovulatory phase (days 2-4 of new cycle). This phase depicts the immediate post-ovulatory morphologic changes. On one of the ovaries examined, a new corpus luteum was developing and appeared like a blood clot (corpus haemorrhagicum). The corpus luteum was very soft textured and in two other ovaries the colour was red. One large and turgid follicle (\(\geq 6\) mm) and an average of four smaller follicles (2-5 mm) which contained fluids were generally seen on each ovary. (Plate 1b).

**Phase III:**- Early luteal phase (days 5-10 of new cycle). The corpus luteum was bigger and had a definite oval shape. It was still soft textured and the colour ranged from brown to orange. The mass of the corpus luteum was highly vascular, indicative of active tissue. Numerous developing follicles (\(\leq 2\) mm) were present on ovarian surface. (Plate 1c).

**Phase IV:**- Central luteal phase (days 11-14 of cycle). The corpus luteum was relatively large and the vasculature was still slightly visible on corpus luteum surface. The colour was bright yellow — a possible sign of complete lutenization. At this phase, the corpus luteum was hard and firm to the touch. One large follicle (\(\geq 6\) mm) was also seen on the ovary. (Plate 1d).

**Phase V:**- Late luteal phase (days 15-18 of cycle). At this period, the corpus luteum appeared to be receding into the matrix of the ovary and the vasculature had visibly become ischemic. The corpora luteal texture was firm while the colour was dull yellow. Many small follicles (\(\leq 2\) mm) were present on surface of the ovary. (Plate 1e).

**Phase VI:**- Early follicular phase (days
Gross morphological and morphometric changes in ovaries of cycling White Fulani cows — Bos indicus

Table 1: Mean values of ovarian characteristics during phases of the ovarian cycle

<table>
<thead>
<tr>
<th>Phase of cycle</th>
<th>Right (gm ± S.E.)</th>
<th>Left (gm ± S.E.)</th>
<th>Ovary pair (gm ± S.E.)</th>
<th>Weight (gm)</th>
<th>Diameter (cm)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2.63 ± 0.19</td>
<td>3.35 ± 0.38</td>
<td>5.98 ± 0.54</td>
<td>6</td>
<td>1.00 ± 0.46a</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>2.80 ± 0.59</td>
<td>2.97 ± 1.07</td>
<td>5.77 ± 0.50</td>
<td>3</td>
<td>0.23 ± 0.03a</td>
<td>3</td>
</tr>
<tr>
<td>III</td>
<td>3.73 ± 0.60</td>
<td>5.06 ± 0.76</td>
<td>8.79 ± 0.90</td>
<td>7</td>
<td>2.84 ± 0.35b</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>4.77 ± 2.65</td>
<td>5.83 ± 1.09</td>
<td>10.60 ± 3.73</td>
<td>3</td>
<td>1.47 ± 0.50ab</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>3.68 ± 0.77</td>
<td>3.30 ± 0.35</td>
<td>6.98 ± 0.41</td>
<td>6</td>
<td>1.33 ± 0.34ab</td>
<td>3</td>
</tr>
<tr>
<td>VI</td>
<td>2.96 ± 0.56</td>
<td>2.68 ± 0.36</td>
<td>5.64 ± 0.69</td>
<td>5</td>
<td>0.53 ± 0.24a</td>
<td>3</td>
</tr>
</tbody>
</table>

n = number of samples used in analysis.

19-21 of cycle). The corpus luteum, cream in colour, appeared like a small but firm outgrowth on the ovarian surface. An average of four follicles (2–5 mm) were present on ovarian surfaces. (Plate 1f).

Morphometric observations:
The mean length of each ovary (n = 60) was 2.41 ± 0.06 cm; range, 1.60 ± 3.50 cm. Average lengths of the right and left ovaries were 2.37 ± 0.08 cm and 2.45 ± 0.09 cm respectively, with no significant difference in the lengths of the two although the left ovary was slightly longer than the right. The mean weight of each ovary was 3.65 ± 0.30 g and ranged between 1.10 – 10.00 g, while the average weights of the right and left ovaries were 3.43 ± 0.33 g and 3.87 ± 0.52 g respectively. Although left ovaries were a little heavier than right ovaries, the difference between the two were not significant. The combined weight per pair of ovaries was 7.29 ± 0.82 g with a range of 3.40 - 18.00 g.

The mean values of weights of the pairs of ovaries and corpora lutea during phases of the ovarian cycle are presented in Table 1. Considerable variations were noticeable in the weights of the ovary pairs during the cycle but these were however not statistically different. Ovarian weights rose through phases I and II, were highest during phases III and IV and diminished thereafter. The corpora luteal weight and diameter were also variable during the cycle, with the highest mean weight and diameter of 2.84 ± 0.35 g and 1.22 ± 0.25 cm respectively occurring during phase III. A significant cyclical variation (P<0.05) in the weights of corpora lutea occurred during phases of the cycle (Table 1). Of the 147 ovulations counted, 66 (44.9%), occurred on the right ovary while 81 ovulations (55.1%) occurred on the left. There was a highly significant difference (P<0.01) on the incidence of ovulation between the right and left ovaries.

A total number of 189 follicles (> 2 mm) were counted on the ovarian surfaces. 89 follicles (47.1%) of the total appeared on the left ovary while 100 follicles (52.9%) occurred on the right. The difference in the number of follicles occurring on the right and left ovaries was highly significant (P<0.01). Furthermore, out of the 189 follicles counted, 177 were used for classifying the follicles into two-size categories viz:

- 2-5 mm : small
- ≥ 6 mm : large

Thus, 136 follicles (76.8%), fell into the small-size category while 41 (23.2%) were in the large-size class. There was a cyclical variation in the number of follicles within the small and large size categories during phases of the ovarian cycle (Fig. 1). As shown in Fig. 1, there appeared to exist two growth waves of follicles during the ovarian cycle of White Fulani cows. The first occurred between phases II and III, while the second occurred between phases IV and V.

Discussion

The ovarian weights and sizes observed in this study are in agreement with values reported for Zebu breeds. Also, the colour changes of corpora lutea
Plate 1 [a]–[f]: Ovarian morphological changes during the ovarian cycle.
Fig. 1: Cyclical Variations in the Mean Number of Follicles (≥ 2mm) per Ovary Pair.
during the ovarian cycle are in consonance with earlier findings\(^\text{[8]}\). Furthermore, the cyclicity of corpus luteum weight in White Fulani cows is similar to that found in Hereford cows\(^\text{[9]}\), although the mean weight per phase was higher for the latter breed. This may be a reflection of the smaller ovarian weight of *Bos indicus* cows as compared to *Bos taurus*\(^\text{[1]}\). The detection of two follicle-growth waves in this study is consistent with previous observations\(^\text{[12,13]}\).

Since significant cyclical variations were detected in some of the parameters investigated, the results tend to suggest that the classification of the ovarian cycle into the described six phases may be a potentially useful approach in conducting fertility studies involving the genital tracts of cows of unknown reproductive history.

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**References**


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GENETIC AND PHENOTYPIC PARAMETER ESTIMATES OF GROWTH TRAITS OF THE DORPER AND DORPER X RED MAASAI SHEEP

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EVALUATION DU PARAMETRE GENETIQUE ET PHENOTYPIQUE DES CARACTERES DE CROISSANCE DES MOUTONS DORPER ET DORPER x RED MAASAI

Résumé
On a utilisé dans la présente étude des données sur 1.550 agneaux recueillies sur une période de dix ans (1978 à 1987) sur les moutons Dorper et Dorper x Red Maasai à Ol'Magogo. Les paramètres étudiés étaient les poids (de la naissance à un an), et les taux absolus de croissance au cours des divers stades de croissance. Les poids moyens et les écarts-types en kg étaient respectivement: le poids à la naissance (PN): 4,02 et 0,76, le poids comparatif au sevrage (PCS): 19,06 et 4,54; le poids comparatif à six mois (PCSM): 24,72 et 5,49; le poids comparatif à neuf mois (PCNM): 29,89 et 5,40; le poids comparatif à douze mois (PCDM): 37,88 et 6,18. Pour les taux de croissance, avant le sevrage (TC1): 0,167 et 0,047; du sevrage à six mois (TC2): 0,62 et 0,041; de six à neuf mois (TC3): 0,057 et 0,040; de neuf à douze mois (TC4): 0,088 et 0,050 et le taux de croissance global de la naissance à un an (TCG): 0,091 et 0,018. Les estimations de l’hérédité (demi-frère et demi-soeur, côté paternel) étaient respectivement de: 0,15±0,07; 0,18±0,08; 0,39±0,11; 0,55±0,13; 0,53±0,13; 0,14±0,07; 0,28±0,09; 0,59±0,14; 0,49±0,12 et 0,49±0,12 pour PN, PCS, PCSM, PCNM, PCDM, TC1, TC2, TC3, TC4 et TCG. Les estimations de l’hérédité après le sevrage étaient en général plus élevées que celles précédant le sevrage, ce qui montre que l’influence génétique est plus faible chez les agneaux nouveaux-nés. Les corrélations génétiques et phénotypiques évaluées entre les poids étaient très positives (0,15 à 0,99 et 0,2 à 0,98 respectivement). Il y avait dans l’ensemble de fortes corrélations génétiques et phénotypiques entre les poids adjacents, entre les poids et les taux de croissance et entre les taux de croissance eux-mêmes.

Summary
Data on 1550 lambs collected over a 10 year period (1978 to 1987) on Dorper and Dorper x Red Maasai sheep at Ol’Magogo was used in this study. Lamb traits studied were weights from birth to yearling and absolute growth rates between adjacent stages of growth. The respective mean weights and standard deviations in kilograms were: Birth weight (BIRTHW), 4.02 and .76; adjusted weaning weight (ADJWWT), 19.06 and 4.54; adjusted six months weight (ADJSWMW), 24.72 and 5.49; adjusted nine months weight (ADJNWMW), 29.89 and 5.40; adjusted twelve months weight (ADJTMW), 37.88 and 6.18; and for growth rates: preweaning (GR1), .167 and .047; weaning to six months (GR2), .062 and .041; six to nine months (GR3), .057 and .040; nine to twelve months (GR4), .088 and .050; and overall growth rate from birth to yearling (OVRGR), .091 and .018. Heritability estimates from paternal half-sib analysis were: .15±.07, 18±.08, .39±.11, 55±.13, .53±.13, .14±.07, 28±.09, 59±.14, .49±.12 and .49±.12; for BIRTHW, ADJWWWT, ADJSWMW, ADJTMW, GR1, GR2, GR3, GR4 and OVRGR, respectively. Post-weaning heritability estimates were generally higher than those for pre-weaning suggesting a lower direct-genetic influence early in life. Genetic and phenotypic correlations estimated between weights were mainly positive (.15 to .99 and .02 to .9, respectively). There were generally high genetic and phenotypic correlations between adjacent weights, between weights and rates of growth, and among growth rates themselves.

INTRODUCTION

Body weight and rate of gain are among the most economically important and easily-measured traits of meat animals. Although weight is an important objective in selection, knowledge of the particular phase of the animal's growth upon which to base selection is of utmost importance. The potential for genetic improvement is largely dependent on the heritability of the trait and its genetic
relationship with other traits of economic importance upon which some selection pressure may be applied. Information on heritabilities is essential for planning efficient breeding programmes and for predicting response to selection. Genetic correlations, on the other hand, are essential in predicting indirect responses to selection and are needed in order to determine the optimum weighting and expected response to multiple trait selection. Genetic and phenotypic parameter estimates are scarce in sheep reared under Kenyan conditions and where such information is available, analytical methods used tend to be inadequate.

The purpose of this study was to estimate genetic and phenotypic parameters of growth traits in a flock of Dorper and Dorper x Red Maasai sheep at various stages of growth from birth to yearling and to investigate environmental sources of variation influencing these traits.

Materials and Methods

The data used in this study consisted of growth records of lambs from Dorper and Dorper x Red Maasai ewes. These data were collected from records of the Sheep and Goat Development Project (SGDP) based at Ol’Magogo, a substation of the National Animal Husbandry Research Centre (NAHRC), Naivasha, between 1978 through 1987. Out of a total of 3343 records initially available, only 1550 records contained complete information from birth to yearling which could be used for correlation estimates.

Body weights analysed included weight at birth, at three months (weaning), at six months, at nine months and at twelve months (yearling). In addition, each lamb record included sire, dam and lamb identifications, type of birth, sex and dam breed. Three seasons of birth were defined on the basis of the monthly rainfall distribution. Two rainy seasons were identified with April and May (season 1) forming the peak of the long rains while October and November were classified as season of short rains (season 2). The remaining months were classified as dry season (season 3).

Parities were defined based on the number of times the ewes had lambed giving rise to parities 1, 2, 3 and 4, the latter comprising ewes with 4 or more lambings. Due to disproportionate distribution of data across years which resulted into disconnectedness in the data, it was not possible to include actual years in the analysis. Therefore, to adjust for differences in weather conditions across years, periods of birth were defined by grouping adjacent years on the basis of annual rainfall pattern. This otherwise uncommon grouping method was implemented after examination of meteorological data, and was felt to be the best method under the circumstances. Period 1 consisted of the years 1978-1980 which received the highest rainfall, period 2 (1981-1985) received intermediate amounts while period 3 (1986-1987) received the lowest.

The absolute growth rates were derived by taking the difference in weight within the period and dividing it by the time interval in days. The absolute rate of gain for each lamb was calculated over five growth periods namely:- Birth to weaning (GR1), weaning to six months (GR2), six to nine months (GR3), nine to twelve months (GR4) and birth to twelve months (OVRGRT). These together with the body weights constitute the 10 traits analysed in this study.

In all cases the sires were pure Dorpers. The dams were either pure Dorpers or crosses between Dorper and Red Maasai. The dam genotypes used in this study were:- Dorper, Return 3 x DRM, Return 4 x DRM, Return 1 x Return 1, and Return 2 x Return 2, coded 1, 2, 3, 4 and 5 respectively. DRM represents a Dorper x Red Maasai first cross. These genotypes were developed as follows:-

<table>
<thead>
<tr>
<th>Rams</th>
<th>Ewes</th>
<th>%Dorper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorper x Red Maasai</td>
<td>---F1 (DRM)</td>
<td>50%</td>
</tr>
<tr>
<td>Dorper x F1</td>
<td>---F2</td>
<td>75%</td>
</tr>
<tr>
<td>Dorper x F2</td>
<td>---F3 (Return 1)</td>
<td>87.5%</td>
</tr>
<tr>
<td>Dorper x Return 1</td>
<td>---Return 2</td>
<td>93.75%</td>
</tr>
<tr>
<td>Dorper x Return 2</td>
<td>---Return 3</td>
<td>96.88%</td>
</tr>
<tr>
<td>Dorper x Return 3</td>
<td>---Return 4</td>
<td>98.44%</td>
</tr>
</tbody>
</table>
The genotypes of the ewes were 100% Dorper, 73.44% Dorper, 74.22% Dorper, 87.5% Dorper and 93.75% Dorper and were coded 1 through 5, respectively. The resultant lambs were thus of the following genotypes:

<table>
<thead>
<tr>
<th>Rams</th>
<th>Genotype of Ewes</th>
<th>Genotype of Lambs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorper x (1)</td>
<td>Pure Dorper</td>
<td>Pure Dorper</td>
</tr>
<tr>
<td>Dorper x (2)</td>
<td>73.44% Dorper</td>
<td>86.72% Dorper</td>
</tr>
<tr>
<td>Dorper x (3)</td>
<td>74.22% Dorper</td>
<td>87.11% Dorper</td>
</tr>
<tr>
<td>Dorper x (4)</td>
<td>87.5% Dorper</td>
<td>93.75% Dorper</td>
</tr>
<tr>
<td>Dorper x (5)</td>
<td>93.75% Dorper</td>
<td>96.88% Dorper</td>
</tr>
</tbody>
</table>

Thus, the use of a single sire breed in this study provides a one-to-one correspondence between the genotype of the dam and that of the lamb. Lambs were nursed by their dams up to weaning.

In view of the differences in actual age at which weights were taken, the latter were pre-adjusted as follows:-

\[
\text{ADJJWT} = (\text{Adjusted 90-day weaning weight}) = GR1 \times 90 \text{ days} + \text{birth weight (BIRTHW)}
\]

\[
\text{ADJSWMW} = (\text{Adjusted six months weight}) = GR2 \times 90 \text{ days} + \text{ADJJWT}
\]

\[
\text{ADJNMMW} = (\text{Adjusted nine months weight}) = GR3 \times 90 \text{ days} + \text{ADJSWMW}
\]

\[
\text{ADJTMW} = (\text{Adjusted twelve months weight}) = GR4 \times 90 \text{ days} + \text{ADJNMMW}.
\]

Adjustment for fixed effects (sex, season of birth, period of birth, parity and dam breed) was achieved by including them in the model.

Genetic and phenotypic parameters estimated were:- heritability of each trait, and genetic and phenotypic correlations among these traits as traits of the lamb. Also estimated were repeatabilities for preweaning growth traits.

**Statistical Analyses.** The statistical models used to relate observations with independent variables were as follows:-

**Model 1:**

\[
Y_{ijklmn} = u + a_i + b_j + c_k + d_l + f_m + g_n + e_{ijklmn} + \text{where } Y_{ijklmn} = \text{the } ijklmn^{th} \text{ observation.}
\]

\[
u = \text{an underlying constant for the trait}
\]

\[
a_i = \text{effect of the } i^{th} \text{ sire (} i = 1, ..., 63) \text{ assumed random, } N(0, \sigma^2_s)
\]

\[
b_j = \text{effect of the } j^{th} \text{ season of birth (} j = 1, 2, 3)
\]

\[
c_k = \text{effect of the } k^{th} \text{ dam genotype "breed" (} k = 1, 2, 3, 4, 5).
\]

\[
d_l = \text{effect of the } l^{th} \text{ parity (} l = 1, 2, 3, 4).
\]

\[
f_m = \text{effect of the } m^{th} \text{ period of birth (} m = 1, 2, 3).
\]

\[
g_n = \text{effect of the } n^{th} \text{ sex (} = \text{male, } 2 = \text{female}).
\]

\[
e_{ijklmn} = \text{random error associated with the } ijklmn^{th} \text{ observation; } N(0, \sigma^2_e).
\]

Pure Dorpers as well as various combinations of Dorper x Red Maasai lambs were included in this model whose sole purpose was to investigate the differences in the performance of various genotypes. Sires were included in this model to account for possible genetic differences among sires.

**Model 2:**

\[
Y_{ijklmn} = \mu + a_i + b_j + c_k + d_l + f_m + e_{ijklmn}
\]

where \( Y_{ijklmn} = \text{the } ijklmn^{th} \text{ observation.} \)

\[
u = \text{an underlying constant for the trait}
\]

\[
a_i = \text{effect of the } i^{th} \text{ sire (} i = 1, ..., 63) \text{ assumed random, } N(0, \sigma^2_s)
\]

\[
b_j = \text{effect of the } j^{th} \text{ season of birth (} j = 1, 2, 3)
\]

\[
c_k = \text{effect of the } k^{th} \text{ dam genotype "breed" (} k = 1, 2, 3, 4, 5).
\]

\[
d_l = \text{effect of the } l^{th} \text{ period of birth (} l = 1, 2, 3).
\]

\[
f_m = \text{effect of the } m^{th} \text{ period of birth (} m = 1, 2, 3).
\]

\[
e_{ijklmn} = \text{random error associated with the } ijklmn^{th} \text{ observation; } N(0, \sigma^2_e).
\]

The lambs included in this model were pure Dorpers.

Parameters were estimated from covariances of relatives using paternal half-sib (PHS) analysis using Model 2 based on the Least Squares Method in which sires were cross-classified with fixed effects. The analytical complications introduced in half-sib analysis by
use of litters was avoided by including only lambs born as singles. Use of intermediate genotypes (crosses) in the estimation of genetic parameters was avoided because of the concomitant difficulty in estimating additive genetic effects free from heterotic effects. Heritability was estimated from variance components as

\[ h^2 = 4\sigma^2_s / (\sigma^2_s + \sigma^2_w) \]

where \( h^2 \) = heritability estimate
\( \sigma^2_s \) = sire variance component
\( \sigma^2_w \) = variance of records within sires

The approximate method of Swiger et al. \((3)\) was used to estimate the standard error of the heritability estimate. Genetic correlations between two traits 1 and 2, \( r_{12} \), were estimated as

\[ r_{12} = \sigma_{s1s2} / (\sigma_{s1} \sigma_{s2}) \]

where \( \sigma_{s1s2} \) is the sire covariance component for the two traits and \( \sigma_{s1} \) and \( \sigma_{s2} \) are square roots of respective sire variance components. Repeatability estimate (as a trait of the dam) was based on the formula:

\[ r = \sigma^2_d / (\sigma^2_d + \sigma^2_w) \]

where \( \sigma^2_d \) and \( \sigma^2_w \) are components of variance of records between dams and records within dams, respectively. These components were estimated by substituting dams for sires in the above model.

Results and Discussion

Analysis of Fixed Effects.

Analysis of variance for body weights and growth rates are presented in Tables 1 and 2, respectively. Corresponding least squares means are presented in Tables 3 and 4 by subclasses.

Sex. Least squares means (Tables 3 and 4) indicate that male lambs performed, in all cases, considerably better than their female counterparts. These differences were significant (at least at P<0.05 level) for all the traits except for preweaning growth rate (GR2) for which it was not significant. Consistent superiority of male lambs has been reported by several workers\((3,4,5,6,7)\) and has been attributed to hormonal differences between sexes and their resultant effects on growth\((6,9)\).

Genotype. Genotype of dam significantly influenced only six months weight (P<0.05) (Table 1). The Dorper x Red Maasai crosses performed better than the pure Dorpers in this trait (Table 3). This superiority could be attributed to the complementarity arising from the adaptability of the Red Maasai sheep to the local conditions and the inherent fast growth rates of Dorper sheep\((10)\). From the results of this study it is apparent that lambs with 93.75% Dorper blood nursed by genotype 4 ewes consistently performed better than all other genotypes. Thus, further upgrading to Dorper may not be desirable and this particular genotype would be preferred at Ol’Magogo. The fact that dam genotype did not significantly influence growth traits seems to stem from the near uniformity in the dam genotype (ranging from 73.44%-100% Dorper) and lamb genotype (86.72%-100%). Despite the lack of statistically significant difference in performance among these genotypes for the other traits (notably ADJNMM, ADJTMW, GR1, and GR2) genotype 4 (i.e. 93.75% Dorper) and genotype 2 (86.72%) lambs seemed to have had numerically better performance than the other genotypes. These results indicate that the composition of the ideal genotype for Ol’Magogo may be somewhere between that of genotype 2 and that of 4. However, the design of this study could not provide conclusive results in this regard. Besides, some genotypes had small subclass numbers hence large standard errors of subclass least squares constants (and hence least squares means). A study designed specifically for these comparisons, including actual estimates of maternal and individual heterosis for these respective genotypes in this environment may provide results which could be used in choosing the desired breed combinations. Kiririo\((7)\), has reported that breed of lamb has a highly significant effect on
#### Table 1: Analysis of Variance of Body weights (Model 1)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Mean squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
</tr>
<tr>
<td>Sires</td>
<td>62</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
</tr>
<tr>
<td>Dam genotype</td>
<td>4</td>
</tr>
<tr>
<td>Season of birth</td>
<td>2</td>
</tr>
<tr>
<td>Parity</td>
<td>3</td>
</tr>
<tr>
<td>Period of birth</td>
<td>2</td>
</tr>
<tr>
<td>Error</td>
<td>1124</td>
</tr>
</tbody>
</table>

***P<0.001 **P<0.01 *P<0.05

#### Table 2: Analysis of Variance of Growth rates (Model 1)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Mean squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
</tr>
<tr>
<td>Sires</td>
<td>62</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
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<tr>
<td>Dam genotype</td>
<td>4</td>
</tr>
<tr>
<td>Season of birth</td>
<td>2</td>
</tr>
<tr>
<td>Parity</td>
<td>3</td>
</tr>
<tr>
<td>Period of birth</td>
<td>2</td>
</tr>
<tr>
<td>Error</td>
<td>1124</td>
</tr>
</tbody>
</table>

***P<0.001 **P<0.01 *P<0.05

#### Table 3: Least Squares Means and Standard Errors of Body Weights (Model 1)

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of observ.</th>
<th>BIRTHW (kg)</th>
<th>ADJJWT (kg)</th>
<th>ADJSMW (kg)</th>
<th>ADJNMW (kg)</th>
<th>ADJTMW (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall mean±S.E.</td>
<td>1199</td>
<td>4.23±0.07</td>
<td>19.71±0.36</td>
<td>24.97±0.46</td>
<td>30.53±0.51</td>
<td>38.69±0.62</td>
</tr>
<tr>
<td>Males</td>
<td>579</td>
<td>4.34±0.08</td>
<td>20.35±0.38</td>
<td>25.74±0.48</td>
<td>31.48±0.53</td>
<td>40.15±0.65</td>
</tr>
<tr>
<td>Females</td>
<td>620</td>
<td>4.12±0.07</td>
<td>19.06±0.37</td>
<td>24.20±0.47</td>
<td>29.59±0.52</td>
<td>37.20±0.64</td>
</tr>
<tr>
<td>Dam Genotype</td>
<td>1</td>
<td>4.24±0.06</td>
<td>19.49±0.29</td>
<td>24.55±0.36</td>
<td>30.04±0.40</td>
<td>37.41±0.49</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.37±0.14</td>
<td>20.37±0.73</td>
<td>25.77±0.93</td>
<td>30.13±1.02</td>
<td>38.77±1.25</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4.13±0.11</td>
<td>19.66±0.57</td>
<td>24.80±0.73</td>
<td>31.03±0.80</td>
<td>38.81±0.98</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4.30±0.08</td>
<td>20.06±0.43</td>
<td>25.85±0.55</td>
<td>31.59±0.60</td>
<td>39.79±0.73</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4.11±0.16</td>
<td>18.91±0.78</td>
<td>23.87±1.00</td>
<td>29.86±1.10</td>
<td>38.61±1.34</td>
</tr>
<tr>
<td>Season of birth</td>
<td>1</td>
<td>4.19±0.06</td>
<td>20.79±0.32</td>
<td>26.41±0.40</td>
<td>30.71±0.44</td>
<td>39.33±0.54</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.28±0.15</td>
<td>17.53±0.78</td>
<td>21.88±0.99</td>
<td>30.07±1.09</td>
<td>37.16±1.33</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4.23±0.06</td>
<td>20.80±0.28</td>
<td>26.63±0.35</td>
<td>30.81±0.39</td>
<td>39.54±0.59</td>
</tr>
<tr>
<td>Parity</td>
<td>1</td>
<td>4.14±0.07</td>
<td>18.99±0.35</td>
<td>24.41±0.44</td>
<td>30.65±0.49</td>
<td>39.48±0.59</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.29±0.07</td>
<td>19.76±0.37</td>
<td>25.08±0.47</td>
<td>31.06±0.52</td>
<td>38.99±0.64</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4.26±0.09</td>
<td>20.02±0.45</td>
<td>25.30±0.57</td>
<td>29.95±0.63</td>
<td>38.24±0.76</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4.24±0.12</td>
<td>20.05±0.62</td>
<td>25.08±0.79</td>
<td>30.26±0.87</td>
<td>37.99±1.06</td>
</tr>
<tr>
<td>Period of birth</td>
<td>1</td>
<td>4.12±0.08</td>
<td>19.55±0.43</td>
<td>23.16±0.54</td>
<td>29.81±0.60</td>
<td>36.32±0.73</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.10±0.08</td>
<td>17.55±0.41</td>
<td>22.90±0.52</td>
<td>27.96±0.57</td>
<td>38.98±0.70</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4.47±0.07</td>
<td>22.02±0.37</td>
<td>28.86±0.47</td>
<td>33.83±0.51</td>
<td>40.73±0.63</td>
</tr>
</tbody>
</table>

Key: Dam genotype 1 = Dorper, 2 = Return 3 x DRM, 3 = 4 x DRM, 4 = Return 1 x Return 1, 5 = Return 2 x Return 2
Table 4: Least Squares Means and Standard Errors of Rates of Growth (Model 1)

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of observ.</th>
<th>GR1 (kg/d)</th>
<th>GR2 (kg/d)</th>
<th>GR3 (kg/d)</th>
<th>GR4 (kg/d)</th>
<th>OVRGRVT (kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall means±S.E.</td>
<td>1199</td>
<td>0.171±0.004</td>
<td>0.058±0.004</td>
<td>0.061±0.004</td>
<td>0.090±0.005</td>
<td>0.104±0.002</td>
</tr>
<tr>
<td>Males</td>
<td>579</td>
<td>0.177±0.004</td>
<td>0.059±0.004</td>
<td>0.063±0.004</td>
<td>0.096±0.005</td>
<td>0.107±0.002</td>
</tr>
<tr>
<td>Females</td>
<td>620</td>
<td>0.165±0.004</td>
<td>0.057±0.004</td>
<td>0.059±0.004</td>
<td>0.084±0.005</td>
<td>0.101±0.002</td>
</tr>
<tr>
<td>Dam Genotype 1</td>
<td>990</td>
<td>0.169±0.003</td>
<td>0.066±0.003</td>
<td>0.061±0.003</td>
<td>0.081±0.004</td>
<td>0.101±0.001</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>0.177±0.008</td>
<td>0.059±0.008</td>
<td>0.048±0.008</td>
<td>0.096±0.009</td>
<td>0.104±0.004</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>0.172±0.006</td>
<td>0.057±0.006</td>
<td>0.069±0.007</td>
<td>0.086±0.007</td>
<td>0.106±0.003</td>
</tr>
<tr>
<td>4</td>
<td>114</td>
<td>0.175±0.005</td>
<td>0.064±0.005</td>
<td>0.063±0.005</td>
<td>0.091±0.005</td>
<td>0.106±0.002</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>0.164±0.008</td>
<td>0.054±0.009</td>
<td>0.066±0.009</td>
<td>0.097±0.010</td>
<td>0.104±0.004</td>
</tr>
<tr>
<td>Season of birth 1</td>
<td>465</td>
<td>0.184±0.003</td>
<td>0.062±0.004</td>
<td>0.047±0.004</td>
<td>0.095±0.004</td>
<td>0.092±0.002</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>0.147±0.008</td>
<td>0.048±0.009</td>
<td>0.091±0.009</td>
<td>0.078±0.010</td>
<td>0.127±0.004</td>
</tr>
<tr>
<td>3</td>
<td>713</td>
<td>0.184±0.003</td>
<td>0.064±0.003</td>
<td>0.046±0.003</td>
<td>0.097±0.004</td>
<td>0.093±0.001</td>
</tr>
<tr>
<td>Parity</td>
<td>731</td>
<td>0.165±0.004</td>
<td>0.060±0.004</td>
<td>0.071±0.004</td>
<td>0.095±0.004</td>
<td>0.106±0.002</td>
</tr>
<tr>
<td>2</td>
<td>310</td>
<td>0.171±0.004</td>
<td>0.059±0.004</td>
<td>0.066±0.004</td>
<td>0.088±0.005</td>
<td>0.104±0.002</td>
</tr>
<tr>
<td>3</td>
<td>117</td>
<td>0.175±0.005</td>
<td>0.058±0.005</td>
<td>0.051±0.006</td>
<td>0.092±0.006</td>
<td>0.103±0.002</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>0.175±0.007</td>
<td>0.055±0.007</td>
<td>0.057±0.007</td>
<td>0.085±0.008</td>
<td>0.104±0.003</td>
</tr>
<tr>
<td>Period of birth 1</td>
<td>578</td>
<td>0.171±0.005</td>
<td>0.039±0.005</td>
<td>0.073±0.005</td>
<td>0.072±0.005</td>
<td>0.099±0.002</td>
</tr>
<tr>
<td>2</td>
<td>259</td>
<td>0.149±0.004</td>
<td>0.059±0.005</td>
<td>0.056±0.005</td>
<td>0.122±0.005</td>
<td>0.102±0.002</td>
</tr>
<tr>
<td>3</td>
<td>362</td>
<td>0.194±0.004</td>
<td>0.075±0.004</td>
<td>0.055±0.004</td>
<td>0.076±0.005</td>
<td>0.111±0.002</td>
</tr>
</tbody>
</table>

Key: Dam genotype 1 = Dorper, 2 = Return 3 x DRM, 3 = Return 4 x DRM, 4 = Return 1 x Return 1, 5 = Return 2 x Return 2

Birth weight, weaning weight and preweaning growth rate. Thus, conditions at the experimental location seem to favour some combination of Dorper x Red Maasai breed, and it may be recommended that the crossbred ewes be maintained in order to harness the advantages accruing from them. The generally better performance of the crosses may be a result of heterosis for growth and adaptability in the study environment.

Season of birth. The effect of season of birth was significant for all traits except birth weight and preweaning growth rate. The effect of season of birth arises from seasonal variation in the physical environment resulting from changes in weather conditions (including rainfall amounts, temperature, and humidity) which directly affect feed availability, especially in a situation (such as is the case in this study) with no supplementary feed. Seasonal influence on a trait such as birth weight operates through its effect on the dam’s uterine environment mostly in late gestation(11). Such factors operating in seasons prior to lambing will be manifested in birth weight. This may explain the higher (albeit non-significant) birth weight of lambs born in the dry season. That is, lambs born in the long dry season may be those whose ewes enjoyed the wet season during the critical stages of gestation. Such lambs would be expected to weigh more at birth compared to those whose dams underwent a nutritionally stressful period during lactation. It is, therefore, expected that the season when the ewe is in gestation is likely to play a more important role in birth weight than the actual season of birth. On the other hand, season of birth plays an important role in growth performance indirectly through its influence on the dam’s nutrition (and hence amount of milk available to the unweaned lamb) and later, directly, through its effect on the pasture availability and quality on which the lamb is subsequently weaned. Growth traits are known to have positive correlations, both genetic and phenotypic12,13,14,15. The significance of season of birth for early growth performance may thus be responsible, as a carry-over effect, for its significant influence on growth traits up to weaning. That growth rate from weaning to six months was not significantly influenced by season of birth — although season of birth was a significant source for growth rate.
Table 5: Heritabilities, Genetic and Phenotypic Correlations from Paternal Half-sib Analysis (Model 2)

<table>
<thead>
<tr>
<th>Trait</th>
<th>BIRTHW</th>
<th>ADJVWT</th>
<th>ADJSMW</th>
<th>ADJTMW</th>
<th>GR1</th>
<th>GR2</th>
<th>GR3</th>
<th>GR4</th>
<th>OVRGRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIRTHW</td>
<td>0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.46</td>
<td>0.47</td>
<td>0.84</td>
<td>0.91</td>
<td>-0.04</td>
<td>0.15</td>
<td>0.67</td>
</tr>
<tr>
<td>±0.07</td>
<td>±0.21</td>
<td>±0.24</td>
<td>±0.22</td>
<td>±0.18</td>
<td>±0.18</td>
<td>±0.31</td>
<td>±0.29</td>
<td>±0.24</td>
<td>±0.22</td>
</tr>
<tr>
<td>ADJVWT</td>
<td>0.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.18</td>
<td>0.80</td>
<td>0.59</td>
<td>0.70</td>
<td>0.99</td>
<td>0.44</td>
<td>-0.02</td>
<td>0.29</td>
</tr>
<tr>
<td>±0.08</td>
<td>±0.12</td>
<td>±0.16</td>
<td>±0.16</td>
<td>±0.15</td>
<td>±0.15</td>
<td>±0.01</td>
<td>±0.28</td>
<td>±0.23</td>
<td>±0.23</td>
</tr>
<tr>
<td>ADJSMW</td>
<td>0.19</td>
<td>0.64</td>
<td>0.39</td>
<td>0.64</td>
<td>0.46</td>
<td>0.86</td>
<td>0.89</td>
<td>-0.15</td>
<td>-0.13</td>
</tr>
<tr>
<td>±0.11</td>
<td>±0.11</td>
<td>±0.11</td>
<td>±0.11</td>
<td>±0.15</td>
<td>±0.15</td>
<td>±0.13</td>
<td>±0.08</td>
<td>±0.19</td>
<td>±0.19</td>
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<tr>
<td>ADJTMW</td>
<td>0.21</td>
<td>0.54</td>
<td>0.69</td>
<td>0.55</td>
<td>0.76</td>
<td>0.61</td>
<td>0.50</td>
<td>0.67</td>
<td>0.15</td>
</tr>
<tr>
<td>±0.13</td>
<td>±0.08</td>
<td>±0.18</td>
<td>±0.16</td>
<td>±0.10</td>
<td>±0.10</td>
<td>±0.18</td>
<td>±0.07</td>
<td>±0.10</td>
<td>±0.18</td>
</tr>
<tr>
<td>GR1</td>
<td>0.15</td>
<td>0.98</td>
<td>0.63</td>
<td>0.52</td>
<td>0.45</td>
<td>0.14</td>
<td>0.52</td>
<td>-0.05</td>
<td>0.21</td>
</tr>
<tr>
<td>±0.07</td>
<td>±0.07</td>
<td>±0.31</td>
<td>±0.25</td>
<td>±0.26</td>
<td>±0.26</td>
<td>±0.07</td>
<td>±0.23</td>
<td>±0.14</td>
<td>±0.18</td>
</tr>
<tr>
<td>GR2</td>
<td>-0.10</td>
<td>-0.17</td>
<td>0.65</td>
<td>0.35</td>
<td>0.24</td>
<td>-0.16</td>
<td>0.28</td>
<td>-0.22</td>
<td>-0.42</td>
</tr>
<tr>
<td>±0.08</td>
<td>±0.08</td>
<td>±0.08</td>
<td>±0.15</td>
<td>±0.15</td>
<td>±0.15</td>
<td>±0.15</td>
<td>±0.08</td>
<td>±0.16</td>
<td>±0.16</td>
</tr>
<tr>
<td>GR3</td>
<td>0.61</td>
<td>-0.05</td>
<td>-0.27</td>
<td>0.51</td>
<td>0.32</td>
<td>-0.06</td>
<td>-0.31</td>
<td>0.59</td>
<td>-0.06</td>
</tr>
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<td>±0.04</td>
<td>±0.04</td>
<td>±0.04</td>
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<td>±0.04</td>
<td>±0.04</td>
<td>±0.04</td>
<td>±0.04</td>
<td>±0.04</td>
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</tbody>
</table>

<sup>a</sup>Heritabilities with standard errors below them on primary diagonal.
<sup>b</sup>Genetic correlations with standard errors below them above the diagonal.
<sup>c</sup>Phenotypic correlations below the diagonal.

before and after this period — may be due to the postweaning stress which may have obscured the effect of season of birth. In general, season 1 and 3 were associated with better performance than season 2 (the short rains). The impact of this advantage early in life appears to be perpetuated up to yearling. As far as the body weights are concerned, season 3 was consistently associated with superior performance. From the results of this study it is evident that lambs born in the dry season performed better than those born in the rainy season. It is therefore recommended that breeding at Ol’Magogo should be planned so as to lambing to occur in the dry season. This way lambs benefit from favourable prenatal nutrient availability via their dams. However, lambing in the dry season has serious nutritional implications to the ewes. This is a time when ewes require good pastures so as to support their young and improve their own body condition. The best compromise would be to time lambing to occur towards the end of the dry season just preceding the rainy season.

Parity of Dam. Parity was a significant source of variation for preweaning growth rate and adjusted weaning weight (P<0.01). Least squares means (Tables 3 and 4) indicate that as far as preweaning growth rate and weaning weight are concerned, the performance of lambs improved with increase in parity. That young ewes tend to produce smaller lambs at birth has been documented<sup>3,10</sup>. First parity ewes are still growing and thus must provide for their own growth in addition to the foetal demand. It is generally known that mothering ability, especially milk production increases with parity: Older ewes are larger in body and better milkers<sup>3,11,12,17</sup>. Hence, influence of the superior maternal environment of such ewes is expected to be translated into better lamb performance up to weaning. It was, therefore, not surprising that postweaning growth performance was not significantly influenced by parity. The effect of parity of dam on lambs is thus imparted as maternal influence whose direct influence is limited to the nursing
Period of Birth. Period of birth was a significant source of variation for all traits except birth weight and yearling weight. As has been alluded to, period of birth was defined by grouping adjacent years which, from meteorological data, generally had same rainfall pattern. To this end, the significance of this factor was only important because it facilitated the adjustments of records for the effect of 'periods’. Any particular period, on its own, has no important bearing on the interpretation of the results and therefore did not have any management implications.

Genetic and Phenotypic parameters.

Heritability. Heritability estimates are summarized in Table 5. Heritability of birth weight was found to be \(0.15 \pm 0.07\). This estimate compares favourably with estimates of \(0.19^{[13]}\), \(0.21^{[14]}\) and \(0.24^{[18]}\). The estimate for weaning weight was \(0.18 \pm 0.08\) which was lower than \(0.28 \pm 0.11^{[12]}\) and \(0.36 \pm 0.12^{[15]}\). Thus, in general, both estimates for birth and weaning weight were lower than those in the literature. Heritability for six months weight was estimated at \(0.39 \pm 0.11\). This was slightly above the estimates of \(0.28 \pm 0.10^{[14]}\) and \(0.21^{[19]}\). The estimate for weight at nine months \((0.55 \pm 0.13)\) compares favourably with the range of \(0.30\) to \(0.50^{[20]}\). However, few studies have reported heritability estimates of nine months weight. That for twelve months weight was estimated at \(0.53 \pm 0.13\) and was higher than values reported in other studies: \(0.38 \pm 0.23^{[3]}\); \(0.26 \pm 0.11^{[12]}\); and \(0.11 \pm 0.11^{[14]}\). Heritability estimates of growth rates progressively increased from \(0.14 \pm 0.07\) for preweaning growth rate to \(0.59 \pm 0.14\) for growth rate between six to nine months then declined to \(0.49 \pm 0.12\) for rate of gain between nine to twelve months. The range of heritability for preweaning growth rate in the literature\(^{[21,22,23]}\) was \(0.18-0.37\). Overall growth rate had a heritability estimate of \(0.49 \pm 0.12\). However, this was higher than \(0.29 \pm 0.11^{[12]}\). Rae\(^{[20]}\) reported a range of \(0.20-0.40\) for postweaning growth rate while a high figure of \(0.58 \pm 0.14\) has been reported in Columbia sheep\(^{[19]}\).

It is clear from these results that postweaning growth generally had higher heritability estimates than preweaning growth. This would indicate that environmental factors, in relation to additive genetic factors, had more influence on early lamb gain than on gains later in the lamb's life. This may be attributed to the high maternal influence associated with lamb growth performance early in life. High maternal influence has a tendency to increase the component of variance environmental to the lamb thereby lowering heritability estimates\(^{[24,25]}\).

The best time to evaluate an animal's additive genetic value for a desired trait is under circumstances which assure maximum expression of the genes, that is under conditions when heritability is highest, provided that the genetic expression at this time is highly correlated with the genetic expression during the time period in life when the trait is most valuable or important\(^{[19]}\). However, one should not ignore the effect of time of evaluation on generation interval. Moreover, the desired genotype might be more accurately evaluated through another highly heritable trait, or an index, which is highly correlated genetically with it.

These results, therefore, indicate that to select lambs for their own genetic merit for weights and gains, it would be best to use body weight at nine months as the selection criterion rather than weaning weight as is often practised. This trait should be superior to weaning weight or preweaning growth rate since it is much less influenced by maternal effects which tend to obscure the direct additive genetic effect for growth. Although the generation interval may not be considerably shortened, overhead costs should certainly be curtailed when the rest of the lamb crop is disposed of at this stage. On the other hand, selection of ewes as dam must be based on lamb performance preweaning and at weaning. In any case, the objective should be to choose a practical selection criterion which will maximize the annual rate of progress for the trait to be improved without seriously impairing merit in important correlated traits\(^{[19]}\).
Genetic correlations. Genetic correlations between growth traits at various ages was generally high and positive ranging from .15±.24 to .99±.01 (Table 5). Genetic correlations between adjacent traits were generally higher than the ranges reported in the literature .21-.77 for correlation between birth weight and weaning weight\(^{13,15}\), .13-.22 for birth weight and twelve months weight, and .21-.72 for weaning weight and twelve months weight\(^{12,14}\). The high genetic correlations among these traits suggests that selection for any one of these traits would result in considerable positive change in other traits. The complications brought about by maternal environment early in the lamb's life (hence the lowered estimate of direct genetic effects) may be overcome by utilizing correlated response. One could concentrate on traits with high heritability as long as there exists a high positive correlation with other traits of economic value. Moreover, selection directed towards weights at later ages would minimize response in birth weight and possible increased frequency of dystocia\(^{16,26,27,28,29}\). However, selection for weights at later ages would be expected to lead to increased yearling weights which is desirable for meat animals, but may be associated with increased maintenance costs for breeding animals and those kept for wool production. Genetic correlations between growth rates and various weights and between growth rates themselves ranged from medium and negative to high and positive (.42 to .99). Most of the estimates were not statistically significantly different from zero. Such (negative) estimates could be explained by the effect of compensatory growth obscuring underlying genetic relationships. Thus, in general, genetic correlations were low to high positive. There is, therefore, potential of exploiting correlated response for most of these traits. Traits such as birth weight, weaning weight and preweaning growth rate could be incorporated in a selection index aimed at selecting for yearling weight since these traits are highly correlated with twelve months weight. However, care must be taken to avoid problems related to dystocia which may result due to selection for increased birth weights.

Phenotypic correlations. Phenotypic correlations between weights were all positive and generally high (.19-.74) (Table 5). As was the case for genetic correlations among weights, phenotypic correlations between adjacent weights were higher. The correlations tended to decrease as the time interval separating the observed weights increased.

In the case of genetic correlations between growth rates and weights, and among growth rates themselves, the phenotypic correlations ranged from low and negative to high positive values (-.17 to .98). The fact that there exists a negative (although low) correlation between preweaning growth rate and growth rate in the intervals weaning to six months and six to nine months (-.16 and -.06, respectively), may indicate that a slower growth rate preweaning tended to be followed by faster growth rate postweaning. This can be explained by compensatory growth of those lambs stressed before and at weaning. It seems logical to suggest, in general, that the low negative correlations which appear in some growth periods such as between weaning to six months and nine to twelve months (-.08), and six to nine months and nine to twelve months (-.16), are consequences of compensatory growth and not antagonistic as such. There was, as expected, a consistent positive phenotypic correlation between overall growth rate and all other growth rates of the lamb before yearling indicating common environmental effects.

Repeatability. Repeatability was estimated for three traits, namely birth weight, weaning weight and preweaning growth rate. These are the traits usually considered to have a high enough maternal component to be analysed as traits of the dam\(^{30,31,32}\). In the postweaning stage the ability of the lamb to grow is largely an expression of its genetic potential and non-maternal effects of the dam. All the repeatability estimates were high (.55 for birth weight, .57 for weaning weight and .56 for preweaning growth rate). This
indicates that replacement ewes can be selected for these traits on the basis of initial lambs with a considerably high accuracy.

From the results of this study, it is concluded that selection for weight and weight gain would be best be based on postweaning traits though the generation interval is likely to be slightly longer. Positive correlated response should be expected in other correlated traits due to the generally large and positive genetic correlations. Preliminary selection could also be conducted during the preweaning period since repeatability estimates are favourable. However the high maternal influence preweaning must not be ignored as it tends to mask the true genetic merit in the lambs. There is need to study various breed combinations of the Dorper x Red Maasai for purposes of choosing the ideal genotype at Ol’Magogo.

References

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STUDIES ON FACTORS AFFECTING ABSORPTION OF COLOSTRAL IMMUNOGLOBULINS IN NEWBORN LAMBS

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ETUDES SUR LES FACTEURS AFFECTANT L’ABSORPTION D’IMMUNOGLOBULINE DU COLOSTRUM CHEZ LES AGNEAUX NOUVEAUX-NES

Résumé
Des études expérimentales ont été menées sur les facteurs affectant l’absorption d’immunoglobuline chez les agneaux nouveaux-nés. Des agneaux Ouda et Balami étaient soit autorisés à téter soit retirés de leurs mères avant l’allaitement et nourris au biberon de colostrum de brebis. L’alimentation avec le substitut de lait avant le colostrum a entrainé une baisse significative des concentrations d’immunoglobuline du sérum (P<0,05). L’alimentation au colostrum en rations a aussi provoqué une diminution notable (P<0,001) des concentrations de sérum. Les concentrations d’immunoglobuline du sérum étaient en rapport avec la quantité de colostrum servi. Les agneaux nourris uniquement de substitut de lait avaient de très faibles concentrations (P<0,001), tandis que ceux servis de colostrum avaient des concentrations beaucoup plus élevées par rapport aux sujets témoins. Il n’y avait pas de différence significative (P>0,1) entre la concentration de sérum chez les agneaux témoins restant avec leurs mères et entretenus par celles-ci après l’alimentation au colostrum et ceux séparés de leurs mères après avoir pris du colostrum.

Summary
Experimental studies were conducted on factors affecting absorption of immunoglobulins from colostrum by new born lambs. New born Ouda and Balami lambs were either allowed to suckle or were removed from their dams before suckling and bottle fed pooled ewe colostrum. The feeding of milk substitute before colostrum resulted in a significant (P<0.05) lowering of serum immunoglobulin concentrations. The feeding of colostrum in fractions also resulted in a significant (P<0.001) lowering of serum concentrations. Serum immunoglobulin concentrations were related to the quantity of colostrum fed. While lambs fed only milk substitute attained very low concentrations (P<0.001), those fed a large dose of colostrum attained significantly higher (P<0.001) concentrations compared to controls. There was no significant (P>0.1) difference between the concentration in control lambs left with their dams after feeding of colostrum for “mothering” and in those separated from their dams after feeding of colostrum.

INTRODUCTION
The importance of immunoglobulins in the protection of mammals against infections has been well established. Young ungulates including calves and lambs which are born with little or no immunoglobulins depend on passively acquired antibodies, from the colostrum of their dams, for protection against neonatal infections. However, a substantial proportion of naturally-suckled calves and lambs fail to attain sufficient passive transfer of immunoglobins due to inadequate concentration of immunoglobulins in the dam colostrum, interference with transfer from dam to offspring and other factors. The sheep industry thereby incurs significant losses from lambs which die due to failure of passive immune transfer. Consequently, artificial systems for feeding lambs have been developed and Larson et al. pointed out the need for adequate and efficient methods of supplying the necessary colostral immunoglobulins under such conditions. Clearly, this requires an
understanding of factors which affect absorption of immunoglobulins by newborn lambs. The present study was thus aimed at investigating the effect of certain feeding regimes on absorption of immunoglobulins in ewe colostrum by newborn lambs.

Materials and Methods

Experimental Animals, Collection and Feeding of Pooled Colostrum

The investigations were carried out at the Sheep Meat Production Project Farm of the Federal Livestock Department in Katsina, Nigeria, where batches of 200 to 300 Ouda and Balami ewes are bred monthly by natural mating between April and July and lamb during the months of September to December. To obtain colostrum for lambs to be fed artificially, ewes were milked out by hand on the day they lambed and the colostrum collected were pooled and stored at -20°C. When a sufficient quantity was obtained, the pooled colostrum was thawed and thoroughly mixed; 250 ml portions were put in baby feeding bottles (NovaR, England) and kept at -20°C until used.

When needed, the 250 ml aliquots of pooled Colostrum were warmed to about 40°C, mixed and the required amounts were fed to the lambs with the feeding bottles. Any remaining colostrum was discarded.

Collection of Blood Samples:

Lambs were removed from their dams after birth before suckling, dried with a hand towel, ear-tagged and weighed to the nearest 0.05 kg with a baby scale (WaymasterR, England). About 5 ml of blood was collected from the jugular vein of each lamb into plain evacuated tubes (VacutainerR, Becton Dickinson, England) immediately after weighing (precolostral sample) and at 48 h. after the assigned feeding regime (post-colostral sample). Blood samples were also collected from naturally suckled lambs at 48 h post partum. The accruing serum samples were stored at -20°C until analysed.

EXPERIMENTAL PROTOCOL:

Naturally suckled lambs:

Fifty newborn lambs were allowed to remain with their dams from birth in order to be naturally suckled. The immunoglobulin concentrations in these lambs were compared with those in lambs subjected to the various artificial feeding regimes.

Artificially fed lambs:

We adopted a technique of standardised conditions of colostrum feeding which results in uniform absorption of immunoglobulins from colostrum and has been used for studies on factors affecting immunoglobulin absorption in newborn calves9,10. Two criteria are used to determine the amount of colostrum to be fed to the newborn. Firstly, the chosen volume should be consumed within a short period of time. Secondly the amount should result in an adequate serum immunoglobulin concentration. A dose rate of 50 ml of pooled colostrum per kg body weight meets these criteria11,12. All lambs that received colostrum were fed from the same pool. After the appropriate colostrum feeding regime, the lambs were maintained on a milk substitute ration (Lactogen StarterR, Nestle Co. Ltd., U.K.) which was offered at the rate of 50 ml/kg birthweight twice daily until the collection of post-colostral blood samples.

The experiments involved six groups of lambs (A to F) each containing 10 newborn lambs viz:

Group A lambs were fed pooled colostrum 1h. post partum at the rate of 50 ml/kg body weight and were allowed to remain with their dams; however, they were precluded from suckling (see later). They (Group A lambs) served as artificially fed controls for experiments 1-5.

Experiment 1: Effect of grooming:

Group B lambs were fed pooled colostrum 1h. post partum at the rate of 50 ml/kg body weight and kept away from their dams to preclude grooming.
Experiment 2: Effect of feeding colostrum in divided doses:

Group C lambs were fed pooled colostrum at the rate of 50 ml/kg bodyweight; the total amount to be fed to each lamb was divided into 3 equal parts and each part was fed at 1, 5 and 9h. post partum.

Experiment 3: Effect of quantity of colostrum fed.

Group D lambs were fed pooled colostrum 1h. post partum at the rate of 100 ml/kg.

Experiment 4: Effect of feeding milk substitute before colostrum.

Group E lambs were fed milk substitute at the rate of 50 ml/kg birthweight at 1h. post partum and then fed pooled colostrum at the rate of 50 ml/kg birthweight at 9h. post partum.

Experiment 5: Effect of feeding only milk substitute.

Group F lambs were fed only milk substitute at the rate of 50 ml/kg at 1h. post partum.

In a previous study\(^{12} \) severance of ewe-lamb bond commonly occurred after separation of lambs from their dams for 48h. Therefore all dams, except those of Group B lambs, remained with their lambs throughout the period of the experiments but were fitted with udder covers to preclude suckling.

Determination of colostral whey and serum protein concentrations:

Colostral whey was prepared as described by Halliday\(^{13} \). Total protein concentrations of colostral whey and serum samples were determined by the Biuret method. For determination of gammaglobulin concentration, colostral whey and serum protein samples were separated by electrophoresis on cellulose acetate strips (Oxoid\(^{R} \), Oxoid Ltd., England), stained with Ponceau-S and the strips cleared in a solution of 75 per cent paradoxane and 25 per cent iso-butyl alcohol. The protein bands were automatically evaluated with a densitometer (Elphormat\(^{R} \), Bender and Hobein, FGR). The serum gammaglobulin value for pre-colostral samples were subtracted from the post-colostral readings and the difference was assumed to be due to absorbed gammaglobulin\(^{19} \).

Statistical Analyses:

Differences between groups of lambs were evaluated by the Student’s “t” test\(^{14} \).

Results

The whey gammaglobulin concentration of the colostrum pool fed to lambs in the various artificial regimes was 9.25 g/100 ml.

A summary of the results of this study is presented in Table 1. The mean birthweight of naturally suckled lambs was 3.56 ± 0.79 kg while their mean 48h. serum gammaglobulin concentration was 2.74 ± 1.12 g/100 ml.

Experiment 1: Effect of grooming.

The mean serum immunoglobulin concentration in ungroomed or unmothered (Group B) lambs (2.58 g/100 ml) was not significantly (P>0.1) different from that in either naturally suckled lambs (2.74 g/100 ml) or in the artificially fed controls (Group A), which were left with their dams for grooming (2.63 g/100 ml).

Experiment 2: Effect of feeding colostrum in divided doses

Group C lambs that were fed the dose colostrum in 3 equal fractions, over a period of 8h. attained a mean immunoglobulin concentration of 1.83 g/100 ml which was significantly (P<0.01) lower than the concentration in either naturally suckled lambs (2.74 g/100 ml) or the artificially fed controls (2.63 g/100 ml).

Experiment 4: Effect of feeding milk substitute before colostrum.

Lambs that were fed milk substitute 8h. before the feeding of colostrum (Group E) attained a mean serum immunoglobulin concentration of 2.2 g/100 ml which was significantly (P<0.05) lower than in naturally suckled lambs. The concentrations were however not significantly (P>0.1) different from that in artificially fed controls (2.63 g/100 ml).
Table 1: Effects of grooming, methods of feeding, nature and quantity of feed on serum immunoglobulin concentrations in newborn lambs

<table>
<thead>
<tr>
<th>+ Lambs</th>
<th>Lambs of lambs</th>
<th>Birthweight (kg)</th>
<th>Volume of colostrum fed (ml)</th>
<th>Serum Ig conc. (g/100ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means±sd</td>
<td>Range</td>
<td>Mean±sd</td>
<td>Range</td>
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<tr>
<td>Group A</td>
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<td>193±17.9</td>
<td>2.58±0.63NS</td>
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<td>Group C</td>
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<td>3.44±0.54</td>
<td>172±27.1</td>
<td>1.83±0.42**</td>
</tr>
<tr>
<td>Group D</td>
<td>10</td>
<td>3.66±0.34</td>
<td>366±34.4</td>
<td>4.37±1.28***</td>
</tr>
<tr>
<td>Group E</td>
<td>10</td>
<td>3.43±0.32</td>
<td>172±16.3</td>
<td>2.20±0.67*</td>
</tr>
<tr>
<td>Group F</td>
<td>10</td>
<td>3.45±0.62</td>
<td>0</td>
<td>0.10±0.04***</td>
</tr>
<tr>
<td>Sucked</td>
<td>50</td>
<td>3.56±0.49</td>
<td>1.8–4.5</td>
<td>2.74±1.12</td>
</tr>
</tbody>
</table>

Group A: Lambs remained with their dams after feeding of colostrum 1h. post partum (controls).
Group B: Lambs separated from their dams after feeding of colostrum 1h. post partum.
Group C: Lambs fed colostrum in 3 divided parts over an 8h. period (1, 5 and 9h. post partum).
Group D: Lambs fed twice the standard dose of colostrum 1h. post partum.
Group E: Lambs fed milk substitute 1h. post partum and colostrum 8h. later.
Group F: Lambs fed only milk substitute.
NS Not significant
*P<0.05
**P<0.01
***P<0.001

Experiment 5: Effect of feeding only milk substitute.

Lambs that were fed only milk substitute throughout the duration of the experiment (Group F) attained a mean serum immunoglobulin concentration of 0.1 g/100 ml which was significantly (P<0.001) lower than in both naturally suckled (2.74 g/100 ml) and artificially fed lambs (2.63 g/100 ml).

Between 24 and 36h. post partum, 3 of the lambs fed only milk substitute started showing signs of ill-health. The 3 lambs survived the period of the experiment but died at about 3 days after birth from septicaemia (2 lambs) and bloody diarrhoea (1 lamb).

Discussion

The mean 48h serum immunoglobulin concentration attained by naturally suckled lambs in this study (2.74 g/100 ml) was somewhat higher than the corresponding 2.40 g/100 ml and 2.29 g/100 ml recorded in Blackface and Merino lambs respectively. It was however close to the 2.87 g/100 ml recorded in West African Dwarf lambs of the same age. The feeding regime administered to the artificially fed control (Group A) lambs resulted in a mean serum immunoglobulin concentration (2.63 g/100 ml) which was not significantly (P>0.1) different from that in the naturally suckled lambs. This finding confirmed that the regime results in an adequate serum immunoglobulin concentration.

A study in cattle showed that mothered calves attained significantly higher 48h. serum immunoglobulin concentrations than non-mothered calves. However, in another study, mothered calves attained slightly but not significantly higher 48h. serum concentrations than non-mothered calves, even though the former were also allowed to suckled their dams. In the present study, there was no significant difference between the serum immunoglobulin concentrations in mothered and non-mothered lambs indicating that grooming or mothering per se does not significantly influence absorption of serum immunoglobulins in lambs. The authors of this study are not aware of previous published works on the effect of mothering per se on serum immunoglobulin concentrations in lambs. However, in a study by Halliday and Williams, lambs were artificially fed colos-
Studies on factors affecting absorption of colostral immunoglobulins in newborn lambs

trum 1h. after birth and were either fostered to newly lambed ewes or bucket fed with milk substitute at 24h. post partum. Fostered lambs attained serum immunoglobulin concentrations at 48h. slightly but not significantly higher than lambs that received milk substitute. The finding indicated that neither mothering per se nor a second feed given 24h. after birth will result in significantly higher immunoglobulin absorption.

In some studies on immunoglobulin absorption by newborn calves and lambs, colostrum was fed in divided amounts presumably because, in contrast to single feeding, this practice stimulates what happens when the newborn is left with the dam. Furthermore, it is conceivable that feeding colostrum bit by bit would enhance absorption thus leading to higher concentrations in lambs. In this study however, lambs that were fed the standard dose of colostrum in 3 equal amounts at 1, 5 and 9h. after birth attained significantly lower serum immunoglobulin concentrations than single fed, control lambs or naturally suckled lambs. This finding thus suggests that in artificial colostrum feeding, it is better to feed all available colostrum at once rather than in divided doses. It also supports the view that "closure" of gut epithelium to macromolecules follows first feed.

The significantly higher immunoglobulin concentration attained by lambs fed double the standard dose of colostrum supports previous assertions that the concentrations absorbed by lambs is correlated to the immunoglobulin content of colostrum.

Lack of dam colostrum at birth due to either lack of production or leakage before parturition has often been found in cattle and in sheep. It may therefore be necessary to rear lambs of such dams on plain milk or milk substitute before availability of colostrum. The study on effect of feeding milk substitute before colostrum was therefore an attempt to investigate the influence of this practice on the immunoglobulin concentrations attained by lambs. The present result showed that the mean concentration in lambs fed milk substitute 1h. after birth and colostrum 8h. later was slightly lower than in artificially fed control (Group A) lambs. The concentrations were however significantly lower than in naturally suckled lambs. This finding indicates that the feeding of milk substitute in order to provide energy, before availability of colostrum, might result in diminished absorption of immunoglobulins from a subsequent feed of colostrum. It has been stated that the rapidity of gut "closure" is largely dependent on the amount of substances capable of inducing "closure" which was fed. It is therefore necessary to conduct further studies on the relationship between amount of plain milk or milk substitute offered to the lamb and the rate of gut "closure".

The finding in this study of very low 48h. serum immunoglobulin concentrations in lambs fed only milk substitute confirms previous findings on colostrum-deprived lambs. Since deaths occurred only among lambs that were wholly raised on milk substitute, it also confirms earlier finding that colostrum deprivation predisposes lambs to neonatal infections.

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A STUDY OF BASELINE HAEMATOLOGICAL VALUES OF DOMESTIC AND COMMERCIAL CHICKENS IN GHANA

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UNE ETUDE SUR LES VALEURS HEMATOLOGIQUES PRINCIPALES DES POULETS DE BASSE-COUR ET DES POULETS DE RAPPORT AU GHANA

Résumé

On a déterminé les valeurs hématologiques de deux espèces de poulet de rapport exotiques et celles des poulets de basse-cour locaux (jeunes et adultes). A l’âge de dix semaines, les poulets de basse-cour indigènes et les deux races de poulet de grill exotiques (Hypeco et Starbro) avaient les mêmes valeurs hématologiques, excepté que les Starbro avaient une concentration d’hémoglobine (Hb) plus forte (P<0,05) que les Hypeco. Le sexe n’avait aucun effet sur les valeurs hématologiques de tous les poulets à dix semaines d’âge.

Cependant, chez les poulets de basse-cour locaux adultes (32 semaines), les mâles avaient des valeurs beaucoup plus élevées (P<0,05) d’hématocrite (PCV) et de Hb que les femelles. PCV moyen, Hb, la numération totale d’hématies (GR) et la numération totale de globules blancs (GB) pour les poulets de basse-cour locaux adultes étaient respectivement de 38,52% ; 9,22gm% ; 2,54 × 10⁹/mm³ et 25,44 × 10⁹/mm³. Même si la valeur du PCV était la même que celle signalée pour les poulets exotiques, le nombre de GR était plus réduit chez les poulets de basse-cour locaux. En revanche, ceux-ci avaient une taille de l’érythrocyte plus grande, comme le montre le volume corpusculaire moyen qui était plus élevé que les valeurs relevées pour les races de poulet exotiques.

Summary

Haematological values were determined for two common commercial exotic broiler strains, as well as for young and adult local domestic chickens. At ten weeks of age, the local domestic chickens and the two exotic broiler strains (Hypeco and Starbro), all had similar haematological values, except that the Starbro had a significantly higher (P<0.05) haemoglobin concentration (Hb) than the Hypeco. Sex had no effect on haematological values in all the birds at ten weeks.

In the adult local domestic chickens (32 weeks), however, the males had significantly higher (P<0.05) packed cell volume (PCV) and Hb values that the females. The mean PCV, Hb, total red blood cell count (RBC) and total white blood cell count (WBC) for the adult local domestic chicken were 38.52%, 9.22gm%, 2.54 × 10⁹/mm³ and 25.44 × 10⁹/mm³, respectively. Although the PCV value was similar to that reported for temperate chickens, the RBC was lower in the local domestic chicken. The local domestic chickens however, had larger erythrocyte size as indicated by the mean corpuscular volume (MCV), which was higher than values quoted for temperate breeds of chickens.

INTRODUCTION

For any successful livestock production enterprise, the analysis of blood is important clinically, because it provides a means of assessing the health status of the animals. Normal haematological parameters for a given species of animal are affected by sex, strain, age and climate⁴,⁵,⁶,⁷.

Much of the available information in Ghana and other West African countries on the blood picture of livestock, are those from temperate countries. Only a few studies have been undertaken on the haematology of livestock in Ghana. Studies on the haematology of cattle were reported by Vohradsky⁸, while Ahunu and Assoku⁹ reported values for sheep and goats. The aim of this study was therefore to establish haematological indices for two common strains of
Materials and Methods

Blood samples for analysis were taken from two broiler strains of chickens, the HYPECO and STARBRO as well as from local domestic chickens. The blood samples from the broiler strains were taken from 10 males and ten females at 10 weeks of age. Blood from the local chickens were taken from 10 young males and 10 young females at 10 weeks of age and also from 10 adult males and ten adult females, 32 weeks of age.

All the birds used for this work were kept in deep litter houses at the University of Ghana's Agricultural Research Station (A.R.S. Legon). They were fed with a standard broiler mash prepared at the station. Water was provided ad libitum. Standard vaccination programmes were followed.

Each blood sample was taken from the wing vein into a collecting tube containing ethylene diamine tetra acetic acid (EDTA). The haematological parameters measured for each sample were: packed cell volume (PCV), haemoglobin concentration (Hb), total red blood count (RBC), total leukocyte count (WBC) and differential leukocyte count.

Standard haematological assay procedures were utilized in determining the various parameters.

Results

At ten weeks, the local domestic chickens and the two exotic broiler strains had similar PCV, RBC and MCV values (Table 1). The mean Hb value for the Starbro chickens (9.20 ± 0.61) was significantly higher (P < 0.05) than that for the Hypeco chickens (6.54 ± 0.38). The higher haemoglobin value for the starbro was also reflected in higher MCH and MCHC values. The leukocytic values were also similar for the two commercial broiler strains and the local domestic chickens (Table 2). There were no significant differences, at ten weeks, between the sexes in both erythrocytic and leukocytic values for the broiler strains and the local domestic chickens (Table 2).

At 32 weeks, the male local domestic chickens had significantly higher (P < 0.05) PCV and Hb values than the females (Table 3). The males also had a higher RBC value than the females, though this difference was not statistically significant (P > 0.05). There were no significant differences between the sexes in the leukocytic values for the 32 weeks old local domestic chickens (Table 4).

The PCV, Hb MCH and MCHC values for the adult female domestic chickens (32 weeks) were similar to those for the 10 weeks old birds. Age did not affect either the total leukocyte count or the percentages of the different leukocytes. Even though the percentage of heterophils was higher in the 10 weeks old local domestic chickens while the percentage of lymphocytes was higher in the adults birds, these differences were not significant (P > 0.05).

Discussion

Although several authors[1,3,8,9,10] have reported of the role of androgens in increasing erythrocytic values in males, no such differences between the sexes were observed in the 10 weeks old broiler strains and local domestic chickens in the present study. This was presumably because at 10 weeks of age, the birds were too young for the differences between the sexes to show up. In adult local domestic chickens, the role of androgen became evident by the higher erythrocytic values of the males. Similar results have been reported for Nigerian domestic chickens by Oyewale[11].

The PCV values obtained for the 10 weeks old birds in the present study were slightly higher than the range of 28.7% to 31.5% recorded by Washburn and Guill[8] for the Leghorn strains of chickens at 8 weeks. The mean PCV value for the adult male and female Ghananian domestic chickens however were similar to those reported for temperate breeds[3,4].
### Table 1: Erythrocytic Values in 10 weeks old domestic and Commercial Chickens in Ghana

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sex</th>
<th>No. of Birds</th>
<th>Local Domestic Chickens</th>
<th>Starbro</th>
<th>Hypeco</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCV (%)</td>
<td>M</td>
<td>10</td>
<td>33.20 ± 1.36</td>
<td>35.45 ± 2.70</td>
<td>35.60 ± 2.80</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>32.55 ± 1.27</td>
<td>33.44 ± 3.14</td>
<td>31.30 ± 2.24</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>32.88 ± 1.48</td>
<td>34.45 ± 3.06</td>
<td>34.45 ± 2.93</td>
</tr>
<tr>
<td>Hb (gm %)</td>
<td>M</td>
<td>10</td>
<td>7.83 ± 0.48</td>
<td>9.10 ± 0.48</td>
<td>6.86 ± 0.41</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>7.61 ± 0.44</td>
<td>9.30 ± 0.53</td>
<td>6.21 ± 0.35</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>7.72 ± 0.48</td>
<td>9.20 ± 0.61</td>
<td>6.54 ± 0.38</td>
</tr>
<tr>
<td>Total RBC count (x 10^6/mm³)</td>
<td>M</td>
<td>10</td>
<td>2.56 ± 0.35</td>
<td>2.33 ± 0.37</td>
<td>2.26 ± 0.43</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>2.53 ± 0.45</td>
<td>2.26 ± 0.37</td>
<td>2.20 ± 0.30</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>2.55 ± 0.49</td>
<td>2.30 ± 0.39</td>
<td>2.23 ± 0.46</td>
</tr>
<tr>
<td>MCH (μg)</td>
<td>M</td>
<td>10</td>
<td>31.09 ± 4.27</td>
<td>39.53 ± 3.02</td>
<td>30.50 ± 3.01</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>30.41 ± 3.63</td>
<td>41.11 ± 4.20</td>
<td>28.31 ± 3.96</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>30.75 ± 4.06</td>
<td>40.32 ± 3.81</td>
<td>29.41 ± 3.81</td>
</tr>
<tr>
<td>MCV (μl)</td>
<td>M</td>
<td>10</td>
<td>132.59 ± 15.44</td>
<td>145.39 ± 14.75</td>
<td>157.56 ± 16.20</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>132.38 ± 16.75</td>
<td>156.64 ± 14.62</td>
<td>143.41 ± 14.17</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>132.49 ± 15.87</td>
<td>151.02 ± 14.84</td>
<td>150.48 ± 16.33</td>
</tr>
<tr>
<td>MCHC (%)</td>
<td>M</td>
<td>10</td>
<td>23.69 ± 2.41</td>
<td>25.35 ± 1.52</td>
<td>19.26 ± 1.55</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>23.44 ± 2.60</td>
<td>27.63 ± 2.39</td>
<td>19.88 ± 1.27</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>23.57 ± 2.64</td>
<td>26.49 ± 2.48</td>
<td>19.57 ± 1.49</td>
</tr>
</tbody>
</table>

### Table 2: Leukocytic Values in 10 weeks old domestic and Commercial Chickens in Ghana

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sex</th>
<th>No. of Birds</th>
<th>Local Domestic Chickens</th>
<th>Starbro</th>
<th>Hypeco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total WBC count (x 10^3/mm³)</td>
<td>M</td>
<td>10</td>
<td>20.12 ± 2.08</td>
<td>21.34 ± 2.36</td>
<td>21.73 ± 3.08</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>22.61 ± 2.94</td>
<td>23.15 ± 3.37</td>
<td>23.67 ± 4.07</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>21.37 ± 3.12</td>
<td>22.25 ± 3.66</td>
<td>22.70 ± 4.28</td>
</tr>
<tr>
<td>Heterophils (%)</td>
<td>M</td>
<td>10</td>
<td>28.42 ± 4.27</td>
<td>20.49 ± 5.32</td>
<td>16.29 ± 3.35</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>30.00 ± 6.85</td>
<td>17.66 ± 4.38</td>
<td>18.46 ± 4.68</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>29.21 ± 5.92</td>
<td>19.08 ± 6.62</td>
<td>17.38 ± 4.91</td>
</tr>
<tr>
<td>Eosinophils (%)</td>
<td>M</td>
<td>10</td>
<td>2.36 ± 1.06</td>
<td>2.44 ± 1.07</td>
<td>1.87 ± 0.72</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>2.43 ± 1.12</td>
<td>2.08 ± 0.84</td>
<td>1.80 ± 0.69</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>2.90 ± 1.34</td>
<td>2.26 ± 1.13</td>
<td>1.84 ± 0.74</td>
</tr>
<tr>
<td>Basophils (%)</td>
<td>M</td>
<td>10</td>
<td>2.34 ± 0.83</td>
<td>1.83 ± 0.85</td>
<td>1.92 ± 0.69</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>4.57 ± 0.72</td>
<td>2.04 ± 0.97</td>
<td>2.03 ± 0.74</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>3.46 ± 0.89</td>
<td>1.94 ± 0.95</td>
<td>1.97 ± 0.82</td>
</tr>
<tr>
<td>Lymphocytes (%)</td>
<td>M</td>
<td>10</td>
<td>63.74 ± 5.81</td>
<td>70.16 ± 7.28</td>
<td>76.66 ± 7.97</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>59.86 ± 6.17</td>
<td>75.24 ± 8.06</td>
<td>74.72 ± 6.43</td>
<td>75.69 ± 8.02</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>61.80 ± 7.03</td>
<td>72.70 ± 9.27</td>
<td>76.66 ± 7.97</td>
</tr>
<tr>
<td>Monocytes (%)</td>
<td>M</td>
<td>10</td>
<td>3.16 ± 0.49</td>
<td>5.08 ± 1.07</td>
<td>3.27 ± 1.08</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>2.15 ± 0.39</td>
<td>2.96 ± 0.78</td>
<td>3.01 ± 1.23</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>2.66 ± 0.45</td>
<td>4.02 ± 1.13</td>
<td>3.14 ± 1.41</td>
</tr>
</tbody>
</table>
Table 3: Erythrocytic values in adult domestic chickens in Ghana (32 weeks)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sex</th>
<th>No. of Birds</th>
<th>Mean values ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCV (%)</td>
<td>M</td>
<td>10</td>
<td>43.15 ± 1.37</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>33.89 ± 1.09</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>38.52 ± 1.62</td>
</tr>
<tr>
<td>Hb (gm %)</td>
<td>M</td>
<td>10</td>
<td>10.64 ± 0.53</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>7.80 ± 0.42</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>9.22 ± 0.55</td>
</tr>
<tr>
<td>Total RBC count</td>
<td>M</td>
<td>10</td>
<td>2.69 ± 0.39</td>
</tr>
<tr>
<td>(x 10^6/mm^3)</td>
<td>F</td>
<td>10</td>
<td>2.38 ± 0.37</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>2.54 ± 0.40</td>
</tr>
<tr>
<td>MCH (μg)</td>
<td>M</td>
<td>10</td>
<td>39.23 ± 2.06</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>32.53 ± 2.20</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>35.88 ± 3.38</td>
</tr>
<tr>
<td>MCV (μL)</td>
<td>M</td>
<td>10</td>
<td>160.45 ± 15.01</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>142.07 ± 17.02</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>151.26 ± 16.94</td>
</tr>
<tr>
<td>MCHC (%)</td>
<td>M</td>
<td>10</td>
<td>24.68 ± 2.12</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>20</td>
<td>23.95 ± 2.61</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>24.32 ± 2.84</td>
</tr>
</tbody>
</table>

Table 4: Leukocytic values in adult domestic chickens in Ghana (32 weeks)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sex</th>
<th>No. of Birds</th>
<th>Mean values ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total WBC count</td>
<td>M</td>
<td>10</td>
<td>27.39 ± 6.40</td>
</tr>
<tr>
<td>(x 10^3/mm^3)</td>
<td>F</td>
<td>10</td>
<td>23.49 ± 5.25</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>25.44 ± 5.67</td>
</tr>
<tr>
<td>Heterophils (%)</td>
<td>M</td>
<td>10</td>
<td>18.40 ± 4.52</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>14.43 ± 3.88</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>16.42 ± 4.76</td>
</tr>
<tr>
<td>Eosinophils (%)</td>
<td>M</td>
<td>10</td>
<td>1.20 ± 0.79</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>2.44 ± 1.33</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>1.82 ± 0.97</td>
</tr>
<tr>
<td>Basophils (%)</td>
<td>M</td>
<td>10</td>
<td>1.46 ± 0.67</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>2.56 ± 1.42</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>2.01 ± 1.06</td>
</tr>
<tr>
<td>Lymphocytes (%)</td>
<td>M</td>
<td>10</td>
<td>77.28 ± 6.70</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>79.47 ± 4.75</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>78.38 ± 7.28</td>
</tr>
<tr>
<td>Monocytes (%)</td>
<td>M</td>
<td>10</td>
<td>1.70 ± 0.85</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>1.11 ± 0.78</td>
</tr>
<tr>
<td></td>
<td>M&amp;F</td>
<td>20</td>
<td>1.41 ± 0.93</td>
</tr>
</tbody>
</table>

The mean Hb content in the Starbo strain and young local domestic chickens were similar to values reported for chickens of comparable age in temperate regions\(^5\). The values for the adult domestic chickens, however, were lower than the range of 13.9 gm % to 14.10 gm % for male chickens and 8.6 gm % to 10.20 gm % for female chickens recorded in temperate regions\(^3,4,12\). This seems to support
the results of some workers[2,13,14] who have reported that when birds are reared at higher temperatures they tend to have lower Hb values than those reared at lower temperatures. The Hb values obtained in the present study for the adult Ghanaian chickens were also slightly lower than the values of 12.93 gm % and 9.67 gm % reported by Oyewale[11] for male and female Nigerian domestic chickens respectively.

The RBC counts for the 10 week old broiler strains and local domestic chickens were similar to values observed by Vo, Boone and Johnston[10] for 12 week old Leghorns exposed to an environmental temperature of 29.4°C. The RBC counts for male and female adult Ghanaian domestic chickens however were lower than values reported for chickens in temperate regions[1,3,4,15]. Oyewale[11], working with Nigerian domestic chickens, also recorded RBC counts that were lower than those for temperate breeds, even though PCV values were comparable to those of birds in temperate regions. Oyewale[11] suggested that this may be due to large size of the erythrocytes in Nigerian domestic chickens. Results obtained in the present work support this suggestion, as shown by the high MCV value (151.26 μ3) of the adult Ghanaian domestic chicken which was similar to that obtained by Oyewale[11] for Nigerian domestic chicken (156.8 μ3), but was far higher than the 127.8 μ3 reported by Assoku, Penhale and Buxton[16] for White Leghorn. It is therefore probable that the high temperatures in the tropics depresses RBC production in chickens but this could be compensated for by the relatively larger size of erythrocytes in tropical breeds of chickens.

The total WBC counts for the 10 week old birds in the present study fall within the range reported for temperate birds of comparable age[3,17]. White blood cell values for the adult birds were also comparable to those for temperate birds[3]. Lymphocytes formed by far the greatest proportion of leukocytes in both broiler strains and in the young and adult local domestic chickens. The fact that lymphocytes form a greater proportion of total leukocyte counts in chickens has been well documented[5,11,16,17,18,19].

The pattern of distribution of the different leukocytes in adult domestic chickens was different from that reported by Oyewale[11] for Nigerian domestic chickens. The percentage of heterophilis in the Ghanaian domestic chicken (16.42%), for instance, was higher than that of the Nigerian domestic chicken (5.11%), while the percentage of monocytes in the Ghanaian domestic chicken (1.41%) was far lower than that of the Nigerian domestic chicken (19.29%).

Conclusion

With the exception of haemoglobin concentrations and red blood cell counts which were lower in the local domestic chickens, all the other haematological values were similar to those quoted for temperate breeds of chickens. The low RBC production in the local chickens, however, was compensated for by the relatively larger size of their erythrocytes.

Acknowledgement

The author is grateful to Mr. M.O. Quar-tey for technical assistance and the University of Ghana for funds to execute the project.

References


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AFLATOXIN RESIDUES IN POULTRY TISSUES AND EGGS: A REVIEW

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Animal Science Department, University of Maiduguri, P.M.B. 1069, Maiduguri, Nigeria

RESIDUS D’AFLATOXINE DANS LES TISSUS ET LES OEUFS DE VOLAILLE: UNE ETUDE DE CAS

Résumé

L’aflatoxine est produite lorsque des souches productrices de toxine de Aspergillus flavus ou A. parasiticus se développent sur un substrat en milieu favorable. L’aflatoxine a été détectée dans les tissus et les œufs de volaille nourrie d’aliments contaminés par ce produit. On a trouvé les niveaux les plus élevés de résidus d’aflatoxine dans le rein et le foie. Les résidus dans les tissus et les œufs de volaille sont proportionnels aux niveaux d’aflatoxine contenus dans ses aliments. Une partie de l’aflatoxine ingérée pourrait être retenue, comme l’aflatoxine initiale ou comme l’un ou plusieurs métabolites dont certains ont des propriétés toxiques.

Il y a des variations entre les tissus et entre les espèces de volaille quant au temps nécessaire pour éliminer les résidus d’aflatoxine transférés des aliments aux tissus et aux œufs de volaille. Toutefois, certaines des communications sur la rétention d’aflatoxine dans les tissus et les œufs de volaille ne confirmant pas les conséquences éventuelles sur l’homme de la consommation des produits de volaille contaminés d’aflatoxine. Il faut donc recueillir d’autres informations sur la présence, la toxicité et le métabolisme de l’aflatoxine, et ses métabolites en vue de déterminer les effets de ces résidus sur les produits de volaille destinés à la consommation humaine.

Summary

Aflatoxins are produced when toxin-producing strains of Aspergillus flavus or A. parasiticus grow on a substrate under favourable conditions. Aflatoxins have been detected in tissues and eggs of birds that were fed aflatoxin-contaminated diets. The highest levels of aflatoxin residues are found in the kidney and liver. Residues in poultry tissues and eggs are proportional to the levels of aflatoxin in the birds’ diets. Part of the ingested aflatoxins may be retained as the original aflatoxin or as one or several metabolites some of which possess toxic properties.

Variations exist between tissues and between poultry breeds and strains in the amount of time required to achieve clearance of residues of aflatoxins transferred from the feed to poultry tissues and eggs. However, some of the research reports on the retention of aflatoxins in poultry tissues and eggs do not fall into any consistent pattern with respect to their probable effect on human beings that ingest the poultry products. Therefore, more information on the presence, toxicity and metabolism of aflatoxins and their metabolites is needed to determine the importance of these residues in poultry products destined for human consumption.

INTRODUCTION

The most thoroughly studied group of mycotoxins in so far as carcinogenicity is concerned is aflatoxins and their related compounds\(^1\). Aflatoxins are produced by Aspergillus flavus and Aspergillus parasiticus. A. flavus produces aflatoxin B\(_1\) and B\(_2\) whereas A. parasiticus produces aflatoxins B\(_1\), B\(_2\), G\(_1\) and G\(_2\)\(^2\). In poultry, the duckling is the most sensitive followed by the turkey poult, pheasant and chicken\(^3,4\). Differences in susceptibility among strains of hybrid chickens have also been reported\(^5,6\). Several comparative studies\(^5,7,8\) have shown that broiler strains of chickens differed in their tolerance to aflatoxin ingestion.

Aflatoxins are considered to be the most potent carcinogens known to man today and there is considerable concern about these toxins passing from the animal feeds into the human food chain\(^9\). Aflatoxin B\(_1\) (AFB\(_1\)) dissemination in human food has been associated with geographical areas having a high inci-
dence of primary liver cancer. Already, epidemiological studies in Africa and South-East Asia, have indicated a probable association between aflatoxin ingestion and primary liver cancer in humans. Primary cancer in Kenya, Swaziland, Mozambique and Thailand (0.7 to 25.4 cases /10^5/year) could be correlated with daily intake (3.5 - 222.4 μg/kg body weight/day) to give a crude dose-response pattern. Action level of 20 μg/kg was set by the United States Food and Drug Administration for aflatoxin levels permitted in foods and food ingredients intended for human consumption.

The absence of effective quality control legislation and established monitoring procedures in developing countries have resulted in marketing of aflatoxin-contaminated feeds and feed ingredients by both registered and unregistered feed millers. Nigerian livestock and poultry scientists have suggested in conferences and symposia that standards for feed milling should be specified by the public health officials and regulatory personnel and that penalties for infringements be applied to offending feed manufacturers. Quite often mouldy feed ingredients (e.g. maize and groundnut meal) that are not good enough for human consumption are fed to domestic animals in confinement. Since the animals do not usually die immediately after consuming the mycotoxin-contaminated ingredients it is generally assumed that such ingredients are good for them. Bryden et al. in a survey, detected A. flavus in 83 of 109 samples of feed ingredients in Australia that were tested for aflatoxins (Table 1). Out of 49 of the isolates that were randomly selected and tested for AFB1 production, 40 of them produced AFB1 in detectable amounts. This report agrees with earlier reports on similar range of feedstuffs in Africa and the United States of America. Bryden et al. also detected AFB1 in 13 of 16 feedstuffs tested with the highest level being 0.7 ppm in a sample of wheat while the average concentration for all positive samples was 0.15 ppm aflatoxin (Table 2). They however, observed that heat processed feeds and pelleted feeds were low in viable fungal spores when obtained directly from the manufacturers.

While acute aflatoxicosis in poultry provides dramatic signs of disease (17,18,19,20,21,22) biological effects resulting from chronic exposures to subacute levels of aflatoxin may be of greater economic importance. At the moment limited research has been conducted using long term subacute dosing experiments to identify and document the signs of chronic aflatoxicosis in poultry. The objective of this paper is to review the retention of aflatoxin residues in poultry tissues and eggs following ingestion of aflatoxin and the implications of consumption of the poultry products by humans.

Aflatoxin residues in poultry Tissues

The presence of aflatoxins in animal tissues has been widely reported. The concentrations of tissues aflatoxins B1 and M1 have been reported in cattle and poultry (27) and swine (27,24,25,26). The determination of aflatoxin residues in animal tissues is important in evaluating total exposure of humans to these extremely toxic compounds. In 1975, Platonow fed diets that contained 30% toxic groundnutmeal to four weeks old white leghorn males. The toxic diet contained 3.1 ppm of aflatoxin. No detectable amount of aflatoxin or its metabolites could be observed in the breast meat and liver samples extracted and analysed. It was concluded that although aflatoxin produced definite pathological disturbances, it was rapidly metabolized and did not produce a noticeable toxin pool. Results of earlier studies indicated that there was no transfer of aflatoxin to edible tissues of chickens fed diets containing crude aflatoxins. However, the persistence of aflatoxins B1 and M1 in the tissues, breast or thigh muscle of turkey poults that were fed 500 μg/g dietary aflatoxin B1 for 21 days was reported later. Another study, the highest total amount of aflatoxins (B1 + B2 + M1 + M2 + B2a) was found in liver and kidneys. Similar results were reported in pigs and in
Table 1: Incidence of Toxigenic Strains of *Aspergillus flavus* Isolated from Feed Samples

<table>
<thead>
<tr>
<th>Foodstuffs</th>
<th>No. of Samples</th>
<th>No. of Samples containing <em>A. flavus</em></th>
<th>No. of <em>A. flavus</em> Isolates Tested</th>
<th><em>No. of Toxigenic A. flavus</em></th>
<th>Range of Aflatoxin B₁ production (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut meal</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>1.2–5.0</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>2.0–6.7</td>
</tr>
<tr>
<td>Fish meal</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>0.1–4.0</td>
</tr>
<tr>
<td>Linseed meal</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>0.02–0.6</td>
</tr>
<tr>
<td>Lucerne meal</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>1.0–4.7</td>
</tr>
<tr>
<td>Maize meal</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>0.1–1.0</td>
</tr>
<tr>
<td>Meat meal</td>
<td>20</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>0.05–1.0</td>
</tr>
<tr>
<td>Soyabean meal</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>0.1–1.0</td>
</tr>
<tr>
<td>Sunflower meal</td>
<td>10</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>0.1–1.7</td>
</tr>
<tr>
<td>Grower feed</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0.2–4.0</td>
</tr>
<tr>
<td>Horse feed</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0.05–0.2</td>
</tr>
<tr>
<td>Cattle feed</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0.2–3.0</td>
</tr>
<tr>
<td>Layer feed</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>109</strong></td>
<td><strong>83</strong></td>
<td><strong>49</strong></td>
<td><strong>40</strong></td>
<td></td>
</tr>
</tbody>
</table>

*All toxigenic isolates produced aflatoxin B₁ and B₂ while aflatoxin G₁ and G₂ was produced by 1 isolate recovered from fish meal.

*Source:* Bryden et al. (1975).

Table 2: Survey of Sixteen Australian Foodstuffs for Aflatoxin B₁

<table>
<thead>
<tr>
<th>Origin</th>
<th>Foodstuffs</th>
<th>No. of Samples</th>
<th>No. of Samples containing aflatoxin</th>
<th>Concentration of aflatoxin B₁ (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>Barley</td>
<td>2</td>
<td>2</td>
<td>0.1–0.2</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Oats</td>
<td>3</td>
<td>2</td>
<td>0.02–0.04</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>4</td>
<td>4</td>
<td>0.02–0.1</td>
</tr>
<tr>
<td>Queensland</td>
<td>Peanuts</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>1</td>
<td>1</td>
<td>0.07</td>
</tr>
<tr>
<td>Victoria</td>
<td>Crumbles</td>
<td>2</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>1</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>1</td>
<td>1</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16</strong></td>
<td><strong>13</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Aflatoxin B₁ was present in all samples containing aflatoxin while aflatoxin G₁ was found in 1 sample of barley and 1 of wheat. The other barley sample contained aflatoxin B₁, B₂ and G₂.*


Chickens(37). The high capacity of liver and turkeys to concentrate toxic compounds in comparison to other organs is probably related to the important role they play in eliminating xenobiotics(38). In 1985, Chen et al(39) studied broilers with respect to recovery after replacement of aflatoxin-treated diet. They reported that gross lesions of aflatoxicosis disappeared with no evidence of any lesions eight days after removal of the aflatoxin-treated diet. However, the absence of gross lesions did not necessarily mean that microscopic lesions were not present(39). In a study in which laying hens were fed 3310 μg aflatoxin B₁ and 1680 μg aflatoxin B₂ per kg diet for four weeks, only a small fraction of the original compounds or their metabolites were present in some organs(38). The highest levels of the aflatoxins were detected in the gizzard, kidneys and liver with average total concentration
Table 3: Extractable aflatoxins in tissues from laying hens fed B1 at levels of 8 ug/g for 7 days in their feed

<table>
<thead>
<tr>
<th>Hens No.</th>
<th>Eggs</th>
<th>Liver</th>
<th>Kidneys</th>
<th>Muscle</th>
<th>Ova</th>
<th>Blood</th>
<th>Total B1 Intake</th>
<th>Total residue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ro</td>
<td>B1</td>
<td>Ro</td>
<td>B1</td>
<td>Ro</td>
<td>M1</td>
<td>B1</td>
<td>Ro</td>
</tr>
<tr>
<td>1.</td>
<td>53</td>
<td>61</td>
<td>16</td>
<td>38</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>67</td>
</tr>
<tr>
<td>2.</td>
<td>72</td>
<td>79</td>
<td>11</td>
<td>29</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>87</td>
</tr>
<tr>
<td>3.</td>
<td>38</td>
<td>58</td>
<td>10</td>
<td>37</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>74</td>
</tr>
<tr>
<td>4.</td>
<td>44</td>
<td>33</td>
<td>3</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>97</td>
</tr>
<tr>
<td>5.</td>
<td>46</td>
<td>56</td>
<td>11</td>
<td>25</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>6.</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>17</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td>7.</td>
<td>44</td>
<td>37</td>
<td>8</td>
<td>13</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>8.</td>
<td>32</td>
<td>33</td>
<td>8</td>
<td>9</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>96</td>
</tr>
<tr>
<td>9.</td>
<td>49</td>
<td>45</td>
<td>10</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>AVG.</td>
<td>43</td>
<td>46</td>
<td>10</td>
<td>21</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>66</td>
</tr>
</tbody>
</table>

1. Residues are presented on the weight (ng) found in each tissue from each hen and the total residues as present of the total B1 consumed.
4. Percent of B1 Intake

Source: Truckess et al. (1983).

of less than 3 ug/kg while the lowest residue levels were detected in the breast, blood serum and leg. It was also observed that the aflatoxin residues in all the tissues decreased markedly two days after withdrawal of the aflatoxin-contaminated diet. Variations existed between tissues and between individual hens in the amount of time required to achieve tissue clearance. No aflatoxin residues were detected in most tissues eight days on the aflatoxin-free diet.

Studies using labelled aflatoxins have shown that most of the administered dose appears in the tissues and excreta of the dosed hens as water soluble conjugated aflatoxin and metabolites. Of the various aflatoxin metabolites, aflatoxicol (Ro) and aflatoxins M1 and Q1 have been reported to exhibit the greatest carcinogenic potencies with values approximately 80, 10 and 1 percent respectively relative to that of aflatoxin B1. Slow clearance of aflatoxins and their metabolites from tissues was attributed to massive doses of the toxin used in studies which possibly accentuated interactions with cellular compounds. The workers demonstrated that administrations of large amounts of aflatoxins to poultry resulted in tissue residue levels that were toxic when evaluated in a duckling bioassay.

Aflatoxin B1 residues were detected at 100 ppb in the liver and muscle of broiler birds that were fed 0.025 to 15 ppm for 8 weeks. As aflatoxin concentration in feed increased, concentration of the toxin in the liver and muscle increased. In 1983, Truckess et al. reported that aflatoxin B1 and its metabolite, Ro could be detected in edible tissues from hens fed diets contaminated with aflatoxin B1 at a level of 8 ug/g feed (Table 3). The report stated that all tissues from hens sacrificed before aflatoxin withdrawal contained AFB1 or a metabolite. The liver and ova contained the highest level of aflatoxin B1.
and Ro. Kidney was the only tissue in which M1 was found. Blood contained only low levels of B1 while muscle contained only Ro. The workers observed that Ro could still be detected in the muscle seven days after aflatoxin withdrawal at which time all other tissues except liver had no detectable aflatoxin residue.

**Aflatoxin Residues in Poultry Eggs**

Data on aflatoxin residues in poultry eggs at the moment are very limited. The assessment of low levels of aflatoxin residues deposited in animal products has been limited by a complex lipid-protein matrix and by the presence of many fluorescent compounds. These factors have also limited the determination of the length of time required to achieve clearance of residues transferred from the feed.

Aflatoxin contaminated eggs from hens that were fed a diet that contained 15 percent of toxic groundnut meal were freeze-dried, extracted and administered to ducklings. Each received the equivalent of 16 eggs in seven days. No evidence of toxicity was detected. In 1965 Brown and Abrams fed laying hens a diet which contained 0.5 ppm of aflatoxin. When eggs from the hens were fed to ducklings at the rate of two per day, no differences were found between this group and a control group. Similarly, measurable aflatoxin could not be observed in eggs from birds that received 2, 4 or 8 ppm of aflatoxin. However, measurable amounts of aflatoxin were found in eggs from hens that were fed aflatoxin B1 in laying diets at levels of 0.1, 0.2 and 0.4 ppm during feeding periods of 10, 12 and 15 days duration. Measurable amounts of aflatoxin were found in eggs from hens at all feeding levels when eggs were collected, refrigerated at 3°C and analysed before they were 60 days old but not in eggs stored for 9 months before analysis.

In a study in which white and brown hens were fed diets that contained 40-10,000 ppb aflatoxin B1 and 52-13,000 ppb aflatoxin G1 the percentage of aflatoxin transmission into eggs was about 0.001 % in white and less than 0.001 % in brown eggs. The workers observed that a single high oral dose of aflatoxin B1 produced higher residues than continuous feeding. Transfer of aflatoxins to the eggs occurred rapidly reaching maximum levels after 4 to 5 days in a study in which laying hens were fed a diet which contained 3310 ug aflatoxin B1 and 1680 ug aflatoxin B2 per kg diet for 28 days. The report stated that the transfer of the transfer of the aflatoxins to the eggs remained relatively constant throughout aflatoxin feeding period after reaching the maximum levels. The mean values for combined residue levels in eggs were less than 0.5 ug/kg eggs. The workers reported that aflatoxin residues could not be recovered from whole eggs after feeding aflatoxin-free diet for 4 days. They concluded that the transmission of aflatoxins into the eggs of laying hens posed little or no potential public hazard.

In a study in which laying hens were given a diet that was contaminated with aflatoxin B1 at a level of 8 ug/g feed, it was observed that aflatoxin B1 and its metabolite Ro could be detected in eggs. The workers observed that the level of aflatoxin residues in eggs increased steadily for 4 or 5 days to a plateau and decreased after aflatoxin withdrawal. Only trace amounts of Ro (<0.01 ug/g) could be found in eggs. In 1977, Lotzsch and Leistner fed Japanese quail, white and brown HNL hens diets that contained 40-10,000 ppb aflatoxin AFB1 and 30-13,000 ppb AFG1 for 30-56 and 28 days respectively. They reported that measurable amounts of AFB1 were detected in quail eggs at 100 ppb feeding level, in white hens eggs at 3,000 ppb and in brown hens’ eggs at 5,000 ppb. Maximum concentration recovered were 2.5, 0.4 and 0.2 ppb respectively in whole eggs with slightly higher concentration in yolks than in whites. Aflatoxin G1 toxin was detected in hens’ eggs at a feeding level of 1,550 ppb with maximum concentration of 0.2 and 0.05 ppb in white and brown hens’ respectively.

**Conclusion**

Most of the research reports on the
retention of aflatoxin, and their metabolites in poultry products did not fall into any consistent pattern with respect to their probable effect on human beings that ingest poultry meat and eggs. Data on aflatoxin excretion and residue clearance for poultry are very limited and the toxicological significance of aflatoxin residues present at a low concentration in poultry meat and eggs has not been assessed. Human beings who consume poultry products that contain aflatoxin residues may be exposed indirectly to low levels of aflatoxin. At the moment, data on excretion and residue clearance of aflatoxin for man are not yet available as a result the implications of chronic exposure to what is generally considered insignificant amounts of aflatoxins in poultry productions may have serious consequences. Further research should be carried out to determine the interactions of aflatoxin metabolites with drugs and residues of naturally occurring toxicants and potential carcinogens that poultry and human beings are regularly exposed to particularly in the developing countries where aflatoxin levels in the foodstuffs are not frequently monitored.

Lastly, it has been observed from this review that the total aflatoxin concentrations transferred from contaminated feedstuffs to the chicken breast and leg muscles[13], gizzard, liver and eggs[48] were all less than the action level of 20 μg/kg set by the United States of America Food and Drug Administration for aflatoxin levels permitted in foods and food ingredients intended for human consumption. Therefore, consumption of these aflatoxin residues in poultry tissues and eggs pose little or no potential health hazard to humans consuming them. Furthermore, residue levels decrease rapidly after withdrawal of the contaminated feeds[48]. However, more diagnostic investigations are needed to confirm whether or not consumption of the aflatoxin residues at such low levels poses potential hazard to humans, particularly as the interaction of human cellular components with low levels of aflatoxin residues is considered a possibility.

Reference


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PHYTOTOXICOSE PRODUITE PAR L’EXTRAIT ETHANOLIQUE DES FEUILLES DE LA LINNÉE BIXA ORELLANA CHEZ LES RATS

Résumé

On a observé chez les rats les effets toxiques des extraits éthanoliques bruts des feuilles de la linnée Bixa orellana sur l'hémotologie et les paramètres biochimiques. Les extraits, à raison de 80 et 120 mg/kg, ont causé une baisse accentuée du nombre total d'hémáties et de l’hématoctrite, mais il n’y a pas eu de variations importantes du nombre de leucocytes et des concentrations d’hémoglobine.

Sur l’électrolyte du sérum, l’extrait a provoqué l’hypoprotéinémie comme le montre la baisse de la concentration d’albumine, de même il a aussi causé un accroissement des niveaux de potassium, de sodium et de chlorure.

L’extrait a également entraîné une augmentation significative (P<0,05) du niveau d’activités du sérum alanine aminotransferase et de l’aspartate aminotransférase.

Summary

Toxic effects of crude ethanolic extracts of the leaves of Bixa orellana linn have been observed on the haematology, and serum biochemical parameters in the rats. The extracts at doses of 80 and 120 mg/kg produced significant decrease in the total red blood cell count and packed cell volume but produced no significant changes in the leucocytic count or haemoglobin concentrations.

On serum electrolyte it produced hypoproteinaemia reflected in decrease albumin concentration and it also produced increased levels of potassium, sodium and chloride.

The extract also produced significant increase (P<0.05) in the level of activities of the serum alanine aminotransferase and aspartate aminotransferase.

INTRODUCTION

Bixa orellana linn is of the family Bixaceae, a medium sized thick growing shrub or small tree. In Nigeria the plant is generally cultivated sometimes planted in villages. It is a tropical American plant, widely spread in the tropics

Annotta a bright orange colouring matter are obtained by extraction of the pericarp of the fruit of Bixa orellana. Annotta is a vegetable colouring material used in the food industries of Britain, United States, Denmark, Netherlands, New Zealand and other countries with important dairy industries. In the Philippines, it is an ingredient in floor wax, furniture and shoe polishes, nail gloss, brass lacquer, hair oil and wood stains

The colour of Annatto extract is a bright orange or orange red solution or suspension, and bixin (the monomethyl ester) or norbixin is the principal colouring principle

The plant especially the fruit is febrifugal and astringent and is especially useful for dysentry and kidney disease. Livestock, sheep and goats relish the leaves of the plant. The leaves and the fruits when squeezed in the palms produces allergic reaction in the children playing with it with such children showing swollen hands and faces (personal observations).

This study was therefore carried out to observe the effect of an ethanolic extract of the leaves of Bixa orellana linn on the haemogram, serum biochemistry,
hexobarbital sleeping time and gross and histopathology of tissues in the rat.

**Materials and Method**

**Animals**
Sprague Dawley rats strain of both sexes weighing between 200-250 gm were used. They were fed *ad libitum* on rat cubes (Ladokun and Sons Livestock Feeds, Nigeria Ltd.) and allowed free access to fresh clean water in their rat cages.

**Preparation of Extract**
The leaves of Bixa orellana linn were collected during the dry season of January and dried in shade. They were then ground into a coarse form and ethanolic extracted using the soxhlet extractor. The extract was concentrated and dried in the oven to obtain a semi-solid preparation. The extract was weighed into the various doses and administered orally using canula after dissolving in propylene glycol for a period of seven days daily. Groups A, B and C received concentrations of 40, 80 and 120 mg/kg of extract respectively.

**Collection of blood samples and analytical procedures**
At the eight day after the commencement of administering the extract in propylene glycol, each rat was anaesthetised using diethylether and blood samples collected by cardiac puncture for serum and another set of blood collected using anticoagulant ethylene diamine tetracetic acid (EDTA).

The haemoglobin (Hb) concentration was determined by the cyanmethaemoglobin method; total erythrocyte (RBC) and total white blood cell (WBC) count by haemocytometer method; haematocrit (PCV) by the microhaematocrit method; the differential WBC counts were made using blood on slides stained with Giemsa.

Blood coagulation time was estimated by breaking bits of capillary tubes from one filled with blood in a non heparinised capillary tube.

Serum activities of GPT (EC 2.6.1.2.) and GOT (EC. 2.6.1.1.) were estimated according to the method of. Serum Ca estimation, was performed as described by bicarbonate and chloride as described by. Sodium and potassium by flame photometric method using the Flame Analyser.

Total protein was determined by biuret method and albumin determined by the method of . Globulin fraction was computed from the difference between the total protein and albumin determined.

**Histopathology**
Organs such as the liver, lungs, heart, kidney, pancreas and intestine obtained at autopsy were examined grossly and by light microscopy. Histopathology of tissues were prepared by fixation in 10% buffered formalin embedded in formalin, sectioned and stained in haematoxylin and eosin (H & E) stain.

**Results**

**Effect of the Bixa orellana extract on rat haemogram**
The haematocrit, total RBC counts and the haemoglobin concentration have shown progressive decrease as the concentration of the extract administered to the rats increased, as compared with the values obtained from those of the control rats (Table 1). These changes are statistically significant (P<0.05) with the 80 and 120 mg/kg doses. These changes are reflected in the values of the MCHC and MCH which show progressive increases with the concentration of extract administered. The extract did not cause any changes in the values of the leucocytes as shown in Tables 1 and 2.

**Effect of the extract on serum electrolytes and proteins**
The extract decreased the total serum protein as the concentration of the extract administered to the rats increased. This dysprotemaemia is reflected in decreased serum albumin (Table 3). This decrease in serum protein is significant (P<0.05) at concentration of 80 and 120 mg/kg of the extract. The decrease in serum albumin level is only significant (P<0.05)
Table 1: The effect of the ethanolic extract of Bixa orellana linn of erythrocyte and leucocyte values in rats

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose (mg/kg)</th>
<th>Hb (g/dl)</th>
<th>PCV (%)</th>
<th>RBC (10⁶/ml)</th>
<th>WBC (10³/ml)</th>
<th>MCV (μm³)</th>
<th>MCHC (%)</th>
<th>MCH (pg)</th>
<th>Coagulation Time/Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
<td>13.6±6.4</td>
<td>44±0.1</td>
<td>6.4±3.2</td>
<td>6.0±5.8</td>
<td>68.75</td>
<td>30.9</td>
<td>21.25</td>
<td>64±4.2</td>
</tr>
<tr>
<td>Group A</td>
<td>40</td>
<td>12.9±3.8</td>
<td>39.9±6.1</td>
<td>6.1±4.1</td>
<td>6.2±3.8</td>
<td>65.40</td>
<td>32.33</td>
<td>21.14</td>
<td>63±7.8</td>
</tr>
<tr>
<td>Group B</td>
<td>80</td>
<td>12.6±9.1</td>
<td>31±0.3</td>
<td>5.3±6.4</td>
<td>5.9±7.9</td>
<td>58.49</td>
<td>40.65</td>
<td>23.77</td>
<td>59±12.4</td>
</tr>
<tr>
<td>Group C</td>
<td>120</td>
<td>12.3±4.2</td>
<td>29.8±0.4</td>
<td>4.9±3.8</td>
<td>6.9±9.2</td>
<td>60.82</td>
<td>41.28</td>
<td>25.10</td>
<td>66±6.1</td>
</tr>
</tbody>
</table>

Table 2: The effect of Bixa orellana extract on leucocyte differential counts

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose (mg/kg)</th>
<th>Neutrophils</th>
<th>Lymphocytes</th>
<th>Eosinophil</th>
<th>Basophil</th>
<th>Monocytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>0</td>
<td>41</td>
<td>40</td>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>GROUP A</td>
<td>40</td>
<td>40</td>
<td>52</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>GROUP B</td>
<td>80</td>
<td>40</td>
<td>56</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GROUP C</td>
<td>120</td>
<td>32</td>
<td>52</td>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3: The effect of Bixa orellana extract on serum electrolytes and proteins

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose (mg/kg)</th>
<th>Total Protein (g/dl)</th>
<th>Albumin (g/dl)</th>
<th>Globulin (g/dl)</th>
<th>Ca (mmole/l)</th>
<th>K (mmole/l)</th>
<th>Na (mmole/l)</th>
<th>Bicarbonate (mmole/l)</th>
<th>Chloride (mmole/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>0</td>
<td>6.90±4.1</td>
<td>2.7±1.2</td>
<td>4.2±3</td>
<td>8.6±8.9</td>
<td>3.7±11.2</td>
<td>144.3±3.4</td>
<td>18.7±4.8</td>
<td>98.4±1.1</td>
</tr>
<tr>
<td>GROUP A</td>
<td>40</td>
<td>5.50±3.9</td>
<td>2.9±3.6</td>
<td>2.6±5.1</td>
<td>8.8±7.8</td>
<td>7.3±6.4*</td>
<td>145.7±6.1</td>
<td>18.6±7.3</td>
<td>99.2±6.2</td>
</tr>
<tr>
<td>GROUP B</td>
<td>80</td>
<td>3.60±7.4*</td>
<td>2.0±8.9</td>
<td>1.6±2.3</td>
<td>8.0±10.4</td>
<td>7.6±3.8*</td>
<td>126±11.2</td>
<td>19.8±3.3</td>
<td>102.5±4.3*</td>
</tr>
<tr>
<td>GROUP C</td>
<td>120</td>
<td>4.4±3.4*</td>
<td>1.6±7.6*</td>
<td>2.9±9.3</td>
<td>7.9±8.5</td>
<td>4.0±4.6</td>
<td>124±12.3*</td>
<td>20.1±4.0</td>
<td>103.1±3.1*</td>
</tr>
</tbody>
</table>

*Values are significant P<0.05.

Table 4: The effect of the ethanolic extract of Bixa orellana linn on activities of serum enzymes

<table>
<thead>
<tr>
<th>Treatment</th>
<th>DOSE (mg/kg)</th>
<th>GPT (mmole substrate converted/min./ml. serum)</th>
<th>GOT (mmole substrate converted/min./ml. serum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>0</td>
<td>24.2±3.0</td>
<td>39.2±6.8</td>
</tr>
<tr>
<td>GROUP A</td>
<td>40</td>
<td>37.4±6.1</td>
<td>57.8±8.1</td>
</tr>
<tr>
<td>GROUP B</td>
<td>80</td>
<td>35.3±8.2</td>
<td>49.6±2.1</td>
</tr>
<tr>
<td>GROUP C</td>
<td>120</td>
<td>32.8±3.2</td>
<td>52.1±0.2</td>
</tr>
</tbody>
</table>

with the 120 mg/kg dose of the extract. The serum potassium level also showed significant increases with the 40 and 80 mg/kg doses (0.05<p<0.01) though the higher dose of 120 mg/kg showed a slight rise from the control values which is insignificant statistically. On serum sodium the extract caused a progressive significant decrease in blood level as the concentration of the extract increased (P 0.05). The serum chloride level showed significant increases.
Effect of extract on serum enzyme activities
Marked changes in serum enzyme activities were detected in all the rats given the various doses of the Bixa orellana extract. The increased activities of SGOT and SGPT as compared to levels of activities control enzymes were statistically significant (P 0.05).

Gross and histopathologic effects on organs
In all the treatment groups, no gross pathological lesions were observed though some histopathological lesions were observed in the lung tissues. Other organs showed no lesions.
Some rats receiving the 40 mg/kg dose showed evidence of oedema in the alveoli septae and very mild lymphocytic infiltration into the interstitium.
Some rats in the 80 mg/kg group showed mild congestion of blood vessels and clumping of desquamated alveoli cells.
A few rats in the 120 mg/kg dose group showed mild congestion with oedema of the alveolar wall with mild mononuclear infiltration and peribronchiolar lymphoid hyperplasia.

Discussions
Ethanolic extracts from the leaves of Bixa orellana have produced changes in the haematological parameters and these changes are statistically significant with the total red blood cell counts and packed cell volume using the 80 and 120 mg/kg treatment doses (P<0.05). The reduced RBC counts with these two doses cannot be associated with a haemorrhagic syndrome in the experimental rats since all the tissues and organs at postmortem did not show any sign of haemorrhage. The reduced total red blood cell count could therefore be associated with a haemolytic syndrome or due to decreased production of erythrocytes or haemoglobin since the haemoglobin concentration showed slight decrease.
If the decreased total red blood cell count has been due to toxic depression of the erythropoietic activity of the bone marrow, it is not accompanied by a depression of leucopoietic function since the total white blood cell counts or the differential leucocyte counts exhibited no changes.
The extract of Bixa orellana caused hypoproteinaemia due to decrease serum albumin levels.
The extract also produced significant changes in serum electrolyte levels of potassium, sodium, bicarbonate and chloride most especially with the 80 and 120 mg/kg doses of the extract.
The increased activity of the serum enzymes alanine amino transferase is an indication of hepatocellular damage, however, the presence of aspartate aminotransferase in so many tissues precludes its use as being from hepatic damage.
The absence of gross lesions in the organs and tissues of the rats necropsied shows the inability of Bixa orellana extracts to cause acute gross lesions. The histopathologic lesions observed mainly in the lung tissues of a few rats could not be attributed to the effect of the extract.

References

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A SURVEY OF AVIAN INFECTIOUS BRONCHITIS ANTIBODIES IN NSUKKA, NIGERIA

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UNNE ETUDE SUR LES ANTICORPS A LA BRONCHITE AVIAIRE INFECTIEUSE A NSUKKA AU NIGERIA

Résumé

Au total, 543 prélèvements de sérum de poulets abattus à Nsukka, dans l’Est du Nigeria, ont été examinés pour détecter des anticorps au virus de la bronchite aviaire infectieuse (BAI) en utilisant la méthode modifiée de l’hémagglutination-inhibition. Selon les résultats obtenus, seuls 18 ou 3,3%, des prélèvements examinés étaient positifs. Même si l’incidence de la maladie est faible, elle confirme la présence de la BAI dans cette région.

Summary

A total of 543 serum samples from slaughtered chickens in Nsukka, Eastern Nigeria were screened for antibodies to avian infectious bronchitis (AIB) virus by the modified haemagglutination-inhibition method. The results showed that only 18 or 3.3% of the tested samples were positive. Although, the incidence is slow, it confirms the presence of AIB in this area.

INTRODUCTION

Avian infectious bronchitis (AIB) is an acute highly contagious viral infection of the upper respiratory tract of chickens characterized by depression, coughing, sneezing tracheal rales and accumulation of mucus in the bronchi[1]. In adults, especially layers, the infection is usually mild but attended by a drastic drop in egg production and quality[1,2].

The disease was first described in the USA[3] and the viral aetiology established by Beach and Schalm[4]. AIB has since been reported world-wide[5].

A suspected outbreak of AIB in Nigeria was first reported by Komolafe and Erojikwe[6] and later confirmed by Komolafe[7].

The aim of the present study, was to determine the prevalence of AIB antibodies in the sera of slaughtered chickens in Nsukka and its environs in Eastern Nigeria.

Materials and Methods

Blood samples from slaughtered chickens were collected from various hotels at Nsukka and its environs spanning a distance of about 40 km in diameter. Harvested serum samples were stored at -20°C until tested.

The reference AIB virus used in this survey was obtained from the Central Veterinary Laboratory, Weybridge, England. The virus was propagated in embryonating chicken eggs via the allantoic cavity[8] and harvested 5 days post inoculation.

Prior to use, the allantoic fluid was mixed with 1% trypsin in the ratio of 2 mls allantoic fluid to 1 ml of trypsin and the mixture incubated at 37°C for 3 hours as previously described[1].

The determination of 4 haemagglutination (HA) units of the trypsinized antigen was performed as previously described[1] using phosphate buffered saline (PBS) of pH 7.2 as diluent and 0.5% freshly prepared chicken erythrocyte as indicator.

Each of the serum samples was absorbed with a 50% preparation of

AIB Prevalence in Eastern Nigeria.
Table 1: Antibodies to Avian Infectious Bronchitis Virus

<table>
<thead>
<tr>
<th>Township</th>
<th>Number Tested</th>
<th>Number Positive</th>
<th>Titre Range</th>
<th>% Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nsukka</td>
<td>79</td>
<td>5</td>
<td>16-64</td>
<td>6.33</td>
</tr>
<tr>
<td>Orba</td>
<td>87</td>
<td>7</td>
<td>8-32</td>
<td>8.05</td>
</tr>
<tr>
<td>Obololo-Afor</td>
<td>355</td>
<td>5</td>
<td>16-128</td>
<td>1.41</td>
</tr>
<tr>
<td>Ukehe</td>
<td>22</td>
<td>1</td>
<td>64</td>
<td>4.55</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>543</strong></td>
<td><strong>18</strong></td>
<td><strong>8-128</strong></td>
<td><strong>3.3</strong></td>
</tr>
</tbody>
</table>

chicken erythrocytes at 4°C for 2 hours after which the erythrocytes were removed by centrifugation. All the sera were heat-inactivated at 56°C for 30 minutes before use in HI tests by a method already described. The titres were taken as the reciprocal of the highest dilution of virus that showed 100% inhibition of chicken rbc agglutination when the serum samples were used.

Results

Only 18 or 3.3% of the 543 serum samples tested were positive for AIB antibodies with titres ranging from 8 to 128 (Table 1).

Discussion

The result of this survey shows that AIB Infection exists in Nsukka and its environs even though the prevalence is low (3.3%). Despite the limitation in the choice of the sources of the samples, the fact that positive samples were identified from each of the locations is indicative of the widespread nature of AIB not only in this area but perhaps in the entire country as earlier suggested.

Although Corbo and Cunningham were unable to demonstrate the specificity of AIB virus haemagglutinin by inhibition with AIB antiserum, it is interesting to observe a contrast result in this study where the 8 positive sera repeatedly inhibited specific haemagglutination by the reference antigen. This finding is presently being further investigated to establish conclusively or otherwise the specificity of AIB antiserum in haemagglutination-inhibition tests.

Acknowledgement

We gratefully acknowledge Dr. Wescott of the Central Veterinary Laboratory, Weybridge, England, for supplying the reference AIBV used in this survey.

References


Received for publication on 14th February 1989
INTRODUCTION

Coccidiosis is a protozoan disease affecting most of the domestic animals and especially the young. It has cosmopolitan distribution and in certain parts of the world, it has caused heavy losses for example among goats in Texas\(^{1}\). In Australia\(^{2}\), coccidiosis is the single most important disease affecting goats kept in large numbers under intensive management.

In Africa, reports have been made from parts of West Africa, on the seasonality\(^{3}\) and prevalence rates of various species of *Eimeria*\(^{4}\). In Kenya, little is known of coccidiosis in large or small ruminants but report on *Eimeria arloingi* infection in goats indicates that pathogenic *Eimeria* species are prevalent\(^{4}\) and hence the need to examine the overall situation.

Materials and Methods, Results and Discussion

Diagnostic parasitology records from the University of Nairobi Veterinary School for the year 1969 to 1986 were examined. Records of faecal samples of sheep and goats presented to the Parasitology Laboratory were entered as being positive or negative for coccidia oocysts. From the data collected, the proportion of positive samples was worked out on an yearly as well as on a monthly basis and the results obtained are presented in table I and II respectively.

On an yearly basis (Table I) it was found that, over all the years (except two) a higher proportion of goat samples were diagnosed positive compared to those of sheep. At any one year, over 29.3% of the goat samples were positive compared to 11.8% of sheep samples. The highest proportion of sheep samples diagnosed positive was 65.1% (in 1982) in comparison to 73.4% of goat samples (in 1985).

An analysis of the monthly prevalence rate of coccidial infections revealed that, in all months of the year (except in September), a greater proportion of goat samples were positive compared to those sheep. Among both sheep and goats, the highest prevalence of the organisms in samples examined was in June. In both species, the lowest prevalence was recorded between February and April though the rate was low in September among goats.

From this preliminary study, it can be seen that, a good proportion of small ruminants harbour coccidian parasites. The levels of parasite infestation should

<table>
<thead>
<tr>
<th>Year</th>
<th>GOAT</th>
<th>SHEEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>514 (18)</td>
<td>30.4 (181)</td>
</tr>
<tr>
<td>1970</td>
<td>70.6 (12)</td>
<td>29.9 (113)</td>
</tr>
<tr>
<td>1971</td>
<td>70.0 (14)</td>
<td>16.3 (7)</td>
</tr>
<tr>
<td>1972</td>
<td>58.9 (109)</td>
<td>41.7 (51)</td>
</tr>
<tr>
<td>1973</td>
<td>49.6 (58)</td>
<td>42.2 (19)</td>
</tr>
<tr>
<td>1974</td>
<td>49.1 (53)</td>
<td>44.4 (28)</td>
</tr>
<tr>
<td>1975</td>
<td>30.7 (23)</td>
<td>29.8 (31)</td>
</tr>
<tr>
<td>1976</td>
<td>46.6 (54)</td>
<td>27.2 (31)</td>
</tr>
<tr>
<td>1977</td>
<td>57.3 (67)</td>
<td>26.3 (5)</td>
</tr>
<tr>
<td>1978</td>
<td>73.3 (11)</td>
<td>37.4 (39)</td>
</tr>
<tr>
<td>1979</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>66.7 (6)</td>
<td>65.1 (28)</td>
</tr>
<tr>
<td>1983</td>
<td>50.0 (9)</td>
<td>56.1 (23)</td>
</tr>
<tr>
<td>1984</td>
<td>33.3 (3)</td>
<td>11.8 (2)</td>
</tr>
<tr>
<td>1985</td>
<td>73.5 (25)</td>
<td>21.7 (5)</td>
</tr>
<tr>
<td>1986</td>
<td>29.3 (29)</td>
<td>56.8 (25)</td>
</tr>
</tbody>
</table>

The values in parenthesis indicate the total number of positive samples for the year.

* The records for these years would not yield meaningful information due to the manner of recording.
Table II: Monthly prevalence rate of coccidial oocysts among faecal samples from goats and sheep

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GOATS</td>
<td>58 (8)</td>
<td>50 (6)</td>
<td>46.5 (10)</td>
<td>41.5 (10)</td>
<td>57.3 (11)</td>
<td>77 (4)</td>
<td>64.3 (12)</td>
<td>66.6 (13)</td>
<td>36.2 (11)</td>
<td>59.2 (11)</td>
<td>56.9 (14)</td>
<td>94.3 (6)</td>
</tr>
<tr>
<td>SHEEP</td>
<td>45.1 (7)</td>
<td>28.3 (8)</td>
<td>29.2 (15)</td>
<td>30.3 (7)</td>
<td>29.9 (10)</td>
<td>60.2 (13)</td>
<td>39.7 (12)</td>
<td>36.5 (8)</td>
<td>46.6 (12)</td>
<td>39.2 (13)</td>
<td>35.6 (14)</td>
<td>36.7 (9)</td>
</tr>
</tbody>
</table>

( ) These figures represent the number of years over which data has been gathered.

be determined and related to any clinical evidence of disease. The prevalence rates of various *Eimeria* species affecting sheep and goats is unknown and this aspect is worth of examination.

The reason for higher infection rate in goats than in sheep should be looked into.

The feeding habits of sheep as compared to that of goats is such that they should favour higher infection rates in the former because of the increased chances of the sheep ingesting the infective forms (sporulated oocysts) of the coccidia. Hence there must be other factors favouring (accounting for) this trend of higher infection rates in goats. In the Kenya situation many goats farmers (especially the area abounding the veterinary school) keep goats in small enclosures on zero grazing for most of the time. Feeding animals in a confined area must hence lead to a build up of infective oocysts which are ingested. This supports previous observations that among conditions favouring development of coccidiosis are, heavy stocking rates, poor hygiene and moist conditions.

**Acknowledgement**

Many thanks go to the University of Nairobi and the technical staff who carried out Parasitological examinations and kept records that enabled this information to the retrieved for publication.

**References**


Received for publication on 17th February 1989
SHORT COMMUNICATION:

ANTIBODIES TO BLUETONGUE AND AFRICAN HORSE SICKNESS VIRUSES IN THE SERA OF ELEPHANTS IN ZIMBABWE

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*Veterinary Research Laboratory, P.O. Box 0101, Causeway, Harare, Zimbabwe

INTRODUCTION

Domestic and wild animals can act as hosts and hence reservoirs of arthropod transmitted viruses. Sera from elephants in Zimbabwe were tested for complement fixing antibodies to bluetongue and African horse sickness (AHS) viruses.

The sera were collected from 92 African elephants (*Loxodonta Africana), of various ages, shot by the Department of National Parks and Wildlife Management during a culling programme in Hwange and Gonarezhou National Parks, Zimbabwe in July/August 1985.

They were tested for complement fixing antibodies in microtiter plates11. The viral antigens were obtained from acetone ether extract of mouse brains infected with ether BT or AHS viruses.

Thirteen out of 92 (14%) elephant had CFT antibodies to BT virus (Table 1). The titres obtained were low, 1/4 to 1/16. CFT antibodies to AHS were found in 74 out of 92 (80%) elephant sera. The elephant had slightly higher titres to AHS than to BT viruses (Table 1).

The elephant sera contained complement fixing antibodies to AHS and BT or to some closely related viruses. Complement fixing antibodies are relatively short-lived following infection and indicate recent infections by these viruses which are transmitted by arthropod vectors. Although these viruses have not been isolated from healthy elephants the demonstration of complement fixing antibodies could mean that elephants can act as a source of infection for arthropod vectors.

Table 1: Complement fixing antibodies to bluetongue and African horse sickness viruses

<table>
<thead>
<tr>
<th>Virus</th>
<th>No. of animals with CF Titres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;4</td>
</tr>
<tr>
<td>Bluetongue</td>
<td>79</td>
</tr>
<tr>
<td>African horse Sickness</td>
<td>10</td>
</tr>
</tbody>
</table>

References


Present Address: Veterinary Laboratory, Private Bag 0035, Gaborone, Botswana.

Received for publication on 13th March 1989
INTRODUCTION

A farm health survey and a preliminary health evaluation of the dual purpose goats placed on farms in Western Kenya indicated that helminth infections were an important health problem in goats, and Haemonchus contortus was the most dominant helminth. The infections were severe enough to require a control programme.

An understanding of the epidemiology of helminth infections in goats in an area is necessary before effective control measures are decided upon. Management exerts a crucial effect on the course of helminthiasis. It is therefore necessary to consider their epidemiology within the context of particular systems of management and to design control measures specific to particular farm enterprise. It must be recognised that control of helminth infections is only one aspect influencing management decisions. Control plans must make economic sense since helminthiasis in food animals are controlled mostly for economic reasons.

This article concerns a two year study done to establish the prevalence of the important species of helminths, and their seasonality in Western Kenya.

Materials and Methods

Location:
The study was conducted on three sites in Western Kenya, ranging from high to medium potential with rainfall varying from 1000 mm to 2100 mm per annum. The whole area consists of small holder subsistence farms whose sizes vary from 0.9 to 1.09 hectares. The fourth study area is Olmagogo farm near Naivasha. This is a semi arid area. The annual rainfall averages about 600-700 mm. In all the four sites the rainfall distribution is bimodal with the March to June peak (long rains) and the September to November peak (short rains).

Animals:
The three Western Kenya sites, Maseno, Masumbi and Kamosi together had a mean population of 150 adult female dual purpose goats over the study period of 15 months. Most of the dual purpose goats were 3/4 Toggenburg and 1/4 East African crosses and a few 1/2 crosses of the two breeds. At the Olmagogo farm, 90 does were used in the study. Consisting of 30 East African, 30 Galla and 30 Toggenburg. All the animals were treated with an anthelmintic combination (Oxytocinide + levamisole) every month.

Sample Collection and Processing:
Every month five grams of faecal specimen was collected from each animal into a plastic container, labelled and immediately delivered to the laboratory for processing. Differential egg counts were performed by a modified McMaster technique. Infective larvae were periodically recovered from faecal cultures and identified.

Meteorological data:
The rainfall data were obtained from Government meteorological stations situated within the study sites or less than three kilometres from the study sites.
Results

Table 1 is a summary of the strongyle egg per grams (EPG) for the study period. Kaimosi recorded the highest mean followed by Masumbi, Maseno and Olmagogo. The highest monthly mean of 2021 EPG, however, were recorded in Masumbi. Table 3 shows EPG and rainfall figures for each study site. The trends for EPG and rainfall for Kaimosi and Masumbi did not appear to be related, while those of Maseno had fairly similar trends with two prominent peaks for the rainfall in October to December, 1984 and February to May, 1985, and the mean egg counts had peaks in October to December in 1984 and May to August in 1985, lagging slightly behind the rainfall.

Multiple regression analyses for the three locations, however showed that there was no significant correlation between the rainfall patterns and the EPG. Rainfall and EPG trends for Olmagogo were strikingly similar. The rainfall had one prominent peak between January and June, 1985 while the EPG lagged one month behind the rainfall pattern showed a significant correlation ($P = 0.04$). The Tables generally show that EPG was high in the higher rainfall areas of Kaimosi, Masumbi and Maseno, all

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean Herd Size</th>
<th>Mean EPG</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaimosi</td>
<td>20</td>
<td>894 ± 510.9</td>
<td>100-1760</td>
</tr>
<tr>
<td>Masumbi</td>
<td>19</td>
<td>861 ± 644.4</td>
<td>0-2021</td>
</tr>
<tr>
<td>Maseno</td>
<td>111</td>
<td>352 ± 279</td>
<td>0-1022</td>
</tr>
<tr>
<td>Olmagogo</td>
<td>90</td>
<td>119 ± 206.5</td>
<td>0-740</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Monthly Mean</th>
<th>Annual Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaimosi</td>
<td>173.7 ± 85.0</td>
<td>2084.4</td>
<td>48.2-390.9</td>
</tr>
<tr>
<td>Masumbi</td>
<td>118.3 ± 83.04</td>
<td>1419.4</td>
<td>20-288.3</td>
</tr>
<tr>
<td>Maseno</td>
<td>185.5 ± 118.4</td>
<td>2225.9</td>
<td>55-539.7</td>
</tr>
<tr>
<td>Olmagogo</td>
<td>43.5 ± 44.6</td>
<td>522.2</td>
<td>1-195.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MONTH</th>
<th>KAIMOSI EPG</th>
<th>MASENO EPG</th>
<th>OL’MAGOGO EPG</th>
<th>MASUMBI EPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUG.1984</td>
<td>741(15)</td>
<td>288.8</td>
<td>536(52)</td>
<td>97.2</td>
</tr>
<tr>
<td>SEPTEMBER</td>
<td>645(22)</td>
<td>122.9</td>
<td>416(59)</td>
<td>176.2</td>
</tr>
<tr>
<td>OCTOBER</td>
<td>668(20)</td>
<td>118.8</td>
<td>536(65)</td>
<td>140.5</td>
</tr>
<tr>
<td>NOVEMBER</td>
<td>1492(24)</td>
<td>173.8</td>
<td>1022(71)</td>
<td>263.5</td>
</tr>
<tr>
<td>DECEMBER</td>
<td>980(24)</td>
<td>96.8</td>
<td>486(115)</td>
<td>55</td>
</tr>
<tr>
<td>JANUARY1985</td>
<td>1760(24)</td>
<td>48.2</td>
<td>253(115)</td>
<td>139.7</td>
</tr>
<tr>
<td>FEBRUARY</td>
<td>1159(24)</td>
<td>76.3</td>
<td>194(117)</td>
<td>289.1</td>
</tr>
<tr>
<td>MARCH</td>
<td>1205(21)</td>
<td>201.2</td>
<td>227(129)</td>
<td>184.8</td>
</tr>
<tr>
<td>APRIL</td>
<td>1450(22)</td>
<td>390.9</td>
<td>229(137)</td>
<td>289.1</td>
</tr>
<tr>
<td>MAY</td>
<td>296(13)</td>
<td>219</td>
<td>167(149)</td>
<td>194.0</td>
</tr>
<tr>
<td>JUNE</td>
<td>1113(16)</td>
<td>153.1</td>
<td>421(154)</td>
<td>64.5</td>
</tr>
<tr>
<td>JULY</td>
<td>1247(17)</td>
<td>171.1</td>
<td>707(148)</td>
<td>138</td>
</tr>
<tr>
<td>AUGUST</td>
<td>312(15)</td>
<td>184.6</td>
<td>0(112)</td>
<td>199.9</td>
</tr>
<tr>
<td>SEPTEMBER</td>
<td>240(17)</td>
<td>195.5</td>
<td>88(118)</td>
<td>154.5</td>
</tr>
<tr>
<td>OCTOBER</td>
<td>100(19)</td>
<td>164.9</td>
<td>0(123)</td>
<td>125.8</td>
</tr>
<tr>
<td>MEAN</td>
<td>894(20)</td>
<td>173.73</td>
<td>352(111)</td>
<td>185.49</td>
</tr>
</tbody>
</table>
with annual means of between 1400 mm and 2250 mm. Olmagogo, a semi arid area, on the other hand had the lowest annual mean of 522.2 mm and the lowest EPG of slightly over 100.

Discussion

The results, as revealed in Table 3 for Kaimosi, Maseno & Masumbi show that in the high and medium potential areas the monthly anthelmintic treatment did not eliminate the worm burdens. Previous work\(^1\) indicated similar results. The role of management in the control of helminth infections cannot be over emphasized. After anthelmintic treatment, the animals need to be grazed on clean pasture to avoid rapid reinfection and also to prevent contamination of the pasture.

The effect of climatic factors, especially rainfall, in providing the required moisture and appropriate temperatures for the survival of the free-living stages of helminths is known. It is clear from Table 3 that rainfall played a significant role. In the medium and high potential areas where there was the minimum climatic conditions required for the survival of the free-living stages all the year round, it would appear that other factors such as stocking densities, which in turn influenced rates of contamination of the pasture, were important such that the rainfall did not appear to influence directly the level of worm infection. In Olmagogo, however, the rainfall appears to be a critical factor in determining the level of infection.

Conclusions:

1. Anthelmintic treatment is most effective where appropriate management practices are also undertaken.
2. In high and medium potential areas there are factors of management such as stocking densities and rotational grazing which play an equally significant role as the rainfall in determining the level of worm infection.
3. There is a need to study the influence of the various management factors together with anthelmintic regimes to determine the best combination, cost wise, for various regions.

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- des éditoriaux
- le courrier des lecteurs
- analyse d'ouvrages
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- Le matériel et les méthodes utilisés.
- Les résultats présentés brièvement.
- Un débat sur l'importance de l'article.
- Remerciements éventuels.

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