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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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Abstract not exceeding 200 words giving a synopsis of the findings presented and the conclusion(s) reached.
Introduction stating the purpose of the work.
Materials and Methods used.
Results presented concisely.
Discussion of significance.
Acknowledgements.
References numbered consecutively in the order they are first mentioned in the text. Identification of references in the text should be by numbers (in parentheses) and not by authors' names.
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Surname and initials of author(s), year of publication (in parentheses), the exact title (underlined), town of publication, publisher, first page number.

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Name of country, year of reference, followed by the name of the department or organisation, first page number.
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# ORIGINAL ARTICLES

1. Abortion in Goats in Botswana  
M.G. BINTA, E.Z. MUSHI and E.K. ADOM ................................................................. 205

2. Assessment of Practical Potential of Cassava Peels Meal for Growing and Growing-finishing Pigs in Sub-humid Tropics  
S.A. IKURIOR, and S.O. ONUH ................................................................. 209

3. Diseases of Chickens in Botswana  
BINTA, M.G., MUSHI, E.Z., ADOM, E.K. and DITEKO, T ........................................... 215

4. Effect of Graded Levels of Dried Rumen Ingesta on the Performance of Growing Rabbits Fed Concentrate Diets  
D.B. OLUMEYAN, S.B. AFOLAYAN and G.S. BAWA ............................................. 219

5. Evaluation of Browse Forage Preferability by Sheep and Goats in the Northern Guinea Savannah Zone of Ghana  
N. KARBO, P. BARNES and H. RUDAT ....................................................... 225

6. Performance of Cockerel Starters Fed Graded Levels of Dietary Methionine + Cystine in a Tropical Environment  
NWOKORO, S.O. and O.O. TEWE ................................................................. 231

7. Performance of Dwarf Naked Neck and Commercial Cross Laying Hens under local conditions  
K. BENABDELJELIL ................................................................. 237

8. Profitability and Efficiency of N’dama and Zebu Cattle in Southern Ghana  
ANNOR, S.Y., GARRICK, D.J. and BLAIR, H.T. ................................................ 243

# SHORT COMMUNICATIONS

M.G. BINTA, E.K. ADOM and E.Z. MUSHI ................................................................. 251

10. Epidemiology of *Bovine Toxocara vitulorum* in Faecal and Milk Samples in an Endemic District of Kenya  
11. Experimental Infection of Rabbits (*Oryctolagus cuniculus*) with *Toxocara vitulorum* from Calves  

12. *Muellerius Capillans* infection in Impala (*Aepyceros melampus*) in Lake Mbuero Area in Mbarara District in Western Uganda  
M. OCAIDO, L. SIEFERT AND S.K. ARUO ............................................................................................ 259

13. Molluscum contagiosum in Three Horses in Zambia  
M.M. MUSONDA, R.N. SHARMA, G.S. PANDEY, J.O. OMAMEGBE, A.M. MWANZA,  
E.M. MPABALWANI, Y. NOMURA, and A. SHIGA ............................................................................ 263

14. Abortions Due to Malnutrition in Caprine in Zaria Area of Northern Nigeria  
BABAGANA AHMADU ........................................................................................................................ 265

15. Foetal Wastage Through Slaughter of Gravid Sheep and Goats in Nigeria  
A. O. OKUBANJO ............................................................................................................................. 269
ABORTION IN GOATS IN BOTSWANA

M.G. BINTA, E.Z. MUSHTI and E.K. ADOM
National Veterinary Laboratory, Private Bag 0035, Gaborone, Botswana

AVORTEMENT CHEZ LES CHEVRES AU BOTSWANA

Résumé
Il y avait 598 cas d'avortement chez les brebis et les chèvres, qui ont été communiqués au Laboratoire vétérinaire national pendant dix ans (1985-1994). Même s'il y avait des variations quant au nombre de cas signalés, l'incidence moyenne annuelle était de 56,3 ± 4. Le nombre de cas le plus élevé (n = 92) a été constaté en 1987 et le plus faible (n = 28) en 1986. Une moyenne de 4,6 ± 6 cas a été publiée chaque mois. La plupart des cas ont été signalés pendant la période d'hiver (mai à début août).

Environ 9,2% des cas d'avortement étaient dus à : l'helminthiase/la coccidiose, Chlamydia psittaci, Toxoplasma gondii, Anaplasma ovis, la sous-alimentation, l'hypocuprémie et l'hypophosphatémie. Aucun agent causal n'était associé au reste des cas d'avortement (90,8%) pendant la période de dix ans couverte par l'étude.

Summary
There were 598 outbreaks of abortion in sheep and goats reported to the National Veterinary Laboratory for the ten-year period, 1985 to 1994. Although there were fluctuations in the number of cases reported, the mean annual incidence was 56.3 ± 4.0. The highest number of cases (n = 92) was reported in 1987 and the lowest number reported was 28, recorded in 1986. A mean of 4.6 ± 6.0 cases was reported every month. Most of the cases were reported in the winter months of May to early August.

About 9.2% of the abortion cases were associated with helminthiasis/coccidiosis, Chlamydia psittaci, Toxoplasma gondii, Anaplasma ovis, malnutrition, hypocupraemia and hypophosphataemia. No causal agent was associated with the rest of the cases (90.8%) in the ten-year period of study.

Introduction
In Botswana, the majority of the people keep goats which are used for meat mainly and to a minor extent, milk production(10). The two breeds of goats herded in this country are the Boer and Tswana, and their crosses. The Boer goat was introduced from South Africa to upgrade the less productive indigenous Tswana goat.

Most goats are kept under a communal system. There is a need to develop commercial small stock production. Abortion storms occurring among goats in this country during the winter months has resulted in loss of productivity and are as such a major cause for concern (Unpublished reports). The causes of these abortions have been elusive. Although several infectious and non-infectious factors have previously been suspected for causing abortions, the majority were never explained (Unpublished reports).

The purpose of this study was to review the causes of abortion in goats retrospectively for the ten-year period, 1985 to 1994.

Materials and Methods
Specimens collected from aborting goats in the fourteen veterinary districts were submitted to the National Veterinary Laboratory which is the only diagnostic laboratory in the country. Various specimens including blood, serum, vaginal swabs, placenta from the dams and less frequently aborted foetuses were sent to the laboratory whenever abortions occurred in the field. The frequency of submission and the type of samples from cases of abortion depended on how soon the cases were reported to the field.
staff. The distance of the case from the laboratory limited not only the quality of the samples but also the type, such as convalescent serum.

The sera were tested for antibodies to *Brucella* spp. in the Rose Bengal Plate test as described by Mac Millan[9]. The screening for antibodies to *C. burnetii* and *C. psittaci* was done using complement fixation test kits (Cellugonost-Behringwerke, Germany). Antibodies to *Toxoplasma gondii* were determined by the semiquantitative Indirect Haemagglutination Assay using the latter kits. The screening for antibodies to Flaviviruses namely, Rift Valley Fever and the Wesselsbron viruses was carried out using the ELISA test and the Haemagglutination Inhibition Assay, respectively[6]. The agar gel diffusion test[6] was used to demonstrate antibodies to the Bluetongue virus.

Blood smears from the dam and the foetus were stained with Giemsa[5]. Foetal tissue impression smears and placental cotyledons were stained with Gimenez and Mecchiavello stains[5]. The foetal tissues and vaginal swabs were cultured for isolation of bacteria using standard methods[6].

**Results**

A total of 598 outbreaks of abortion were reported from 1985 to 1994. The cases were seen in all the years with a mean of 56.3 ± 4.0 abortions per year. The highest number of cases was reported in 1987 (n = 92) (Figure 1).

A mean of 4.6 ± 6.0 cases was reported every month. Most of the cases were reported in the winter to spring months of May to early August (Figure 2).

As depicted in Figure 3, several infectious and non-infectious agents or factors were identified with these abortion storms either directly or indirectly. Antibodies to infectious agents such as *C. psittaci* and *Toxoplasma gondii* were demonstrated in the serum of some of these animals. A heavy parasitaemia of *Anaplasma ovis* was seen both in the dam’s blood smears and from heart blood and impression smears of the spleen, liver and lung of an aborted foetus.
It was interesting to note that Helminthiasis/coccidiosis accounted for as much as 3.0% of the cases (Figure 2). The most outstanding observation was that in the majority of cases, no specific abortifacient agent could be implicated. Some of these outbreaks occurred after spells of very cold weather during autumn and winter months (May to August).

**Discussion**

Outbreaks of abortion in goats were reported every year throughout the ten-year period under study. However, the highest number was recorded in 1987 when the drought was most severe and grazing was poor (Unpublished reports). During this particular period, the cases of abortion could have been due to malnutrition. Scanty and erratic rainfall with subsequent poor grazing result in poor body condition especially in marginalised pregnant does with no supplementary feeding. This exerts stress which inevitably results in the expulsion of the foetus.

The majority of the outbreaks were encountered during stressful winter months when temperatures go below 0°C, coupled with poor grazing and lack of shelter from inclement weather.

Helminthiasis/coccidiosis was associated with a large number of the outbreaks. These endoparasites cause blood loss, anaemia, malabsorption of essential nutrients such as minerals\(^4\) and loss of protein\(^6\). In this study, a lot of these cases had concurrent mineral imbalance, mostly hypophosphataemia. This was more pronounced in cases of haemonchosis. Failure of the foetus to obtain essential nutrients may result in foetal death and/or abortion. Low levels of serum copper, zinc and protein were associated with some of the outbreaks probably sequel to malnutrition.

The role played by low zinc and copper in instigating abortion was not clear. Zinc and copper deficiencies have been known to result in abortion in early pregnancy while hypoproteinaemia-associated abortions may occur throughout the gestation\(^11\).

Antibodies to *Toxoplasma gondii* and *C. psittaci* were found in only a few cases. It was unfortunate that these agents could not be isolated from clinical cases as they have been implicated in abortion storms in some countries\(^17\). It was speculated that infection aggravated by insufficient nutrients could cause stress with subsequent production and release of endogenous steroids. These are known to be very potent abortifacient agents especially in the late gestation\(^2\). It is possible that the same mechanism could have been operative in the case of abortion associated with *A. ovis* parasitaemia. It was therefore assumed that transplacental transmission was partly responsible for the abortion. Transplacental *A. ovis* infections have been shown to cause abortions in Boer goats\(^3\) especially when the dam is stressed.

In most of the abortions, no causal agent was identified. This could have been due to submission of tissues which had deteriorated by the time they were received at the laboratory. This laboratory is the only one that handles veterinary diagnostic samples from the 14 veterinary districts covering an area of 575,000 square kilometres.

Another plausible explanation could be that the placenta and the foetal tissues may be devoured by dogs. As a result, only serum from the dam and vaginal tissues are the only samples available from these cases.

It is imperative that certain recommendations be implemented in order to curb the losses due to abortion in goats. These should include the following:-

(i) Screening breeding herds for reproductive diseases.

(ii) Prophylactic control of internal parasites before the breeding season and subsequent monitoring of the effectiveness of the anthelmintic and coccidiostat by faecal analysis.

(iii) Supplementation with protein and minerals especially during winter and drought.

(iv) Synchronisation of oestrus in order to avoid kidding in winter.

(v) Construction of an effective shelter or provision of warmth for pregnant does in winter. The latter could be done cheaply by
burning cow dung in the kraals on chilly winter nights.

(vi) Improved management practice incorporating research work needs to be done to assess the abortifacient potential of some plants in the country.

Acknowledgments
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References

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ASSESSMENT OF PRACTICAL POTENTIAL OF CASSAVA PEELS MEAL FOR GROWING AND GROWING-FINISHING PIGS IN SUB-HUMID TROPICS

S.A. IKURIOR*, and S.O. ONUH

Department of Animal Production, University of Agriculture, Makurdi, Nigeria and T.S.B. Tegbe, National Animal Production Research Institute, Swine Research Centre, Otukpo, Nigeria.

EVALUATION DU POTENTIEL PRATIQUE DE LA FARINE DES EPLUCHURES DE MANIOC POUR LES PORCS A LA CROISSANCE/EN FINITION SOUS LES TROPIQUES SUB-HUMIDES

Résumé

Une étude en deux phases était menée pour évaluer tout le potentiel de la farine des épluchures de manioc (FEM) dans les programmes d'alimentation pratique du porc. Cinq régimes alimentaires désignés par I, II, III, IV, V étaient formulés et dans lesquels 0, 20, 50, 75 et 100% de maïs étaient respectivement remplacés par la FEM. La phase "une" portait sur 120 porcs croisés Large White, Landrace et Hampshire, sevrés et à l'engraissement, répartis en trois catégories en fonction du poids. Les moyennes des poids vifs étaient 11,36 kg; 19,36 kg et 28,40 kg. Dans chaque catégorie, 8 porcs étaient répartis en groupe de 4 dans 2 lots semblables, pour chacun des tests de régimes alimentaires pendant 35 jours d'essai d'alimentation. Les porcs de la première catégorie (les plus jeunes) consommaient moins (P < 0,05) les quantités journalières du régime alimentaire V qui est proche du régime alimentaire I. Pour toutes les catégories de poids, le gain de poids quotidien diminuait beaucoup (P < 0,05) pour les porcs nourris avec le régime alimentaire V. L'indice de consommation n'était pas significativement (P > 0,05) affecté par les régimes alimentaires même si les régimes contenant les taux les plus élevés de FEM n'étaient pas aussi bien utilisés que chez les témoins. Le coût de l'aliment/kg de gain de poids vif a considérablement diminué (P < 0,05) avec des taux élevés de FEM dans les régimes alimentaires. Ces données montrent que la FEM peut favoriser la performance de croissance des porcs destinés à la vente avec un coût réduit de l'alimentation. Dans la phase deux de l'étude, 40 porcs à la croissance de même type que ceux de la phase une, étaient répartis de la même façon pour le même test de régimes alimentaires. Les porcs étaient nourris jusqu'à environ 60 kg de poids vif quand ils étaient abattus et leurs carcasses caractérisées. La performance était affectée comme dans la phase une. Les mensurations de la carcasse étaient beaucoup (P > 0,05) influencées par les régimes alimentaires même si la graisse dorsale a diminué, tandis que le pourcentage de tissus maigres s'est accru, très légèrement dans les deux cas, au fur et à mesure qu'augmentait la FEM dans les régimes alimentaires. L'utilisation de la FEM semblerait donc importante, en particulier dans les petites exploitations de porcs en finition avec un petit capital dans les régions tropicales sub-humides.

Summary

A two-phase study was conducted to assess the full potential of cassava peels meal (CPM) in practical pig feeding schemes. Five diets designated I, II, III, IV, V were formulated in which 0, 25, 50, 75, 100% of maize were replaced by CPM respectively. Phase one involved 120 crossbred weaner-grower pigs of Large White, Landrace and Hampshire breeds in 3 weight ranks averaging 11,36 kg, 19,36 kg and 28,40 kg liveweight. Within each rank, 8 pigs were allocated in groups of 4 in two replicates, to each of the test diets for a 35-day feeding trial. Pigs of the first rank (the youngest) consumed less (P < .05) daily amounts of diet V relative to diet I. For all the weight ranks, daily gain declined significantly (P < .05) for pigs fed diet V. Feed conversion ratio was not significantly (P > .05) affected by the diets although diets containing the higher levels of CPM were not as well utilised as the control. Feed cost/kg liveweight gain significantly (P < .05) reduced with increased CPM levels in diets. These data show that CPM may support growth performance of market pigs at reduced feeding cost. In phase two of the study, 40 grower pigs of the same type as in phase one were similarly allocated to the same test diets. The pigs were fed to approximately 60 kg

*To whom correspondence should be addressed.
liveweight when they were slaughtered and their carcasses characterised. Performance was affected as in phase one. Carcass measures were not significantly (P > .05) influenced by the diets, although backfat declined, while per cent lean tissue increased, both marginally, as CPM increased in diets. The use of CPM would, therefore, appear to be valuable, especially in smallholder pig-finishing schemes of low capital status within the sub-humid tropical regions.

Introduction

The potential of cassava peels meal (CPM) as an energy source in pig rations has not been as extensively exploited as has cassava whole root meal. This may be due to among, other reasons, the occurrence of higher levels of cyanogenic glucosides, and higher fibre content, in the peels than in the root\(^1,2\). These components have both been associated with reduced growth rates and feed conversion efficiencies in poultry and pigs\(^3\). This notwithstanding, hundreds of tonnes of cassava peels are produced when cassava root is processed for human food in African and other tropical regions of the world. Cassava production is expected to increase globally into the 21st Century because of increased utilisation of cassava chips as an energy source in livestock feeding. Furthermore, the developing tropical countries have continued to experience short supplies of cereal grains and are turning to cassava products as energy sources in mainly non-ruminant animal feeding.

Conflicting results from animals fed diets containing high levels of cassava have been observed to present problems of interpretation\(^4\). For pigs, variable maximum dietary levels of CPM have continued to be recommended\(^1,4,5\). The present study aimed at exploiting more fully the practical feeding value of cassava peels meal for the growing and growing.finishing pigs in a sub-humid tropical environment.

Materials and Methods

Cassava Peels Meal (CPM)

Cassava Peels, the waste product of cassava flour processing, were collected from Makurdi and Otukpo, 150 km south-east of Makurdi, in Benue State, Nigeria. The fresh material was spread on a paved surface and sun-dried for 3 – 4 days during the December – January harmattan season. The dried peels in the separate locations were milled, and sampled for determination of proximate chemical composition\(^6\). The CPM from the two locations were pooled before incorporation into the test diets.

Dietary Treatments

Five diets were formulated: the control (diet I) contained 50% maize grain, while in diets II, III, IV and V, CPM replaced 25, 50, 75 and 100 percentage portions, w/w, of the maize respectively. The diets were balanced to be isocaloric and isonitrogenous, and were fortified with a commercial mineral-vitamin premix. The ingredient composition of the test diets is given in Table 1. The diets were costed (Table 1) using prevailing market prices of the ingredients within and around the locality of the experiment during the period of the study. The proximate chemical composition of the diets was determined\(^6\), and is presented in Table 2.

Experimental Procedure

The study was conducted in two phases, each phase in a different location. It involved a total of 160 crossbred pigs of Large White, Landrace and Hampshire breeds. In the first phase, 120 weaner-grower pigs, in three weight ranks which averaged 11.36 kg, 19.90 kg and 28.40 kg, were fed the test diets for 35 days and their performance measured. Within the respective weight ranks, 8 pigs were allocated in groups of four, and two replicates, to each of the test diets. Each group was housed in concrete-floored pens which measured 2 x 3 m, where the pigs received weighed amounts of the diets daily to appetite, and had water ad libitum. Daily portions of the feed consumed, as well as weekly weights of the pigs, were recorded. Feed conversion ratio was calculated from the average daily feed consumption and average daily gain.
### Table 1. Ingredient composition (kg/tonne) and cost* of the test diets

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Dietary treatment</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
</tr>
<tr>
<td>CPM substitution level (%)</td>
<td>0</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Maize</td>
<td>500.0</td>
<td>375.0</td>
<td>250.0</td>
<td>125.0</td>
<td>-</td>
</tr>
<tr>
<td>Cassava peels meal (CPM)*</td>
<td>-</td>
<td>125.0</td>
<td>250.0</td>
<td>375.0</td>
<td>500.0</td>
</tr>
<tr>
<td>Soyabean meal*</td>
<td>200.00</td>
<td>220.0</td>
<td>240.0</td>
<td>250.0</td>
<td>270.0</td>
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<tr>
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<td>230.0</td>
<td>210.0</td>
<td>200.0</td>
<td>180.0</td>
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<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Mineral-vitamin-premix*</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Salt (NaCl)</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Zinc Oxide*</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Total (kg)</td>
<td>1000.00</td>
<td>1000.00</td>
<td>1000.00</td>
<td>1000.00</td>
<td>1000.00</td>
</tr>
<tr>
<td>Dietary cost (N/t)</td>
<td>6,803.5</td>
<td>6,066.0</td>
<td>5,312.5</td>
<td>4,491.0</td>
<td>3,753.5</td>
</tr>
</tbody>
</table>

*Obtained using ingredient market prices operating in Benue State, Nigeria during the first quarter of 1994, at which period the exchange rate of Nigeria Naira (N) was 22 to 1 U.S. Dollar.

*Prepress solvent-extracted 44% CP meal.

*Containing, per 50 kg: 10 000 00 IU Vitamin A; 1500000 IU Vitamin D3; 3000 IU Vitamin E; 2000 mg pyridoxin; 1500 mg niacin, 25 mg iron; 40 mg folic acid; 10 mg selenium; 300g choline chloride; 8 g vitamin B12; 125 g antioxidant; 80 g manganese; 60 g zinc; 1.2 g iodine; 0.2 g cobalt; containing, per kg: 180 g calcium; 50 g phosphorus; 40 g available phosphorus; 90 g protein; 11 g lysine; 9 g methionine; 30 g salt; 45 g fibre.

*Zinc oxide was added (+) to supply 100 µg g zink

### Table 2. Chemical composition of Test Diets (g/kg DM)

<table>
<thead>
<tr>
<th>Component</th>
<th>Dietary treatments</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
</tr>
<tr>
<td>CPM substitution level (%)</td>
<td>0</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Dry matter</td>
<td>897.9</td>
<td>908.2</td>
<td>910.3</td>
<td>911.5</td>
<td>911.8</td>
</tr>
<tr>
<td>Crude protein (N x 6.25)</td>
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<td>173.1</td>
<td>171.9</td>
<td>170.7</td>
<td>171.0</td>
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<tr>
<td>Crude fibre</td>
<td>44.2</td>
<td>51.3</td>
<td>58.5</td>
<td>68.8</td>
<td>75.9</td>
</tr>
<tr>
<td>Ether extract</td>
<td>40.7</td>
<td>33.3</td>
<td>31.0</td>
<td>22.3</td>
<td>20.1</td>
</tr>
<tr>
<td>Ash</td>
<td>43.5</td>
<td>42.8</td>
<td>44.9</td>
<td>46.0</td>
<td>47.4</td>
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<tr>
<td>NFE</td>
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<td>699.5</td>
<td>693.7</td>
<td>689.2</td>
<td>685.6</td>
</tr>
<tr>
<td>Calcium*</td>
<td>9.8</td>
<td>10.3</td>
<td>10.3</td>
<td>10.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Phosphorus*</td>
<td>6.2</td>
<td>6.2</td>
<td>6.3</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Lysine*</td>
<td>7.5</td>
<td>7.8</td>
<td>8.1</td>
<td>8.1</td>
<td>8.4</td>
</tr>
<tr>
<td>Methionine*</td>
<td>2.6</td>
<td>2.5</td>
<td>2.3</td>
<td>2.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Energy ME* Kcal/kg</td>
<td>3237</td>
<td>3245</td>
<td>3236</td>
<td>3259</td>
<td>3270</td>
</tr>
</tbody>
</table>

*Calculated values
values. Feed cost for each kg body weight gain was obtained as the product of feed conversion value and the cost/kg of the consumed diet.

The second phase of the study involved 40 grower pigs of average liveweight 32.87 kg. The pigs were allocated to the same test diets and in a similar manner as in the first phase within ranks, and were fed the diets until they reached approximately 60 kg liveweight. Performance parameters of the pigs were measured as described in the first phase. The average number of days it took the 8 pigs to reach 60 kg liveweight was recorded for each of the test diets. When pigs reached this weight ± 2 kg, they were feed-starved for 18 hours, then slaughtered and their carcasses characterised using procedures described by Ikurior and Fetuga(7), and modified as in Ikurior et al.(8).

The data were analysed using the single-factor classification design, and means with significant differences were separated using Duncan’s Multiple-Range Test(9).

Results
Performance of the three weight(7) ranks of growing pigs fed the test diets in phase one, is summarised in Table 3. Daily feed consumption was generally not affected by dietary CPM. However, pigs of the first weight rank (11.36 kg average initial weight) consumed significantly less (P<.05) diet V than diet I (control). Daily gain declined as dietary CPM increased, and for the entire weight range of growing pigs studied, replacing all of the dietary maize with CPM significantly depressed (P<.05) daily gain. Feed conversion became progressively reduced, through not significantly (P>.05), with increasing dietary level of CPM, for the three weight ranks of growing pigs.

Performance of the growing-finishing pigs in the second phase of the study (Table 4) was similarly affected by dietary CPM as of the younger pigs in phase one. In phase two, the pigs fed diet V gained 20.31% less weight than those fed the all-maize diet I. In the first phase, similar reductions in daily gain for the first, second and third weight rank pigs were 23.68, 22.92 and 22.81% respectively.

The linear carcass measures and organ weights of the pigs slaughtered at the end of the second phase study were not significantly (P>.5) affected by the diets. Backfat thickness reduced somewhat, while liver and empty stomach weights tended to increase, with increasing amount of CPM in diet. The jointed carcass proportions of the pigs were also not affected (P>.05) by CPM replacements in the diets. However, pigs which consumed diets IV and V had, marginally, higher percentage of lean tissue in their carcasses.

The economic analysis of the study showed that the cost of the test diets (N/tonne) reduced proportionately as the level of CPM increased in the diets (Table 1). For all weight ranks of the growing pigs and the growing-finishing animals, increasing the level of CPM in diets significantly (P<.05) decreased feed cost per kg liveweight gain (Tables 3 and 4). At the 100% substitution, CPM reduced feed cost/kg liveweight gain by 34.70, 34.31, 32.06 and 37.97% in the first, second, third weight ranks and growing-finishing pigs respectively when compared with the maize-based control diet.

Discussion
Some of the earlier workers(1,4,5) who evaluated CPM in non-ruminant animal feeding, recommended varying, and generally lower than 30% dietary inclusion of it for growing pigs. Depressed feed intake, daily gain and feed utilisation were reported for pigs fed higher levels of CPM. Higher crude fibre and ash contents as well as the fluffiness of CPM, have been reported to contribute to the depressed pig performance(10). In the present study, increasing dietary CPM required corresponding increases in soyabean meal proportions to make the diets isonitrogenous. This may have improved the amino acid balance which allowed for relatively unimpeded consumption of the test diets. However, both crude fibre and ash contents increased with increasing CPM level in diets, and may have contributed to the depressed utilisation of especially the higher CPM
### Table 3. Dietary treatments

<table>
<thead>
<tr>
<th>Dietary treatment</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>CPM substitution level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>SE</td>
</tr>
<tr>
<td><strong>Number of pigs</strong></td>
<td>11.36-23.36</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Initial liveweight (kg)</strong></td>
<td>11.03</td>
<td>11.38</td>
<td>11.80</td>
<td>11.72</td>
<td>10.91</td>
<td>0.88NS</td>
</tr>
<tr>
<td><strong>Final liveweight (kg)</strong></td>
<td>24.40*</td>
<td>24.22*</td>
<td>24.00*</td>
<td>23.00*</td>
<td>21.17*</td>
<td>1.34*</td>
</tr>
<tr>
<td><strong>Daily feed consumption (kg)</strong></td>
<td>0.82*</td>
<td>0.82*</td>
<td>0.80*</td>
<td>0.82*</td>
<td>0.17*</td>
<td>0.10*</td>
</tr>
<tr>
<td><strong>Daily gain (kg)</strong></td>
<td>0.38*</td>
<td>0.37*</td>
<td>0.35*</td>
<td>0.32*</td>
<td>0.29*</td>
<td>0.09*</td>
</tr>
<tr>
<td><strong>Feed conversion ratio</strong></td>
<td>2.16</td>
<td>2.22</td>
<td>2.28</td>
<td>2.60</td>
<td>2.56</td>
<td>0.24NS</td>
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<td><strong>Feed cost/Kg LW gain (N)</strong></td>
<td>14.70*</td>
<td>13.47*</td>
<td>12.11b</td>
<td>11.70bc</td>
<td>9.60*</td>
<td>0.69*</td>
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<tr>
<td><strong>19.90-56Kg</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Initial liveweight (kg)</strong></td>
<td>19.80</td>
<td>19.73</td>
<td>20.03</td>
<td>19.97</td>
<td>19.90</td>
<td>0.12NS</td>
</tr>
<tr>
<td><strong>Final liveweight (kg)</strong></td>
<td>36.50*</td>
<td>35.41*</td>
<td>34.59*</td>
<td>3351*</td>
<td>32.80b</td>
<td>1.45*</td>
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<tr>
<td><strong>Daily feed consumption (kg)</strong></td>
<td>0.97</td>
<td>0.97</td>
<td>0.96</td>
<td>0.97</td>
<td>0.92</td>
<td>0.02NS</td>
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<tr>
<td><strong>Daily gain (kg)</strong></td>
<td>0.48*</td>
<td>0.45*</td>
<td>0.42*</td>
<td>0.39*</td>
<td>0.37*</td>
<td>0.05*</td>
</tr>
<tr>
<td><strong>Feed conversion ratio</strong></td>
<td>2.10</td>
<td>2.16</td>
<td>2.30</td>
<td>2.50</td>
<td>2.50</td>
<td>0.20NS</td>
</tr>
<tr>
<td><strong>Feed cost/Kg LW gain (N)</strong></td>
<td>14.28*</td>
<td>13.15b</td>
<td>12.21b</td>
<td>11.23bc</td>
<td>9.38*</td>
<td>0.70*</td>
</tr>
<tr>
<td><strong>19.90-56Kg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial liveweight (kg)</strong></td>
<td>28.58</td>
<td>20.08</td>
<td>28.35</td>
<td>28.10</td>
<td>28.90</td>
<td>0.35NS</td>
</tr>
<tr>
<td><strong>Final liveweight (kg)</strong></td>
<td>48.60*</td>
<td>46.78*</td>
<td>45.10*</td>
<td>45.00*</td>
<td>44.40b</td>
<td>1.71*</td>
</tr>
<tr>
<td><strong>Daily feed consumption (kg)</strong></td>
<td>1.44</td>
<td>1.44</td>
<td>1.40</td>
<td>1.40</td>
<td>1.36</td>
<td>0.08NS</td>
</tr>
<tr>
<td><strong>Daily gain (kg)</strong></td>
<td>0.57*</td>
<td>0.54*</td>
<td>0.48*</td>
<td>0.48*</td>
<td>0.44*</td>
<td>0.11*</td>
</tr>
<tr>
<td><strong>Feed conversion ratio</strong></td>
<td>2.50</td>
<td>2.65</td>
<td>2.91</td>
<td>2.91</td>
<td>3.08</td>
<td>0.32NS</td>
</tr>
<tr>
<td><strong>Feed cost/Kg LW gain (N)</strong></td>
<td>17.00</td>
<td>16.09*</td>
<td>15.45*</td>
<td>13.07*</td>
<td>11.55*</td>
<td>0.82*</td>
</tr>
</tbody>
</table>

*The same number applies to all the weight ranks; NS = not significant (P > .05)

*Significant differences between means in rows (P<.05)

a,b,c, ab,c, abcMeans within rows with different superscripts differ (P<.05)

### Table 4. Effect of substituting cassava peels meal for maize in diets on performance of growing-finishing pigs

<table>
<thead>
<tr>
<th>Component</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>SE</th>
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<tr>
<td><strong>Dietary treatments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CPM substitution level (%)</strong></td>
<td>0</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Number of pigs</strong></td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Initial liveweight (kg)</strong></td>
<td>32.70</td>
<td>32.88</td>
<td>32.94</td>
<td>32.85</td>
<td>32.90</td>
<td>0.14NS</td>
</tr>
<tr>
<td><strong>Final liveweight (kg)</strong></td>
<td>61.02</td>
<td>60.85</td>
<td>60.85</td>
<td>61.10</td>
<td>60.48</td>
<td>0.24NS</td>
</tr>
<tr>
<td><strong>Daily feed consumption (kg)</strong></td>
<td>2.17</td>
<td>2.21</td>
<td>2.18</td>
<td>2.08</td>
<td>2.10</td>
<td>0.06NS</td>
</tr>
<tr>
<td><strong>Daily gain (kg)</strong></td>
<td>0.64a</td>
<td>0.62a</td>
<td>0.60ab</td>
<td>0.56bc</td>
<td>0.51c</td>
<td>0.05*</td>
</tr>
<tr>
<td><strong>Feed conversion ratio</strong></td>
<td>3.36</td>
<td>3.58</td>
<td>3.62</td>
<td>3.71</td>
<td>3.78</td>
<td>0.16NS</td>
</tr>
<tr>
<td><strong>Feed cost/Kg LW gain (N)</strong></td>
<td>22.86a</td>
<td>21.72a</td>
<td>19.23ab</td>
<td>16.66bc</td>
<td>14.18</td>
<td>3.60*</td>
</tr>
<tr>
<td><strong>Number of days fed</strong></td>
<td>44.20c</td>
<td>45.00c</td>
<td>46.40bc</td>
<td>50.82ab</td>
<td>54.08a</td>
<td>4.35*</td>
</tr>
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</table>

NS = Not significant

*Significant differences between means in rows (P<.05)

a,b,c, ab,c, abcMeans within rows with different superscripts differ (P<.05)
diets with consequent reduced daily gain of pigs. As the pigs grew older, they appeared somewhat better able to utilise higher levels of CPM in diets, and this agrees with earlier findings.(10,11)

Characterisation of carcasses of pigs fed different levels of CP in diets revealed no adverse effects traceable to diets. The somewhat leaner carcasses of the lower growing pigs fed the 75% and 100% CPM substitution diets conformed with normal physiological responses of pigs to the growth process.(12) The observed trend in liver weight may have been a consequence of increased activity of the organ in detoxifying the residual HCN ingested in the diets containing higher CPM levels. The HCN content of the CPM evaluated was not determined, since it was thought not to pose any problem to the pigs. Reports(13,14) show that cassava peeling processes coupled with sun-drying the peels for 3–4 days eliminate up to 98% of HCN contained in the fresh material. Furthermore, if diets are adequate in protein and iodine, HCN as is present in cassava has little effect on the health of pigs.(14) The crude fibre content of the test diets containing higher levels of CPM may have been causative to the increased weight of the empty stomach pigs. Such weight increase has been regarded as an adaptive feature for the pigs to cope with the larger bulk in the high fibre diets.(15)

In practical terms, substitution of CPM for maize in diets depressed weight gain of growing pigs. Pigs fed the all maize control diet reached the slaughter weight 10 days earlier than those fed the all CPM diet. On the other hand, CPM substitution significantly reduced feed cost of each kg liveweight gained by pigs, with the all CPM diet effecting 38% lower such cost than the control. No health problems were observed with the pigs and those fed the higher levels of CPM had slightly higher percentages of lean in the carcasses. Cassava peels meal would thus, appear to have the potential as energy feed for growing and growing-finishing pigs in the sub-humid tropics. For the time being in Nigeria, CPM is priced only in as much as its collection, sun-drying and handling costs are concerned. Should the wide use of the material attract pricing as is often the case, such pricing is expected to be only a fraction of maize price, because CPM is, and will remain, a waste product of cassava root processing for various products usable by man.

Acknowledgement

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Reference


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DISEASES OF CHICKENS IN BOTSWANA, 1985 TO 1994

BINTA, M.G., MUSHI, E.Z., ADOM, E.K. and DITEKO, T.*
National Veterinary Laboratory, Private Bag 0035, Gaborone, Botswana

MALADIE DES POULETS AU BOTSWANA POUR LA PERIODE 1985-1994

Résumé

Une étude rétrospective sur une période de dix ans portant sur 3.718 cas aviaires chez des races locales et exotiques, a été conduite au Laboratoire vétérinaire national de Gaborone au Botswana. Il s'agit de l'unique laboratoire vétérinaire de diagnostic, qui examine les échantillons provenant des divers services vétérinaires dans le pays.

Les principales et les plus fréquentes causes de mortalité étaient: la colisepticémie (12,3%); la péritonite de l’œuf (9,6%); la maladie de Newcastle (6,3%); les parasites internes (4%); les problèmes nutritionnels (tels que les carences en substances nutritives) (3,3%); la salmonellose (3%) et les ectoparasites: les poux, les tiques, les acariens (2,1%).

Summary

A ten-year retrospective study of 3718 avian cases both from indigenous and exotic breeds of chickens was made at the National Veterinary Laboratory, Gaborone, Botswana. This is the only diagnostic veterinary laboratory handling specimens from the various veterinary districts in the country.

The commonest and major causes of mortality were Colisepticaemia 12.3%; Egg peritonitis 9.6%; Newcastle Disease (NCD) 6.3%; Internal parasites 4%; Nutritional problems (such as deficiencies) 3.3%; Salmonellosis 3% and Ectoparasites (lice, ticks, mites) 2.1%

Introduction

The past decade has seen rapid expansion of the poultry industry not only in the commercial broiler and layer operations but also backyard holdings rearing indigenous chickens. Backyard chickens are a source of meat and eggs for domestic consumption only. These are often in flocks of 10 – 20 birds. Indigenous chickens are not as frequently vaccinated as the exotic breeds reared on commercial farms. The fact that the indigenous backyard flocks are free ranging makes them not only carriers of diseases such as Newcastle Diseases (NCD) but also makes them vulnerable to NCD and IBD as was mentioned. The free ranging system of managing backyard chickens may predispose them to both external parasites and helminthiasis.

The study was conducted in order to further elucidate the epidemiology of diseases affecting indigenous backyard and exotic breeds of chickens in Botswana. There is need to increase awareness about the disease situation and the control measures to be instituted. Hitherto, only the epidemiology of individual diseases has been alluded to.

Materials and Methods

A ten-year study (January 1985 to December 1994) of diseases of indigenous and exotic breeds of chickens in Botswana was conducted at the National Veterinary Laboratory, Gaborone.

All the chickens were submitted to the laboratory from the fourteen veterinary districts of the country for confirmatory diagnosis. In addition, serum collected from exotic breeds of chickens from three commercial farms was screened for antibodies to (NCD) virus in the haemagglutination inhibition test and to Infectious Bursal Disease using the Elisa test (Flock test).

Postmortem examinations were conducted.
on dead birds and relevant tissues taken for microbiological and parasitological assessment.

The diseases were studied based on aetiology, age and season of occurrence.

The age groups were arbitrarily divided into:
(i) Adult over 150 days
(ii) Growers 42 to 150 days
(iii) Chicks day old to 42 days

The seasonal distribution of the cases during autumn (April to May), winter (June to July), spring (August to September) and summer (October to January) months was studied.

Winter months are cold and dry. The rains are usually expected during the spring and summer months.

Results
A total of 3718 cases were handled during the period between 1985 and 1994. The commonest causes of death were colisepticaemia, egg peritonitis sequel to obstructed oviduct, NCD, nutritional deficiencies mainly Vitamin B and A, starvation, obesity, and endoparasitism. The mortality was highest in the chicks and the grower group.

Infections with IBD disease predisposed the chickens also to Staphylococcus aureus septicaemia, Mycoplasma spp. and Salmonella spp infections. Concurrent infections were more common during the cold winter months (May to July).

Newcastle Disease virus infection was more common in indigenous backyard flocks holding involving 10 to 20 chickens than in the exotic type of breeds. The incidence of the major diseases was highest in 1988 and lowest in 1991 (see Figure 1). However, subsequently isolated outbreaks in exotic breeds have been reported. Whenever the NCD cases occurred in the exotic breeds (growers and adults) it was concurrent with or a sequel to IBD. The latter was reported in exotic broiler breeds aged between 3 and 6 weeks. It was not unusual to recover Staph. aureus and Mycoplasma spp. from these cases in the same chicken.

On the other hand, colisepticaemia was found to be more of a problem of intensively managed commercial units than free ranging, slow maturing indigenous chickens. Peak incidence of this disease were reported under conditions of extreme hot or cold. It was often associated with concurrent Mycoplasmosis.

Egg peritonitis was a problem in the intensively managed commercial layers and rarely a problem of free ranging indigenous chickens. The inflammation was sequel to obstructed oviduct. Peak incidence of the condition was noted during both extreme cold winters and the hot summers, characteristic of this country.

The commonest nutritional problems were starvation, obesity, mineral deficiencies mainly of calcium and phosphorus, and Vitamin B and Vitamin A deficiency. The latter vitamin deficiencies were less commonly reported in the commercially raised chickens.

Endoparasitism included helminthiasis and to a minor extent, coccidiosis. The commonest helminths were Ascaridia gallinae, tetramerines and Rairellina echinobothrida exclusively found in indigenous free ranging chickens only. There were no cases of helminthiasis reported in exotic birds even when kept in deep litter. While outbreaks of coccidiosis were reported between 1985 to 1988, very few were reported in both the indigenous and exotic breeds of chickens after this period.
External parasitism was a problem of only indigenous chickens. Lice (*Linognathus* spp.), mites, especially the scaly leg mite (*Khexidocotes mutans*), soft ticks (*Argus persicus*) and fleas were the commonest ectoparasites.

Infestation with mites often concurrent with helminthiasis especially tetrameres was more frequently encountered in indigenous backyard chickens than in intensively managed flocks of exotic birds. Ectoparasitism and endoparasitism showed no seasonal incidence.

*Salmonella* spp. infections were often traced to the hatchery as the source of infection for day-old chicks. Latent infections in such chickens often flared up after transportation as a result of stress.

Noteworthy was the septicaemia caused by *Staphylococcus aureus* which often concurred with *Mycoplasma* spp. infections both of which were a sequel to IBD.

Other conditions encountered were pullorum disease, fowl typhoid, Marek’s disease, Avian leukosis, fowl pox, cannibalism, waterbelly, ruptured liver and subcutaneous emphysema. Spirochaetosis and neoplasms other than Avian leukosis tumours were rare (See Figure 2).

### Figure 2: Other poultry diseases in Botswana

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fowl typhoid</td>
<td>30</td>
</tr>
<tr>
<td>External parasites</td>
<td>20</td>
</tr>
<tr>
<td><em>Argus persicus</em></td>
<td>10</td>
</tr>
<tr>
<td>Water belly</td>
<td>50</td>
</tr>
<tr>
<td>Marek’s Disease</td>
<td>40</td>
</tr>
<tr>
<td>Avian leukosis</td>
<td>50</td>
</tr>
<tr>
<td>Fowl Pox</td>
<td>60</td>
</tr>
<tr>
<td>Gumboro Disease</td>
<td>70</td>
</tr>
</tbody>
</table>

### Discussion

This study showed that colisepticaemia, egg peritonitis, Newcastle Disease, nutritional deficiencies, helminthiasis, ectoparasites and Salmonellosis were the most important disease conditions of indigenous and exotic chickens in Botswana.

It also showed frequent concurrence of the bacterial and viral conditions with IBD. Helminthosis with ectoparasitism were more frequently encountered in indigenous backyard chickens than in intensively managed breeds of chickens.

Newcastle Disease was found to be the most important viral disease of local or indigenous birds. Observations in this study were that NCD occurred in the warm spring months of August to November. This concurred with the observations of some authors that outbreaks occurred in susceptible populations of indigenous chickens which were not frequently vaccinated. The immunosuppressive effects of IBD which could have made chickens more vulnerable are well documented.

Colisepticaemia was found to be the commonest disease of commercial exotic birds especially the broilers aged between 2 and 8 weeks. The disease was not frequently encountered in free ranging indigenous breeds. This was contrary to what was found in the study conducted on indigenous Nigerian chickens. A possible explanation for this may be poor sanitation in the intensively managed poultry holdings.

### Acknowledgments

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### References


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EFFECT OF GRADED LEVELS OF DRIED RUMEN INGESTA ON THE PERFORMANCE OF GROWING RABBITS FED CONCENTRATE DIETS

D.B. OLUKEYAN, S.B. AFOYAYA and G.S. BAWA
Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria.
College of Agriculture, Ahmadu Bello University, Samaru - Zaria.

EFFETS DES NIVEAUX CROISSANTS D'INGESTA DE RUMEN SECHES SUR LA PERFORMANCE DES LAPINS A LA CROISSANCE NOURRIS DE REGIMES ALIMENTAIRES BASES SUR DES CONCENTRES

Résumé

Vingt-cinq lapins à la croissance de races croisées et ayant un poids initial moyen de 791 g (variations entre 790 - 794 g) étaient utilisés pour évaluer l'effet de l'alimentation avec des niveaux croissants d’ingesta de rumen séchés (IRS) sur leur performance. Les animaux étaient soumis au hasard à cinq traitements sur la base du poids initial et du sexe. Il y avait cinq lapins par traitement, ils étaient logés individuellement pendant toute la période expérimentale de 42 jours. IRS étaient utilisés à 0; 6; 12; 16 et 20% pour remplacer le maïs dans un régime contenant 17% PB. L’eau et l’aliment étaient servis ad libitum. Les performances des animaux étaient suivies en termes de consommation alimentaire, de changements des poids vifs et d’efficience alimentaire. À la fin de l'expérience, deux lapins par traitement étaient abattus et les données sur la carcasse recueillies.

La moyenne de la consommation alimentaire/jour, le gain moyen quotidien (GMQ) et l'efficience alimentaire (EA) n’ont pas indiqué de différences significatives (P > 0,05) pour les cinq traitements au régime alimentaire. Cependant, les lapins qui ont reçu 12% d’IRS, avaient une meilleure performance en termes de gain pondéral et d’efficience alimentaire, comparé aux animaux soumis aux autres traitements. Le poids de la carcasse, les organes et autres parties du corps n’étaient pas beaucoup affectés (P > 0,05) par les niveaux d’IRS dans le régime. Il a été conclu que les IRS peuvent remplacer le maïs dans les régimes alimentaires des lapins à la croissance jusqu’à un niveau de 20% sans aucun effet néfaste sur la performance. Toutefois, on peut obtenir une performance maximale au niveau d’incorporation de 12% d’IRS. Dans la présente étude, l’utilisation des ingesta de rumen séchés a permis de faire des économies sur les coûts des aliments.

Summary

Twenty-five growing rabbits of mixed breeds and of an average initial weight of 791.0g (range, 790-794.0g) were used to evaluate the effect of feeding graded levels of dried rumen ingesta (DRI) on their performance. Animals were randomly assigned to five treatments based on initial weight and sex. There were five rabbits per treatment and were housed individually throughout the 42-day experimental period. Dried rumen ingesta was fed at 0, 8,12,16 and 20% levels to replace maize in a 17% CP diet. Water and feed were offered ad libitum. Performances of the animals were monitored in terms of feed intake, body weight changes and feed conversion efficiency. At the end of the experiment, two rabbits per treatment were slaughtered and carcass data collected.

Average daily feed intake, average daily gain (ADG) and feed conversion efficiency (FCE) showed no significant differences (P > 0.05) among the dietary treatment. Rabbits on the 12% DRI level of inclusion, however, performed better in terms of weight gain and feed conversion efficiency when compared to animals on other treatments. Weight of carcasses, organs and body parts were not significantly affected (P > 0.05) by dietary DRI levels. It was concluded that DRI could replace maize in growing rabbit diets up to 20% without any adverse effects on performance. Optimum performance may, however, be achieved when replacement is at 12% level. The use of dried rumen ingesta in the present study resulted in savings of feed cost.
Introduction

In most developing countries, the production of cereal and oil seed grains is very low and does not satisfy the demand for human consumption. The possibility of having surpluses for livestock production has earlier been in doubt\(^{(5)}\). It has, therefore, become imperative to look for alternative feed sources that are not consumed by man and are enough to substitute for the conventional ones. One of the non-conventional and locally available feedstuffs whose nutritional value is at present being studied is rumen ingesta. It is a by-product of abattoir processing of ruminants and obtained by cleaning out the gut of slaughtered animals. With increasing urbanisation and development of modern abattoirs in Nigeria, rumen ingesta has now become a major bulk of animal waste and environmental pollution. It also provides niches for various parasites and their intermediate hosts. Therefore, the possibility of its inclusion in livestock diets will change this potential source of pollution into a valuable source of feed.

Rumen ingesta contains appreciable proportions of energy and crude protein\(^{(6)}\) and could, therefore, serve as a substitute for them in livestock diets. It is fibrous, which could be an added advantage to the rabbits as they require quite a high proportion of fibre in their diets to minimise enteritis\(^{(5)}\). Earlier work\(^{(4)}\) has shown that dry rumen ingesta could replace poultry grower’s mash up to 40% and still meet the rabbits growth requirements. Information on the use of rumen ingesta in rabbit diets especially in the tropics, is limited.

The objective of this study was to evaluate the effects of graded levels of dried rumen ingesta as a replacement of maize in rations of growing rabbits.

Materials and Methods

Twenty-five growing rabbits of mixed breed with an average initial weight of 791.0 g (range, 790 – 794.0 g) and 10 weeks old were fed the same diet for an initial two-week adjustment period. After the adjustment period, they were ear-tagged and inspected for good health. They were then weighed and randomly allotted to five treatments on the basis of their initial weight and sex. The rabbits were randomly assigned individually to wire cages (40 x 40 x 60 cm) of a three-tier arrangement with feeders, waterers and faecal collection trays. There were five rabbits per treatment. The treatments consisted of a basic grower’s diet with 17% crude protein (control). The maize in the control diet was replaced by dried rumen ingesta at 8%, 12% 16% and 20% on a weight for weight basis (Table 2). The rabbits were individually fed with weighed quantities of feed twice daily at 08.00 and 16.00 hours and had unrestricted access to water. Refused or wasted feed was collected daily, air-dried and weighed. Rabbits were weighed weekly and feed intake, live-weight and feed intake per unit weight gain were determined. The experiment lasted for 42 days. At the end of the feed trial, two rabbits per treatment were selected on the basis of average pen weight and slaughtered. Their hot carcasses, internal organs and other body parts were weighed. Proximate chemical analysis of DRI,

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CP</th>
<th>CF</th>
<th>EE</th>
<th>ASH</th>
<th>Ca</th>
<th>P</th>
<th>Na</th>
<th>C</th>
<th>MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried Rumen Ingesta</td>
<td>9</td>
<td>40.50</td>
<td>2.39</td>
<td>2.39</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.68</td>
</tr>
<tr>
<td>Maize</td>
<td>9</td>
<td>2.7</td>
<td>4.0</td>
<td>1.3</td>
<td>0.02</td>
<td>0.29</td>
<td>-</td>
<td>-</td>
<td>14.36</td>
</tr>
<tr>
<td>Soyabean (Roasted)</td>
<td>38</td>
<td>5</td>
<td>18</td>
<td>4.6</td>
<td>0.25</td>
<td>0.59</td>
<td>-</td>
<td>-</td>
<td>13.81</td>
</tr>
<tr>
<td>Wheat offl</td>
<td>15</td>
<td>11</td>
<td>5.14</td>
<td>6.4</td>
<td>0.14</td>
<td>1.2</td>
<td>-</td>
<td>-</td>
<td>7.83</td>
</tr>
<tr>
<td>Blood Meal</td>
<td>80</td>
<td>1.0</td>
<td>1.0</td>
<td>4.4</td>
<td>0.28</td>
<td>0.22</td>
<td>0.32</td>
<td>0.30</td>
<td>12.89</td>
</tr>
<tr>
<td>Bone Meal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36</td>
<td>16.82</td>
<td>0.46</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lime Stone</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>38</td>
<td>0.02</td>
<td>0.06</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Salt (NaCl)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>39.34</td>
<td>60.66</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
maize, soyabean (full-fat), wheat offal and blood meal used in the experiment were carried out in accordance with A.O.A.C\(^{(6)}\) methods. These values (Table 1) were used in calculating the dietary chemical values reported in Table 2.

Data obtained from the study were analysed using analysis of variance (ANOVA) technique\(^{(6)}\) and treatment differences (P < 0.05) were determined by Duncan’s multiple range test\(^{(7)}\).

### Table 2: Percentage Composition Of Diets

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>I (CONTROL)</th>
<th>II (8% DRI)</th>
<th>III (12% DRI)</th>
<th>IV (16% DRI)</th>
<th>V (20% DRI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>50.04</td>
<td>42.04</td>
<td>38.04</td>
<td>34.04</td>
<td>30.04</td>
</tr>
<tr>
<td>Soyabean (Roasted)</td>
<td>17.74</td>
<td>17.74</td>
<td>17.74</td>
<td>17.74</td>
<td>17.74</td>
</tr>
<tr>
<td>Dried Rumen Ingesta (DR^)</td>
<td>0</td>
<td>8.0</td>
<td>12.0</td>
<td>16.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Wheat Offal</td>
<td>25.02</td>
<td>25.02</td>
<td>25.02</td>
<td>25.02</td>
<td>25.02</td>
</tr>
<tr>
<td>Blood Meal</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Bone Meal</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Lime Stone</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Salt</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vitamin Mineral Mix(^*)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

#### Calculated Analysis

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein %</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Crude Fibre %</td>
<td>4.77</td>
<td>7.79</td>
<td>9.30</td>
<td>10.81</td>
<td>12.33</td>
</tr>
<tr>
<td>Ether Extract %</td>
<td>6.51</td>
<td>6.38</td>
<td>6.31</td>
<td>6.25</td>
<td>6.18</td>
</tr>
<tr>
<td>Ash %</td>
<td>3.18</td>
<td>4.12</td>
<td>4.60</td>
<td>5.07</td>
<td>5.54</td>
</tr>
<tr>
<td>Energy (Mekcal/Kg)</td>
<td>2848</td>
<td>2643</td>
<td>2541</td>
<td>2439</td>
<td>2337</td>
</tr>
<tr>
<td>Cost/Kg Diet (N)</td>
<td>0.55</td>
<td>0.51</td>
<td>0.50</td>
<td>0.48</td>
<td>0.46</td>
</tr>
</tbody>
</table>

*Y: Contains Per Kg: 8,000 IU Vit A; 1,500,000 IU Vit. D\(_3\); 3,000 IU Vit. E; 3.0g Vit. K; 5.0mg Iron; 10.0g Manganese; 0.20g Copper; 4.5g Zinc; 0.15g Iodine; 0.02 cobalt; 0.01g Selenium.*

### Table 3: Performance of growing rabbits fed graded levels of dried rumen ingesta (D.R.I)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>I (CONTROL)</th>
<th>II (8% DRI)</th>
<th>III (12% DRI)</th>
<th>IV (16% DRI)</th>
<th>V (20% DRI)</th>
<th>SEM</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial body weight (g)</td>
<td>790</td>
<td>790</td>
<td>792</td>
<td>796</td>
<td>794</td>
<td>98.50</td>
<td>NS</td>
</tr>
<tr>
<td>Final body weight (g)</td>
<td>1290</td>
<td>1455</td>
<td>1343</td>
<td>1305</td>
<td>1425</td>
<td>106.60</td>
<td>NS</td>
</tr>
<tr>
<td>Daily feed intake (g/day)</td>
<td>45.4</td>
<td>52.5</td>
<td>51.7</td>
<td>49.3</td>
<td>55.1</td>
<td>5.60</td>
<td>NS</td>
</tr>
<tr>
<td>Daily weight gain (g/day)</td>
<td>14.36</td>
<td>16.30</td>
<td>17.86</td>
<td>16.36</td>
<td>15.46</td>
<td>2.70</td>
<td>NS</td>
</tr>
<tr>
<td>Feed Conversion Efficiency</td>
<td>3.45</td>
<td>3.23</td>
<td>2.96</td>
<td>3.11</td>
<td>3.52</td>
<td>0.40</td>
<td>NS</td>
</tr>
</tbody>
</table>

S.E.M. = Standard Error of Differences of Means  
N.S. = Not Significant (P > 0.05)
Table 4. Weight of parts and organs of growing rabbits fed graded level of dried rumen ingesta (D.R.I.)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CONTROL</th>
<th>8%DRI</th>
<th>12%DRI</th>
<th>16%DRI</th>
<th>20%DRI</th>
<th>SEM</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slaughter wt. (g)</td>
<td>1290</td>
<td>1455</td>
<td>1343</td>
<td>1305</td>
<td>1425</td>
<td>106.60</td>
<td>NS</td>
</tr>
<tr>
<td>Carcass wt. (g)</td>
<td>644</td>
<td>730</td>
<td>687</td>
<td>679</td>
<td>685</td>
<td>3.94</td>
<td>NS</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>49.75</td>
<td>50.22</td>
<td>51.21</td>
<td>52.06</td>
<td>48.03</td>
<td>2.91</td>
<td>NS</td>
</tr>
<tr>
<td>Liver %</td>
<td>4.20</td>
<td>3.57</td>
<td>3.50</td>
<td>2.99</td>
<td>3.22</td>
<td>0.42</td>
<td>NS</td>
</tr>
<tr>
<td>Kidneys %</td>
<td>0.89</td>
<td>0.76</td>
<td>0.86</td>
<td>0.73</td>
<td>0.78</td>
<td>0.10</td>
<td>NS</td>
</tr>
<tr>
<td>Heart %</td>
<td>0.46</td>
<td>0.34</td>
<td>0.37</td>
<td>0.35</td>
<td>0.35</td>
<td>0.14</td>
<td>NS</td>
</tr>
<tr>
<td>Lungs %</td>
<td>1.03</td>
<td>0.62</td>
<td>0.56</td>
<td>0.84</td>
<td>0.70</td>
<td>0.18</td>
<td>NS</td>
</tr>
<tr>
<td>Spleen %</td>
<td>0.11</td>
<td>0.07</td>
<td>0.07</td>
<td>0.12</td>
<td>0.07</td>
<td>0.04</td>
<td>NS</td>
</tr>
<tr>
<td>Head %</td>
<td>10.02</td>
<td>9.97</td>
<td>10.18</td>
<td>9.57</td>
<td>9.35</td>
<td>0.98</td>
<td>NS</td>
</tr>
<tr>
<td>Empty gut %</td>
<td>8.83</td>
<td>8.01</td>
<td>7.94</td>
<td>7.97</td>
<td>9.68</td>
<td>1.82</td>
<td>NS</td>
</tr>
<tr>
<td>Skin, Limbs &amp; tail %</td>
<td>12.11</td>
<td>12.78</td>
<td>11.39</td>
<td>11.97</td>
<td>12.26</td>
<td>1.49</td>
<td>NS</td>
</tr>
<tr>
<td>Slaughter loss %*</td>
<td>12.60</td>
<td>13.87</td>
<td>13.39</td>
<td>13.41</td>
<td>15.56</td>
<td>4.51</td>
<td>NS</td>
</tr>
</tbody>
</table>

S.E.M. = Standard Error of Differences of Means
N.S. = Not Significant (P > 0.05)

Results

Table 3 gives the summary of the performances of the rabbits fed the tested diets. Average daily feed intake showed no significant differences (P > 0.05) among treatment means. Average daily weight gain was statistically comparable across the treatments (P > 0.05). Growth rates increased up to 12% DRI level of inclusion and then started declining. The efficiency of feed conversion (feed : gain) by rabbits on the different treatments was not significantly different (P > 0.05). However, a slight improvement was obtained for the 12% DRI level of inclusion. The cost of feed per kg diet decreased as the level of DRI increased in the diets. There was, however, no significant differences among the treatment means (P > 0.05).

Data on carcass characteristics, weight of various organs and other body parts are presented in Table 4. No significant differences (P > 0.05) existed in the proportions and weights of various organs.

Discussion

The results of feed intake are in agreement with previous findings where it was reported that feed intake increased by 7, 12, and 15% for diets containing 10, 20 and 30% sun-dried rumen content (SDRC) over the control (0% SDRC) although the results were not statistically significant. Growing rabbits had been shown to maintain constant energy intake. The substitution of dried rumen ingesta for maize in diets of rabbits in the present study consistently lowered the metabolisable energy concentration. It is, therefore, possible that more of the DRI diets were consumed by the rabbits compared to the 0% DRI so as to meet their energy requirements. This observation is in support of an earlier work in which diets rich in energy were consumed less per unit body weight than diets low in energy.

The average daily gain results showed that although not statistically significant, rabbits on the 12% DRI performed better than those on the 0, 8, 16 and 20% levels. Earlier reports have
shown that the best performance in terms of growth in 6 to 12 week-old rabbits was obtained on a diet containing 8 - 9% crude fibre when compared with higher or lower fibre levels\(^{10}\). In the present study, 12% DRI had 9.3% crude fibre and the rabbits were 10 weeks old. Reduced growth rate in young rabbits was observed when the energy level of the ration fell below 10 - 15 MJ/kg\(^{11}\). The 16 and 20% DRI diets in the present study had 10.2 and 9.8 MJ/kg respectively. The slight drop in weight gain of the rabbits on these diets compared to those fed 12% DRI diet (with 10.6 MJ/kg) could be due to the difference in their energy levels which was below 10.5 MJ/kg reported\(^{11}\). The ADG values were generally lower than normal, but conformed with the general trend in developing countries\(^{12,13,14,15}\).

The feed conversion efficiency (FCE) followed the same trend with the ADG results. Rabbits fed the 12% DRI diet were slightly more efficient than those fed the 0, 8, 16 and 20% DRI diets. The FCE result obtained in the present study is in agreement with previous findings\(^{8,16}\) where it was shown that there was a decline in feed conversion efficiency when diets containing crude fibre levels above 8 - 9% and energy levels below 10.5 MJ/kg were fed to rabbits of 8 to 12 weeks of age.

The cost per kg of diets generally decreased as the level of DRI increased in the diets (Table 2). This implies that the use of DRI in rabbit diets on a large scale may result in cost savings.

There was no mortality of any of the experimental animals within the period of the experiment. This suggests that using DRI up to the highest level of inclusion (20% DRI) in the present study may not have deleterious effects on the health of the animals. It is worth mentioning that animals on 0 and 8% DRI exhibited signs of mucoid enteritis at the fourth week of the experiment. A postmortem report showed that \textit{Escherichia coli}, a causative organism for enteritis in rabbits, were present in the liver of these animals. The low level of fibre in the 0 and 8% DRI diets could be another possible cause of the enteritis\(^{13}\).

Dried rumen ingesta (DRI) had no significant (P > 0.05) effect on carcass measurements. This is in agreement with earlier findings\(^{3,17}\).

Our results suggest that DRI could be included in growing rabbit diets up to 20% level without any adverse effects on their performance. Optimum performance may, however, be achieved when replacement is at the 12% level.

Acknowledgment

The authors wish to express appreciation to Mr. Tope Joel who assisted in the management of the experimental animals and data collection.

References

EVALUATION DE LA PREFERENCE POUR LES PLANTES A BROTHER CHEZ LES MOUTONS ET LES CHEVRES DANS LA ZONE DE SAVANE GUINEENNE DU NORD DU GHANA

Résumé
Vingt-huit moutons Djallonké et douze chèvres naïnes de l’Afrique de l’Ouest étaient utilisés dans une expérimentation, qui consiste en une technique d’alimentation, type de la cafétéria, pour étudier la préférence des moutons et des chèvres pour quatre espèces de plantes à brouter nouvellement coupées, à savoir: Leucaena leucocephala, Gliricidia seplum, Cajanus cajan et Seabania seeban, que l’on trouve à la Station d’expérience agricole de Nyankpala et à l’Institut de recherche sur l’élevage, également à Nyankpala, dans la région Nord du Ghana. Les animaux étaient examinés individuellement et en groupes.

La préférence pour les fourrages chez les moutons Djallonké était dans l’ordre suivant: Cajanus > Leucaena > Seabania > Gliricidia, tandis que l’ordre de préférence chez les chèvres naïnes était comme suit: Leucaena > Cajanus > Seabania > Gliricidia. On a observé que le nombre d’animaux par unité de temps, qui consommaient leur fourrage préféré était beaucoup plus élevé (4,2) chez les moutons avec Cajanus que chez les chèvres (1,5) avec Leucaena. Les bagarres ou les bruits de groupe (comportement antagonique) lors de l’alimentation étaient plus fréquents chez les chèvres que chez les moutons et avaient pour conséquence la valeur comparativement faible enregistrée.

On a constaté que les plantes à brouter utilisées dans cette étude contenaient des niveaux assez élevés de protéines et de minéraux sur la base de la matière sèche (MS): protéine brute (8,68 – 28,26%), calcium (0,62 – 1,89%), magnésium (0,027 – 0,063%), phoshphore (1,31 – 1,88%), manganèse (68 – 283 mg/kg), zinc (7 – 36 mg/kg), cuivre (3 – 36 mg/kg) et fer (139 – 1106 mg/kg). S’ils sont disponibles, ces fourrages peuvent fournir des protéines supplémentaires aux aliments ainsi que des minéraux dont les moutons et les chèvres ont besoin.

Summary
Twenty-eight Djallonke sheep and twelve West African Dwarf goats were used in a cafeteria type experiment to study the preference of sheep and goats to four freshly cut browse species, viz. Leucaena leucocephala, Gliricidia seplum, Cajanus cajan and Seabania seeban established at the Nyankpala Agricultural Experimental Station (NAES) and the Animal Research Institute, both of Nyankpala, Northern Region, Ghana. Animals were studied individually and in groups.

Forage preferability by Djallonke sheep was in the order of Cajanus > Leucaena > Seabania > Gliricidia, while the preference order by Dwarf goats was Leucaena > Cajanus > Seabania > Gliricidia. Animal count per unit time at their most preferred forage site was observed to be more (4.2) for sheep at Cajanus than for goats (1.5) at the Leucaena site. Fighting or group disturbance (agonistic behaviour) at feeding was observed to be dominant with goats and not in sheep and accounted for the comparatively low value recorded.
The browse plants used in the study were found to contain appreciably high levels of protein and minerals on dry matter (DM) basis: crude protein (18.69–26.26%), calcium (0.62–1.89%), magnesium (0.027–0.063%), phosphorus (1.31–1.86%), manganese (66–268 mg/kg), zinc (7–36 mg/kg), copper (3.0–36.0 mg/kg) and iron (139–1106 mg/kg). Such forages, if made available, could supply both supplementary and dietary protein and mineral requirements of sheep and goats.

Introduction

In the Northern Guinea Savanna Zone of the country where the environment and land degradation has been severe over the years due to biotic and abiotic factors, the concept of an integrated crop-livestock production aimed at improving soil fertility and sustaining a healthy environment for increased productivity is of utmost importance. Agroforestry through alley farming involving the use of a host of trees/shrub plant species (e.g. *Butyrospermum parkii, Acacia albida*, *Leucaena leucocephala, Gilricidea sepium*, etc.) for the purpose have been widely suggested for similar zones. Furthermore, it is known that some of such tree/shrubs will provide forage for livestock (ruminants) as well as wood fuel for the household. However, information as to which of such forages sheep and goats will prefer in this ecological zone of the country is lacking. Different species of animals may generally relate themselves differently to a given forage. A given animal species may also react differently to a variety of forages by way of choice. Guided by their senses of sight, smell and taste, animals are able to select which food material is immediately desirable for ingestion.

For successful tree/crop-livestock integrated farming systems, knowledge of forage preference by animal could enhance a balanced or rational and efficient utilisation of limited available farmlands for both food or cash crops and fodder banks for livestock. The present study is to evaluate the preferability of *Leucaena leucocephala, Gilricidea sepium, Cajanus cajan* and *Sesbania sesban* by sheep and goats. These plant species have been earmarked by researchers in alley cropping for the farming systems of the area.

Materials and Methods

In November 1992, a series of supplementary forage feeding studies were carried out using Djjallonke sheep and West African Dwarf (WAD) goats to evaluate their preference for forages from *Leucaena leucocephala, Gilricidea sepium, Cajanus cajan* and *Sesbania sesban* alley rows established at the Animal Research and Crop Research (NAES) stations at Nyankpala in Northern Ghana.

Experiment 1

Eight young Djjallonke sheep were housed in individual pens and studied individually. Three species of freshly cut forages (*Leucaena leucocephala, Sesbania sesban* and *Cajanus cajan*) were used in a cafeteria feeding technique over a 3-day period. Animals had free access to drinking water and were not starved before the experiment. The three forages were separately tied loosely in bundles of 1.0 kg and randomly placed along the 1.5 metre length feed front in a 2.0 x 4.5 m pen. The allotted feeding time was 2–3 hours and for the first 15 minutes, animal behaviour in relation to time spent sniffing, eating or idling was monitored. Feed leftovers were weighed after offering in order to determine the consumption of each species.

The coefficient of preference (COP) which is the ratio of the percentage of a particular forage specified consumed to the percentage of the total forage mixture consumed was used in determining forage species preference. A forage species was said to be preferred to the others when the calculated mean COP is more than unity (COP > 1).

In another scenario, six adult sheep and goats were separately used in a group feeding management system to determine and compare animal species forage preference. Seven kilograms (7.0 kg) of each of the three forage species were separately heaped in an enclosed yard (6.5 x 9.5 m) in the animal house and
animals released into it to feed for 15 minutes. Animal number count per unit time eating at the forage source and the COP were the parameters used to determine preference.

Experiment 2
The same number and categories of animals (8 young and 6 adult sheep and 6 adult goats) were randomly selected for a second experiment. The experimental procedures as obtained in Experiment 1 were repeated except that Sesbania sesban was replaced with a more leafy forage of Gliricidia sepium and the quantities of forages offered in the individual study was 800 gm each. Furthermore, after the preference ranking, the least preferred in forage specie was offered alone to the animals for 15 minutes in another study to establish whether it would be patronised or rejected as such.

Chemical Analysis of Forages
Samples of the forage species used in the study were taken to the Crops Research Institute (NAES) chemical laboratory, dried and analysed for crude protein and mineral levels using the Kjeldahl method and Atomic Absorption Spectrophotometer (AAS), respectively.

Results
Chemical Composition of Forages
All the four browse species used in the preference studies were legumes. As expected the crude protein levels were found to be appreciably high. The levels of most macro- and micro-minerals were also found to be high and could additionally serve as important sources of minerals for livestock. Data on the crude protein and mineral concentrations are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Crude protein and mineral levels of browse species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage source</td>
</tr>
<tr>
<td>G. sepium</td>
</tr>
<tr>
<td>L. leucocephala</td>
</tr>
<tr>
<td>S. sesban</td>
</tr>
<tr>
<td>C. cajan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Behavioural time check and mean forage consumption by sheep (= 8) individually fed 3 browse species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1. Quantity of forage offered, gm</td>
</tr>
<tr>
<td>2. Behavioural time check, mins</td>
</tr>
<tr>
<td>- time spent sniffing</td>
</tr>
<tr>
<td>- time spent eating</td>
</tr>
<tr>
<td>3. Average forage intake after 3 hours, gm</td>
</tr>
<tr>
<td>4. Coefficient of Preferences (COP)</td>
</tr>
</tbody>
</table>
Experiment 1

In the individual study with the eight young sheep, Cajanus cajan was the forage specie of choice. The first 15 minutes of observation revealed that much sniffing time at forages by sheep was given to Sesbania sesban (2 mins) and Leucaena leucocephala (1.5 mins). However, animals on the average spent much of the time eating Cajanus (6.3 mins). The mean consumption and COP values of forages are presented in Table 2.

In the group study monitored for 15 minutes, animal (sheep) count per minute at a particular forage source eating was found to be higher for Cajanus cajan (2.6 animals). The counts for Leucaena leucocephala and Sesbania sesban were negligible. The total quantity of Cajanus consumed by sheep in the given time was 450 gm.

Goats in the group study showed preference for Leucaena leucocephala. The number of goats found at a forage source eating per minute was higher for Leucaena (1.3 goats). The total amount of forages consumed by the animals within the time period monitored were 925, 250 and 50 gms for Leucaena, Cajanus and Sesbania, respectively. The COP was 2.19 in favour of Leucaena.

Experiment 2

When Leucaena, Gliricidia and Cajanus were offered to sheep in the individual study, Cajanus was still selected as the forage of choice. Although the mean sniffing time at Cajanus and Leucaena was the same (0.5 min), the time spent by sheep at forage site eating was higher for Cajanus (9.8 min). Animals therefore showed a liking for Cajanus with COP of 2.81 (Table 3). Gliricidia was completely rejected.

Generally, the results obtained were similar when a group of six adult sheep were offered the three sources of forages. Animal count per minute for sniffing at Gliricidia and Leucaena was the same (0.2). Sniffing count for Cajanus was zero. However, the eating count was higher (4.2) for Cajanus, compared to Leucaena (0.1). Animals only sniffed at Gliricidia but the eating count was zero. For 15 minutes of monitoring, the total quantities of forages consumed by the sheep were 2000, 50 and 0 gm in the order of Cajanus, Leucaena and Gliricidia, respectively.

When the group of 6 goats was presented with the three sources of forages (Leucaena, Gliricidia and Cajanus), Leucaena was again the forage of choice. The sniffing count per minute was 0.1 for Leucaena and Gliricidia, but zero for Cajanus. However, the eating counts per minute were 1.5, 1.1 and 0.0 for Leucaena, Cajanus and Gliricidia, respectively.

The total amount of forages consumed by goats within the given time of 15 minutes were: Leucaena – 1250 gms and Cajanus – 200 gms. Gliricidia was not eaten by the goats.

When the same experimental procedures were adopted with Gliricidia sepium offered as the only forage source, the results in both the

| Table 3. Behavioural time check and mean forage consumption by sheep (n = 8) individuality exposed to 3 browse species |
|--------------------------------------------------|------------------|------------------|------------------|
| Index                                                                                                                 |
| 1. Quantity of forage offered, gm                     | 800              | 800              | 800              |
| 2. Behavioural time check, mins                       |                   |                   |                   |
| - time spent sniffing                                 | 0.5              | 0.0              | 0.5              |
| - time spent eating                                   | 0.9              | 0.0              | 9.8              |
| 3. Average forage intake after 3 hours, gm           | 12.5             | 0.0              | 192.8            |
| 4. Coefficient of Preferences (COP)                   | 0.18             | 0.0              | 2.81             |
individual and group study were not different from that reported above. *G. sepium* was simply not patronised by the sheep and goats.

**Discussion**

The ability to select what is palatable was demonstrated in the present study by the ranked order in which the sheep and goats related themselves to the given legume forages. Most probably, due to animal species difference, *Cajanus cajan* was found to be palatable by sheep whereas *Leucaena leucocephala* was preferred by goats. Goats have been indicated to have the liking for tastes cutting across the board—sweet to bitter. As it were, goats in the group study consumed a substantial amount of *Cajanus* (200–250 gms) in addition to their forage of preference. In the case of the sheep, only 50 gms of *Leucaena* was eaten in addition to their preferred one, *Cajanus*.

It is generally known that ruminants on pasture tend to selectively graze plants that contain a high level of crude protein. This may partly also explain the preference by sheep of *Cajanus* which had a higher level of crude protein (26.3%) compared to the others. Goats on the other hand selected *Leucaena* which had the lowest level of crude protein (18.7%).

The level of macro- and micro-minerals in the forages were quite appreciable and most, if made available could meet the dietary requirements of sheep and goats. Similar results for calcium (Ca) were reported in *G. sepium* and *Leucaena* (1). For the purpose of meeting the daily requirements of livestock in micro-elements, the levels of zinc (Zn) and copper (Cu) in *G. sepium* were observed to be rather low. Iron (Fe) was noted to be high in *Cajanus*. It is generally known that the levels of minerals in forages are basically determined by the plant species and the nature of the soil where the plant is grown.

In cattle-feeding experiments, where *G. sepium* was provided at a level of 1.2 kg/head/day as a supplement to cocoa-pod based diet, it was observed that the consumption of *G. sepium* was poor and equaled only 0.2 kg/head/day.

Much earlier reports indicated that cattle did not relish *G. sepium*. In a preference study using WAS goats *G. sepium* was least ranked (ninth) out of ten browse species (3). However, it has also been reported on the contrary, that high intakes were recorded in ruminants (1,11). The findings in our study seem not to agree with some of the literature reported (1,11). *G. sepium* appears to be new to animals in the zone. Its rejection by sheep and goats may be assumed to be partly related to the late introduction (late eighties) in the zone compared to the other legume forages. However, *G. sepium* leaves had very characteristic scent or smell which may not prove attractive to the animals. Furthermore, the presence of a potential toxic substance called *cumarin* which changes to *dicumeral* when leaves are damaged, could also contribute to the rejection of *G. sepium* by animals (9).

The difference in the behaviour of sheep and goats in the group feeding method used is worth commenting on as it slightly affected the data on the animal count per minute at a particular forage source. Fighting or group disturbance (agonistic behaviour) at feeding was observed to be dominant with goats and not in sheep. Animal (sheep) count per minute at their preferred forage site (*Cajanus*) of eating, was always observed to be more (2.6–4.2) than the count for goats (1.3–1.5) at the *Leucaena* site. Due to the bullying behaviour exhibited by the stronger goats, there was group unrest leading to animals constantly moving from one forage site to the other in order to avoid being beaten. In a feedlot, the group method of feeding animals may not be the best for goats.

**Acknowledgments**

The authors wish to thank Prof. W.S. Alhansan for reading through the script before the final print.

**References**


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PERFORMANCE OF COCKEREL STARTERS FED GRADED LEVELS OF DIETARY METHIONINE + CYSTINE IN A TROPICAL ENVIRONMENT

NWOKORO, S.O.¹ and O.O. TEWE
Department of Animal Science, University of Ibadan, Ibadan, Nigeria

PERFORMANCE DES COQUELETS NOURRIS DE REGIMES ALIMENTAIRES CONTENANT DES NIVEAUX CROISSANTS DE METHIONINE + CYSTINE SOUS LES TROPIQUES

Résumé
L’expérience a été faite pour déterminer la réaction des coquelets commerciaux aux régimes alimentaires contenant des niveaux croissants de méthionine + cystine pendant la première période: 0 à 8 semaines. Il étaient soumis à un régime alimentaire à base de tourteau de maïs/arachide avec un complément de méthionine – DL à un taux progressif de 0,08% de telle sorte que la méthionine (M) + la cystine (C) dans le régime alimentaire variaient entre 0,57 et 1,05%. Ces régimes étaient comparés à un régime témoin standard de farine de poisson. L’augmentation du gain pondéral, la proportion aliment consommée/gain (ACG) et le rapport de l’efficience des protéines (REP) étaient observés chez les coquelets à tous les niveaux de supplément de méthionine. Le gain pondéral, ACQ et REP, mais aucune rétention d’azote chez les coquelets nourris de régime contenant moins de 0,73% de M + C (0,41% M), étaient plus petits que ceux des poulets nourris de régimes contenant plus de 0,73% M + C. Les indices de performance étaient maximisés au taux de 0,73% M + C à savoir: gain pondéral (11,83 ± 0,30 g/poulet/jour), ACQ (2,28 ± 0,04), REP (2,09 ± 0,16) et protéine (6,37 mg/dl). Cette étude a montré que 0,73% M + C (0,41% M) d’un régime alimentaire contenant 21% PB et 26,50 Kcal EM/kg peut être recommandé pour les coquelets entre 0 et 8 semaines.

Summary
The experiment was conducted to determine the response of commercial cockerels to graded levels of dietary methionine + cystine during the starter period, 0 – 8 weeks. They were fed a basal maize-groundnut cake diet supplemented with DL-methionine in 0.08% stepwise increments such that dietary methionine (M) + cystine (C) ranged between 0.57 and 1.05%. These were compared with a standard fish meal control diet. Improvement in weight gain, feed per gain ratio (FCR) and protein efficiency ratio (PER) were observed in cockerels at all levels of methionine supplementation. Weight gain, FCR, and PER but not nitrogen retention of birds fed below 0.73% dietary M + C (0.41%M) were poorer than those of chickens fed the diets above 0.73% M-C. Performance indices were maximised at 0.73% M+C and these were weight gain (11.83 ± 0.30g/bird/day), FCR (2.28 ± 0.04), PER (2.09 ± 0.16), and 6.37mg/dl for protein. The study suggests that 0.73% M + C (0.41%M) of a diet containing 21% CP and 26.50 Kcal ME/kg may be recommended for cockerels between 0 and 8 weeks.

Introduction
Commercial cockerel production has become an important poultry meat production enterprise in sub-Saharan African countries. However, most farmers have used feeds developed for broilers or pullets. Recent reports⁴¹,² indicated a separate type of feed (nutrients) requirement for cockerels especially with respect to protein and energy levels. But there is no published information on the methionine (M) + cystine (C) requirements of cockerel starters aged 0 – 8 weeks.

The present study was designed to determine the most optimal M + C dietary requirement for cockerel starters.

1. Current Address: Department of Animal Science, Faculty of Agriculture, University of Benin, P.M.B. 1154, Benin City, Nigeria
2. To whom correspondence should be addressed.
Materials and Methods

In this study, a total of 240 Harco cockerels were used. At day old, the chicks were weighed (averaged 26.67 ± 0.55g) and randomly distributed into 8 similar groups of 30 birds each. Each group was further sub-divided into two groups of 15 birds in floor pens with wood shavings a litter. Each experimental diet (Table 1) was fed to two pens. Continuous lighting was provided and the open sides of the house were covered with polythene sheets for the first 4 weeks of the experiment. Feeders and drinkers were cleaned daily, and feed and water were provided ad libitum. At the end of the seventh week, two chickens per replicate were placed per compartment (36 cm x 36 cm) in metabolism cages for nitrogen balance trials. Blood was collected on replicate basis for serum protein and uric acid analysis.

The basal ration was formulated to contain 21% protein and metabolisable energy (ME) of 2650 Kcal/g(2). Diet 1 contained fish meal (Table 2) and served as the control ration for the cockerels.

Ration 2 lacked fish meal and served as the basal diet for the amino acid studied. Graded levels of crystalline DL- methionine were added to the basal diet in 0.08% stepwise increments such that dietary methionine ranged between 0.25 and 0.73% (0.57 and 1.05% M+C) of the diet.

Table 1. Gross composition of experimental diets (Per cent)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow maize</td>
<td>46.56</td>
<td>44.41</td>
<td>44.41</td>
<td>46.56</td>
<td>44.41</td>
<td>44.41</td>
<td>46.56</td>
<td>44.41</td>
</tr>
<tr>
<td>Maize offals</td>
<td>23.28</td>
<td>22.49</td>
<td>22.41</td>
<td>22.33</td>
<td>22.35</td>
<td>22.17</td>
<td>22.09</td>
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<td>Fishmeal</td>
<td>5.00</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Bonemeal</td>
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<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
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<td>2.00</td>
<td>2.00</td>
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<tr>
<td>Oystershell</td>
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<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
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</tr>
<tr>
<td>Premix*</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
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<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
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<tr>
<td>Salt (NaCl)</td>
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<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>DL-Methionine (M)</td>
<td>-</td>
<td>-</td>
<td>0.08</td>
<td>0.16</td>
<td>0.24</td>
<td>0.32</td>
<td>0.40</td>
<td>0.48</td>
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<tr>
<td>L-Lysine</td>
<td>-</td>
<td>0.47</td>
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<td>0.47</td>
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</tbody>
</table>

Calculated constituents (on as fed basis)

<table>
<thead>
<tr>
<th>Crude protein (%)</th>
<th>21.00</th>
<th>21.00</th>
<th>21.00</th>
<th>21.00</th>
<th>21.00</th>
<th>21.00</th>
<th>21.00</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ME (Kcal/kg diet)</td>
<td>2650</td>
<td>2650</td>
<td>2650</td>
<td>2650</td>
<td>2650</td>
<td>2650</td>
<td>2650</td>
<td>2650</td>
</tr>
<tr>
<td>Total Methionine (%)</td>
<td>0.32</td>
<td>0.25</td>
<td>0.33</td>
<td>0.41</td>
<td>0.49</td>
<td>0.57</td>
<td>0.65</td>
<td>0.73</td>
</tr>
<tr>
<td>M + Cystine (%)</td>
<td>0.62</td>
<td>0.57</td>
<td>0.65</td>
<td>0.73</td>
<td>0.81</td>
<td>0.89</td>
<td>0.97</td>
<td>1.05</td>
</tr>
<tr>
<td>Total Lysine (%)</td>
<td>0.76</td>
<td>1.10</td>
<td>1.10</td>
<td>1.10</td>
<td>1.10</td>
<td>1.10</td>
<td>1.10</td>
<td>1.10</td>
</tr>
</tbody>
</table>

*Vitamin and mineral premix included at 2.5kg per tonne of diet contained the following: Vitamin A, 5,000 000 IU; Vitamin D3, 100,000 IU; Vitamin E, 14,000 IU; Vitamin K3, 800 IU; Vitamin B1, 400 IU; Vitamin B2, 3,000 IU; Vitamin B3, 4,400 IU; vitamin B6, 1,000 IU; Vitamin B12, 5.2 IU; Niacin, 8,000 mg; Folic acid, 200 mg; Biotin, 20 mg; choline, 168,000 mg; Manganese, 32,000 mg; Iron, 16,000 mg; Copper, 30,000 mg; Zinc 22,000 mg; Iodine, 500 mg; Selenium, 48 mg and BHT antioxidant.
Table 2. Proximate and amino acid composition of the ingredients used on as-fed basis

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Dry Matter</th>
<th>Crude Protein</th>
<th>Ether Extract</th>
<th>Crude Fibre</th>
<th>Total Ash</th>
<th>Lysine</th>
<th>Methionine</th>
<th>Cystine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow maize</td>
<td>89.00</td>
<td>9.74</td>
<td>3.98</td>
<td>2.05</td>
<td>1.30</td>
<td>0.24</td>
<td>0.19</td>
<td>0.15</td>
</tr>
<tr>
<td>Maize offals</td>
<td>81.00</td>
<td>11.98</td>
<td>1.50</td>
<td>8.00</td>
<td>4.60</td>
<td>0.40</td>
<td>0.15</td>
<td>0.23</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>91.67</td>
<td>47.97</td>
<td>5.56</td>
<td>9.57</td>
<td>6.05</td>
<td>1.49</td>
<td>0.47</td>
<td>0.69</td>
</tr>
<tr>
<td>Fishmeal</td>
<td>92.10</td>
<td>65.14</td>
<td>5.43</td>
<td>0.96</td>
<td>19.38</td>
<td>4.78</td>
<td>1.81</td>
<td>0.59</td>
</tr>
</tbody>
</table>

The procedures for the nitrogen balance study were as described earlier. Serum was obtained by separation from the blood clot 24 hours post collection by centrifugation and samples were labeled and preserved at -10°C prior to analysis; subsequent thawing for analysis was done at room temperature. The proximate composition of feeds and faeces (nitrogen) were analysed as described by the AOAC. Analysis for serum protein and uric acid were as reported previously, and amino acids were measured by column chromatography-RADDER, 1989-BELGIUM. The calculated composition of all rations were based on values obtained from laboratory analysis of the individual ingredients (Table 2).

During the experiment, the birds were weighed in groups at weekly intervals and feed consumption was also determined. Mortality records were also kept. At the end of the investigation, the data were subjected to analyses of variance and significance of differences assessed.

Results

Results of the experiment are shown in Tables 3 and 4. The analyses revealed that daily weight gain, feed consumption, feed conversion ratio, protein efficiency ratio, serum total protein and uric acid were significantly (P < 0.05) affected by dietary treatment.

The daily weight gain (DWG) increased with increasing levels of supplemental methionine until the maximum weight gain was obtained at 0.41% methionine (0.73% dietary M+C) followed by non-significant reduction afterwards. The lowest growth responses were obtained in control (diet 1) and diet 2 (0.57% M+C). Daily weight gain in the dietary M+C groups (0.81, 0.89, 0.97 and 1.05%) were significantly (P < 0.05) higher than the control fish meal standard diet (diet 1). The regression analyses revealed that more than 60 per cent of the variability in weight was due to dietary treatments. There was a significant positive correlation (r = 0.72) between DWG and dietary treatment.

Results for the feed consumption indicated that with the exception of that obtained at 0.73% dietary methionine (1.05% M + C), others were not significantly (P < 0.05) different. The results of the feed to gain ratio showed an improvement with increasing levels of dietary M + C until an optimal 0.73% M + C (0.41% dietary M) level in the diet was reached. A similar trend was also observed for protein efficiency ratio.

The nitrogen retained (g) and per cent nitrogen retention were not significantly influenced by dietary treatment. Serum total protein increased with increasing methionine supplementation of the diet until maximum concentration was observed at 0.41% and thereafter it decreased consistently. Though uric acid concentration indicated significant (P < 0.05) differences between most diets, the responses were not consistent with dietary treatments.

One bird each died in diets 2 and 3 during the experiment. The postmortem results revealed no specific infection.
### Table 3. Performance characteristics of cockerel starters fed graded levels of dietary methionine

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diets (Methionine level – % Diet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M + C Level (%)</td>
<td>1(0.32) 2(0.25) 3(0.33) 4(0.41) 5(0.49) 6(0.57) 7(0.65) 8(0.74)</td>
</tr>
<tr>
<td>Weight gain (g/day)</td>
<td>8.74 ± 0.11&lt;sup&gt;a&lt;/sup&gt; 7.38 ± 0.12&lt;sup&gt;b&lt;/sup&gt; 10.21 ± 0.33&lt;sup&gt;c&lt;/sup&gt; 11.83 ± 0.01&lt;sup&gt;c&lt;/sup&gt; 11.13 ± 0.30&lt;sup&gt;c&lt;/sup&gt; 11.75 ± 0.28&lt;sup&gt;c&lt;/sup&gt; 11.61 ± 0.41&lt;sup&gt;c&lt;/sup&gt; 11.54 ± 1.30&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Daily feed consumption (g/bird)</td>
<td>26.21 ± 0.70&lt;sup&gt;a&lt;/sup&gt; 26.11 ± 1.19&lt;sup&gt;a&lt;/sup&gt; 26.42 ± 1.21&lt;sup*a&lt;/sup&gt; 27.08 ± 0.80&lt;sup&gt;a&lt;/sup&gt; 27.67 ± 1.12&lt;sup&gt;a&lt;/sup&gt; 23.49 ± 0.85&lt;sup&gt;a&lt;/sup&gt; 30.11 ± 2.35&lt;sup&gt;a&lt;/sup&gt; 33.58 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Feed/gain ratio (g feed/g gain)</td>
<td>3.00 ± 0.60&lt;sup&gt;a&lt;/sup&gt; 3.54 ± 0.21&lt;sup&gt;a&lt;/sup&gt; 2.59 ± 0.02&lt;sup&gt;a&lt;/sup&gt; 2.28 ± 0.04&lt;sup&gt;a&lt;/sup&gt; 2.49 ± 0.20&lt;sup&gt;a&lt;/sup&gt; 2.51 ± 0.20&lt;sup&gt;a&lt;/sup&gt; 2.60 ± 0.21&lt;sup&gt;a&lt;/sup&gt; 2.94 ± 0.39&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein efficiency ratio (g gain/g protein intake)</td>
<td>1.60 ± 1.19&lt;sup&gt;a&lt;/sup&gt; 1.35 ± 0.11&lt;sup&gt;a&lt;/sup&gt; 1.85 ± 0.04&lt;sup&gt;a&lt;/sup&gt; 2.09 ± 0.06&lt;sup&gt;a&lt;/sup&gt; 1.93 ± 0.21&lt;sup&gt;a&lt;/sup&gt; 1.90 ± 0.04&lt;sup&gt;a&lt;/sup&gt; 1.85 ± 0.30&lt;sup&gt;a&lt;/sup&gt; 1.64 ± 0.26&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>0 3.33 3.33 0 0 0 0 0</td>
</tr>
</tbody>
</table>

* Control fishmeal diet
<sup>abc</sup> mean without common superscripts in horizontal rows are significantly (P < .05) different

### Table 4. Nitrogen retention and serum metabolites in cockerels

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diets (Methionine level – % Diet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M + C Level (%)</td>
<td>1(0.32) 2(0.25) 3(0.33) 4(0.41) 5(0.49) 6(0.57) 7(0.65) 8(0.73)</td>
</tr>
<tr>
<td>Daily nitrogen retention (g)</td>
<td>1.74 ± 0.18 1.71 ± 0.02 1.87 ± 0.41 1.79 ± 0.04 1.78 ± 0.00 1.78 ± 0.32 1.72 ± 0.00 1.67 ± 0.011</td>
</tr>
<tr>
<td>Nitrogen retention (%)</td>
<td>73.35 ± 0.29 75.14 ± 1.66 84.18 ± 12.74 84.09 ± 1.21 71.52 ± 2.95 74.06 ± 2.88 70.25 ± 3.25 75.51 ± 4.96</td>
</tr>
<tr>
<td>Serum total protein (mg/dl)</td>
<td>7.53 ± 0.08&lt;sup&gt;a&lt;/sup&gt; 3.74 ± 0.56&lt;sup&gt;a&lt;/sup&gt; 4.26 ± 0.19&lt;sup&gt;a&lt;/sup&gt; 6.37 ± 0.30&lt;sup&gt;a&lt;/sup&gt; 4.66 ± 0.22&lt;sup&gt;a&lt;/sup&gt; 4.37 ± 0.23&lt;sup&gt;a&lt;/sup&gt; 4.07 ± 0.00&lt;sup&gt;a&lt;/sup&gt; 4.66 ± 0.22&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Serum Uric acid (mg/dl)</td>
<td>3.67 ± 0.07&lt;sup&gt;a&lt;/sup&gt; 3.71 ± 0.03&lt;sup&gt;a&lt;/sup&gt; 4.7 ± 0.23&lt;sup&gt;a&lt;/sup&gt; 3.44 ± 0.02&lt;sup&gt;a&lt;/sup&gt; 3.52 ± 0.06&lt;sup&gt;a&lt;/sup&gt; 3.43 ± 0.03&lt;sup&gt;a&lt;/sup&gt; 2.17 ± 0.01&lt;sup&gt;a&lt;/sup&gt; 4.13 ± 0.01&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>abc</sup> mean on the same raw with different superscripts are significantly (P < .05) different

### Discussion

The results of the present study suggest that optimum performance of the cockerel starters was obtained at 0.73% total M + C (0.41% dietary M) in the diet for the 8 weeks of the study. There are no published reports for comparison. However, this optimal M + C level is higher than that recommended for counterpart pullets in the tropics<sup>7</sup> and the temperate areas<sup>8</sup>.

That growth performance indicated an increment with increasing methionine supplementation until the optimal was reached may be indicative that the dietary amino acid at the lower levels were not adequate to provoke
sufficient performance like in the higher levels. The significant growth depression in the basal dietary group is in line with previous observations in other species of birds\(^{(9,10,11,12,13)}\).

It was observed in this study that feed intake increased with dietary work with increment of M + C. This is in agreement with work with broilers\(^{(14)}\) in which feed consumption was depressed by amino acid deficiencies and balances but contrary to earlier observations\(^{(15)}\) that chicken overconsumed feed that was deficient in methionine.

The highest concentration of total protein in the serum was obtained in the dietetic group (0.73% M + C) where optimal DWG was recorded. This is in line with that reported by two authors\(^{(16,17)}\) in rats and poultry respectively.

The present study has shown that performances of cockerels improved with supplemental methionine + cystine. However, there is need for more studies to evaluate the nutrient requirements of cockerels in the tropics.

**Acknowledgments**

The authors wish to thank Mr. D. Lanbo of Radder (Nig.) Ltd., Lagos, and Messrs Radder and Coddern of RADDER, Belgium for their assistance in laboratory analyses of samples especially for amino acids.

**References**


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PERFORMANCE OF DWARF NAKED NECK AND COMMERCIAL CROSS LAYING HENS UNDER LOCAL CONDITIONS

K. BENABDELJELIL
Institute of Agronomy and Veterinary Medicine, Hassan II BP. 6202 Rabat – Morocco

F. MERAT
Laboratoire de Génétique factorielle intra centre de jouy-en-josas 78352, Jouy-en-josas France

PERFORMANCE DES PONDEUSES NAINES AU COU NU ET DES PONDEUSES COMMERCIALES CROISEES ELEVEES DANS DES CONDITIONS LOCALES

Résumé

La performance de production d’un croisement expérimental de pondeuse aux œufs roux, y compris les gènes de l’espèce naine liée au sexe (dw) et de l’espèce au coup nu (Na), était comparée à celle d’un croisement de pondeuse commerciale (ISA-Brown) dans des conditions typiques du Maroc.

On a relevé plusieurs fois pendant une période de 65 semaines le taux de ponte, le poids de l’oeuf, le poids vif, la consommation alimentaire, la qualité de l’oeuf et de la coquille. Il y avait des différences significatives, quant aux taux de ponte, entre les deux croisements de la 38ème à la 60ème semaine d’âge. Le poids moyen de l’oeuf, la consommation alimentaire, les poids de la coquille étaient beaucoup plus réduits pour le croisement expérimental alors qu’aucun effet notable n’a été observé pour le blanc d’oeuf. On a constaté un taux de mortalité plus faible chez le croisement dwNa.

Ces résultats étaient corroborés par une combinaison favorable des gènes de dw et Na sur la thermorésistance en plus de la réduction des besoins d’entretien avec le gène dw. Les réactions pour les principales caractéristiques respectives étaient en faveur du croisement commercial; il existe donc une utilisation potentielle de ces espèces comme l’expérience pour la production d’œufs dans des conditions similaires.

Summary

The productive performance of an experimental cross of the brown-egg layer type including the sex-linked dwarf (dw) and naked neck (Na) genes were compared to those of a commercial (ISA-Brown) layer cross in typical conditions of Morocco.

Laying rate, egg and body weights, feed consumption, egg and shell quality measurements were taken at various times over a 65-week period. There were significant differences in laying rates between the two crosses from 38 to 60 weeks of age. Mean egg weight, feed consumption and shell weights were significantly lower for the experimental cross whereas no significant effects were observed on albumen quality. A lower mortality rate was observed for the dwarf naked neck cross.

These results were supported by a favourable combination of the dw and Na genes on heat tolerance in addition to the reduction of maintenance requirements by the dw gene. The responses for the main respective traits were in favour of the commercial cross. There is therefore potential use for such stocks as the experimental one for egg production in similar conditions.

Introduction

Reports from several countries still emphasise that extensive small scale village or backyard poultry production remains prevalent(1). Several attempts have been made to improve these traditional stems through incorporating major genes with local relevance in breeding pools of hot climate areas. The naked neck type has long been known in the domestic fowl and is widespread in local populations of various
countries\(^2\). Its incorporation increases the productivity in crosses of local strains demonstrating clear advantages in the use of specific high yielding strains.

Previously mentioned results indicated that a dwarf naked neck layer might combine the advantages of the naked neck (Na) gene and the dwarf (dw) gene for predominantly hot areas and recommended that the use of these genes for egg production in temperate conditions be investigated\(^{2,5,10,11}\). This gene combination which may be introduced in various tropical and temperate countries with local indigenous chicken populations\(^3\), can be of higher adaptability to production systems with environmental stress and underdeveloped infrastructure.

The following experiment was designed to further explore the potential of the dwarf naked neck combination in comparison with a commercial cross for egg production under local conditions.

**Material and methods**

The trial was conducted at the National Centre of Poultry Extension “Skikima” located near Rabat on the Atlantic Coast.

The dwarf and naked neck (dwNa) hens were obtained from a cross between males of an experimental dwarf naked neck (sex linked dw and Na) strain and the commercial Isa-brown laying hens of the Isa-Brown terminal cross raised in the same conditions.

The pullets were started on a straw litter in commercial conditions and fed *ad libitum* a commercial diet during the first 8 weeks. From 8 to 19 weeks of age the birds were fed on a commercial grower diet. Ninety birds of each strain were then transferred to a windowed house and placed into laying cages (40 x 45 cm). They received a photoperiod of 16.5 hours light per 24h. The hens were housed 3 per cage until 40 weeks of age (4 thereafter) and were fed the experimental diet presented in Table 1 during the laying period. The diet was formulated to provide 28690 Kcal/kg.

<table>
<thead>
<tr>
<th>Table 1. Composition of the experimental diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredients</td>
</tr>
<tr>
<td>Corn</td>
</tr>
<tr>
<td>Barley</td>
</tr>
<tr>
<td>Peas</td>
</tr>
<tr>
<td>Sunflower Meal</td>
</tr>
<tr>
<td>Fish Meal (65% CP)</td>
</tr>
<tr>
<td>Methionine</td>
</tr>
<tr>
<td>Calcium Carbonate</td>
</tr>
<tr>
<td>Bone Powder</td>
</tr>
<tr>
<td>Salt</td>
</tr>
<tr>
<td>Vitamin-Mineral Premix</td>
</tr>
</tbody>
</table>

**Analytical Composition (%DM)**

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>90.30</td>
</tr>
<tr>
<td>Ash</td>
<td>12.83</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>17.54</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>5.27</td>
</tr>
</tbody>
</table>

**Calculated Composition (%DM)**

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.86</td>
</tr>
<tr>
<td>Methionine + Cystine</td>
<td>0.62</td>
</tr>
<tr>
<td>Calcium</td>
<td>3.50</td>
</tr>
<tr>
<td>Available Phosphorous</td>
<td>0.42</td>
</tr>
</tbody>
</table>

\(^1\) The Vitamin – Mineral Premix provided per kg of feed: 10,000 IU Vit A; 3000 IU Vit D; 10 mg Vit E; 1.8 mg Vit K; 1.2 mg Thiamine; 4.0 mg Riboflavin; 10 mg Pantothenic Acid; 1.6 mg Pyridoxine; 0.008 mg Vit B12; 24.00 mg Nicotinic Acid; 0.6 mg Folic Acid; 0.35 g Choline; 0.0004 g Co; 0.008 g Cu; 0.025 g Fe; 0.001 g I; 0.08 g Mn; 0.0002 g Se et 0.05 g Zn.

Mortality and egg production were recorded daily. Environmental temperatures were also taken at noon each day. Feed consumption levels were recorded at 36, 39, 45, 50 and 55 weeks of age whereas hen body weight were measured at 35, 41, 43, 55 and 66 weeks of age. Egg weight interior and shell quality measurements were determined on all eggs laid on three consecutive days at 51 and 55 weeks of age. Specific gravity was determined every four weeks from 43 to 55 weeks of age, by the egg floatation method using eight salt (NaCl) solutions varying in specific gravity by increments of 0.005 from 1.065 to 1.00. The eggs were then broken and albumen quality was measured and expressed in Haugh Units\(^4\). The shells were washed and then dried at room temperature; shell thickness was determined with intact shell membranes using a micrometre at the equatorial parts of the eggs.
The data obtained were statistically analysed by a "t" test on a cage basis for all parameters except feed intake which was on pen basis.

Results

The results for the main performance traits in productivity are summarised in Tables 2 and 3 while egg quality data are presented in Table 4. Egg production curves for the two crosses are reported in Figure 1 with the main heat stress periods. The average temperatures recorded in the laying house are presented in Table 5.

**Table 2. Comparative performance of Isa-brown and dwarf naked neck laying hens**

<table>
<thead>
<tr>
<th></th>
<th>Week</th>
<th>&quot;Isa-brown&quot;</th>
<th>&quot;dwNa&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Consumption</td>
<td>36</td>
<td>110</td>
<td>100</td>
</tr>
<tr>
<td>(g/pen/day)</td>
<td>39</td>
<td>108</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>121</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>124</td>
<td>101</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>40 to 55</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Egg mass</td>
<td>35</td>
<td>46.4</td>
<td>40.1</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>53.2</td>
<td>43.1</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>46.2</td>
<td>43.9</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>50.8</td>
<td>39.6</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>49.6</td>
<td>41.1</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>53.2</td>
<td>38.3</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>41.4</td>
<td>37.6</td>
</tr>
<tr>
<td>Feed Efficiency</td>
<td>47</td>
<td>2.20</td>
<td>2.31</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>2.30</td>
<td>2.48</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>2.41</td>
<td>2.69</td>
</tr>
</tbody>
</table>

1. Feed consumed/Egg mass

Mortality rates were higher for the commercial cross. The computed rates from 40 to 65 weeks of age averaged 11.0 and 21.0% respectively for the "dwNa" and "Isa-brown" crosses but they were not statistically different (P>0.05).

The experimental dwNa cross had a slight advantage for laying rate and feed efficiency as compared to the commercial cross at the beginning of the laying period. (Figure 1 and Table 3). The egg and body weights of the two crosses were, however, significantly different (Table 4).

**Table 3. Egg and body weight of Isa-brown and dwarf naked neck laying hens**

<table>
<thead>
<tr>
<th></th>
<th>Week</th>
<th>&quot;Isa-brown&quot;</th>
<th>&quot;dwNa&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg Weight</td>
<td>35</td>
<td>57.24</td>
<td>52.20</td>
</tr>
<tr>
<td>(g)</td>
<td>38</td>
<td>63.27</td>
<td>55.63</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>61.61</td>
<td>56.10</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>62.30</td>
<td>55.40</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>63.20</td>
<td>57.50</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>65.70</td>
<td>58.40</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>66.50</td>
<td>59.70</td>
</tr>
<tr>
<td></td>
<td>66</td>
<td>63.49</td>
<td>58.42</td>
</tr>
<tr>
<td>Body Weight</td>
<td>35</td>
<td>1677</td>
<td>1363</td>
</tr>
<tr>
<td>(g)</td>
<td>41</td>
<td>1841</td>
<td>1477</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>1829</td>
<td>1442</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>1952</td>
<td>1530</td>
</tr>
<tr>
<td></td>
<td>66</td>
<td>1782</td>
<td>1435</td>
</tr>
</tbody>
</table>

1. Differences between weekly mean values for each strain were highly significant (P<0.001).

**Figure 1.** Variation with time in the rate of laying of Isabrown and dwarf naked neck hens
Table 4. Comparative data on egg quality of Isa-brown and naked neck laying hens

<table>
<thead>
<tr>
<th>Week</th>
<th>&quot;Isa-brown&quot;</th>
<th>&quot;dwNa&quot;</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumen</td>
<td>51</td>
<td>7.94</td>
<td>7.14</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>55</td>
<td>6.53</td>
<td>5.73</td>
</tr>
<tr>
<td>Haugh Units</td>
<td>51</td>
<td>87.0</td>
<td>85.3</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>76.7</td>
<td>74.7</td>
</tr>
<tr>
<td>Specific</td>
<td>43</td>
<td>1.086</td>
<td>1.085</td>
</tr>
<tr>
<td>Gravity</td>
<td>47</td>
<td>1.088</td>
<td>1.088</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>1.092</td>
<td>1.089</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>1.089</td>
<td>1.087</td>
</tr>
<tr>
<td>Shell Weight (g)</td>
<td>51</td>
<td>6.59</td>
<td>572</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>7.09</td>
<td>6.35</td>
</tr>
<tr>
<td>Shell Thickness (x 0.01 mm)</td>
<td>51</td>
<td>41.3</td>
<td>39.9</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>41.5</td>
<td>39.9</td>
</tr>
</tbody>
</table>

Conversely, the commercial hens had a lower rate of decline in egg production which sustained favourable feed efficiency values. The differences in this parameter measured at 47, 51 and 55 weeks of age were 4.3, 7.3 and 10.4% in favour of the commercial hens.

Overall mean values of the dwNa cross (as per cent of the commercial cross) averaged 93.3, 90.1 and 86.0 per cent respectively for rate of lay, egg weight and feed consumption. No significant differences attributed to the genetic origin of the hens tested were observed on egg quality parameters (Table 5).

Table 5. Average temperatures in the laying house °C.

<table>
<thead>
<tr>
<th>Week</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 – 25</td>
<td>25</td>
<td>29.0</td>
<td>33</td>
</tr>
<tr>
<td>26 – 30</td>
<td>25</td>
<td>30.0</td>
<td>35</td>
</tr>
<tr>
<td>31 – 35</td>
<td>24</td>
<td>29.0</td>
<td>34</td>
</tr>
<tr>
<td>36 – 40</td>
<td>19</td>
<td>23.5</td>
<td>28</td>
</tr>
<tr>
<td>41 – 45</td>
<td>15</td>
<td>18.5</td>
<td>22</td>
</tr>
<tr>
<td>46 – 50</td>
<td>9</td>
<td>16.5</td>
<td>24</td>
</tr>
<tr>
<td>51 – 55</td>
<td>8</td>
<td>15.5</td>
<td>23</td>
</tr>
<tr>
<td>56 – 60</td>
<td>9</td>
<td>15.5</td>
<td>22</td>
</tr>
<tr>
<td>61 – 65</td>
<td>12</td>
<td>16.5</td>
<td>21</td>
</tr>
</tbody>
</table>

Discussion

The birds were hatched in January and moderate temperatures were recorded during the rearing period followed by an increase in ambient temperature around peak of lay. Higher temperatures were recorded during July and August.

A depression in egg laying intensity and a reduction of feed conversion ratio are frequently observed for medium heavy brown egg-laying hens during hot summer months. The overall egg production rates and livability obtained herein were considered satisfactory in spite of the climatic fluctuations recorded during the summer months. The superiority of the commercial cross, (being the result of a long term selection process) for egg production was expected whereas the results of the experimental cross were attributed to the dw and Na genes and their respective effects which have been recently reviewed(2,8).

Naked neck, dwarf and other genes have been especially advantageous because of their ease of integration in appropriate breeding schemes(6). The use of the Na gene in the experimental cross may explain its relatively high laying rate which seems to be less affected by the heat waves. Its laying performance may have not been affected by the dw gene, as its depressing effects on egg production may be less apparent in cross breeding. A reduction in egg laying intensity of heavy and light naked neck birds have been reported, as well as a worsening of feed conversion(7). The overall feed efficiency, egg weight and laying rate obtained herein were in favour of the "Isa-brown" cross. This advantage in feed efficiency ratio, however, was moderate and might have been counter-balanced if a lighting and feed restriction program specifically adapted to the commercial stock had not been used.

Although no data were gathered on the shell breakage, there is evidence that the dw gene may reduce this parameter(6). In addition, an increase in egg weight and an improvement in shell thickness and breaking strength for the naked neck versus the normal breed in the tropics were observed(7).
The known advantages of the Na gene (and the dw gene) for heat tolerance may also explain the higher livability observed for the hens carrying these genes and their performance during hot periods.

Numerous reports have studied the specific effects of the Na and dw genes in relation to ambient temperature\(^{(2,8,9,10)}\). The experimental lines investigated in most of these studies were used to compare the effects of these genes in segregation in climatic chambers or controlled environment\(^{(1)}\) and recommend the testing of these genes and others under a specific environment. The results reported herein provide different and additional information concerning comparison to a commercial cross which may or may not carry the gene(s) studied in local management and climatic conditions. Several authors have shown that dwNa has a worldwide advantage for poultry production systems, where native stocks are still widely represented can be achieved through low cost production systems involving dwarf strains.

Further advantages can be obtained in exploiting special crosses for targeted users such as small egg weight or coloured eggs markets. Their intergration in cross breeding schemes maintaining through favourable gene combination the local fowl productive adaptability and heat tolerance, increasing performance through genetic improvements and providing the required nutrients in a specific environment should be further experimented.

**Acknowledgements**

The authors wish to thank the Director of Skikima Station and his personnel for their technical assistance. This research was funded in part by a grant from the Commission of the European Communities “Life Sciences and Technologies for Developing Countries”.

**References**


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PROFITABILITY AND EFFICIENCY OF N’DAMA AND ZEBU CATTLE IN SOUTHERN GHANA

ANNOR, S.Y., GARRICK, D.J. and BLAIR, H.T.
Animal Science Department, Massey University, Palmerston North, New Zealand

RENTABILITE ET EFFICACITE DE L’ELEVAGE DE BOVINS N’DAMA ET ZEBU DANS LE SUD DU GHANA

Résumé
Les bovins N’dama locaux (trypanotolerants) et les zébus exotiques (trypanosensibles) étaient évalués dans la zone climatique humide au sud du Ghana, en vue de déterminer la rentabilité et l’efficacité de l’élevage de ces races. Cette étude était réalisée par simulation du cycle de production d’une vache reproductrice et la performance de croissance de sa progéniture respectivement chez les N’dama et les zébus. Le profit était défini comme la différence entre les revenus et les dépenses. L’efficacité économique était définie comme le total des profits divisé par le coût total de l’entreprise. L’efficacité biologique était définie de deux façons: (1) la proportion entre la production et la consommation d’aliments et (2) le total des poids corporels de la progéniture vendue, générée par la vache reproductrice en une année. Le bénéfice/vache/an du N’dama était de 17% plus élevé que celui du zébu. Le bénéfice/vache/an a presque doublé chez les deux races, quand le prix de l’aliment était remis à zéro, mais la différence entre les deux races était réduite à 7% seulement en faveur du N’dama. L’efficacité économique pour les systèmes de production de N’dama et de zébu était respectivement de 31 et 24%. L’efficacité biologique définie comme le rapport production/consommation d’aliment était tout juste environ 2% pour les deux races. Les vaches N’dama et zébu étaient capables de générer respectivement environ 0,4 et 0,3 de leur poids corporel en terme de progéniture chaque année. Au total, les N’dama avaient une performance meilleure que le zébu. On a donc proposé qu’il faudrait prendre en compte l’utilisation des races bovines trypanotolérantes dans les régions infestées de tsétsé en Afrique.

Summary
Local N’dama (trypanotolerant) and an exotic Zebu (trypanosusceptible) were evaluated in the humid climatic zone of Southern Ghana to find the profitability and efficiency of raising these breeds. This was done by modelling the life cycle production of a breeding cow and growth performance of her offspring in N’dama and Zebu, respectively. Profit was defined as the difference between income and expense. Economic efficiency was defined as total returns divided by total enterprise cost. Biological efficiency was defined in two ways: (1) the ratio of product output to feed input and (2) the amount of body weight of offspring sold, generated by the breeding cow in a year. Profit per cow per year of N’dama was 17% more than that of the Zebu. Profit per cow per year almost doubled in both breeds, when the price of feed was set to zero, but the difference between the two reduced to only 7% in favour of N’dama. Economic efficiency for N’dama and Zebu production systems were 31 and 24% respectively. Biological efficiency, defined as the ratio of product output to feed input was just about 2% for both breeds. N’dama and Zebu cows were capable of generating only about 0.4 and 0.3, respectively of their body weight in progeny each year. On the whole, the N’dama performed better than the Zebu. It was therefore suggested that consideration should be given to the use of trypanotolerant breeds of cattle in tsetse infested areas of Africa.

Introduction
The traditional or local breeds of cattle in Ghana are the humpless Shorthorn (Bos taurus brachyceros) and N’dama (Bos taurus longifrons)\(^1\),\(^2\). Although the Shorthorn and N’dama cattle are trypanotolerant\(^3\),\(^4\), they are small in size, and have therefore been considered by farmers to be unproductive. This has led to the importation of Zebu cattle (Bos indicus) from neighbouring countries, which are
increasingly becoming popular with smallholder livestock farmers. Although the Zebu is a fairly large animal, it is trypanosusceptible\(^6\,^7\).

The southern part of Ghana has humid tropical forest and coastal grassland vegetation with thick undergrowth and densely wooded river basins\(^7\). This type of vegetation favours the *Glossina spp.*, vectors of trypanosomiasis and is asserted to be inimical to Zebu cattle production\(^8\,^9\).

Control of trypanosomiasis is dependent on the expensive and limited number of trypanocidal drugs that are available or on the reduction of tsetse populations by means of residual or non-residual insecticide\(^10\). Most *Bos indicus* types in tsetse infested areas require expensive and more regular treatment\(^9\).

Since most farmers in Ghana prefer rearing the Zebu to the local cattle, because of the large size of the former, it is necessary to find out the economics of producing each of these breeds. The objective of this work therefore was to compare the profitability and efficiency of N'dama and Zebu cattle production systems in Southern Ghana.

**Materials and Methods**

The objective of the present methodology was to model the life cycle production of a breeding cow and growth performance of her offspring in N'dama and Zebu cattle. The models apply to the situation in southern Ghana, and parameters originated from a variety of sources in Southern Ghana\(^11\). Under such circumstances, it is necessary to define the production and marketing systems of the breeds involved and to identify all the sources of income and expenses in the smallholder herd\(^12\,^13\,^14\,^15\).

**Production and Marketing System**

Five classes of stock were defined: calves, heifers, bullocks, cows and replacement heifers. Two growing stages were distinguished for the calves of cows: (1) from birth to weaning at 6 months, and (2) from weaning to mature age at three years. Table 1 shows the weight distribution by sex for age of the classes of animals, from which the growth rates of all classes of cattle were derived. Growth rates at their respective stages of growth (birth to weaning, and weaning to mature weight at 3 years) were assumed to be linear.

All male calves are castrated after weaning to avoid the problem of separating males and females into different herds. The castrated male calves shall be referred to as bullocks in the rest of the text. Heifer calves would be kept until culling takes place prior to mating at about 26 and 34 months, respectively, in N'dama and Zebu heifers. Surplus heifers and bullocks would be sold for slaughter at 3 years of age, i.e. the time taken for cattle to reach maturity was assumed to be the same for the two breeds. Thus, the weight of heifers and bullocks sold was taken as their expected weight for their age. Culled cows would be disposed off at 90% of the expected weight of marketed heifers\(^16\), since the dressing percentage is slightly higher for finished cattle than for culled cows\(^17\).

Dressing out percentage for N'dama and Zebu were taken to be 50 and 46% respectively. These were assumed to be the same for different classes of cattle of the same breed. It was also assumed that the saleable price of beef carcass of the different classes and breeds of cattle are the same on per kilogram basis.

N'dama and Zebu heifers were assumed to be mated at 26 and 34 months of age to calve for the first time at 35 and 43 months of age, respectively. Mating was not restricted to any season of the year. A calving rate of 74% and 76% was assumed for N'dama and Zebu, respectively, with calving taking place throughout the year. Rebreeding occurred 7 months after calving, i.e. one month after weaning.

An average productive life of 8 years (96 months) was assumed for both N'dama and Zebu cows in this study\(^16\,^19\). When their respective age at first calving (see above) was added to their individual productive life, the average cow on completion of productive life would be 10.9 years or 131 months (N'dama) and 11.6 or 139 months (Zebu). Considering a calving interval of 16 months for each breed,
each cow in both breeds will reach its seventh parity before being culled, when the complete replacement of the cow takes place. However, it was also assumed that a cow rears its seventh parity calf for 6 months (when the calf is weaned) and stays in the herd for an additional one month for reconditioning before it is sold off completely. The cow was then assumed to be replaced by one heifer.

Calf mortality up to weaning was assumed to be 15 and 25% for N'dama and Zebu respectively. From weaning until slaughter in heifers and bullocks, mortality was assumed to reduce to 5 and 15% in N'dama and Zebu respectively. Mortality in the breeding cow was also assumed to be 5 and 15% for N’dama and Zebu respectively. This assumption is particularly reasonable, when a cow herd of size n is considered. Although cow mortality was accounted for by replacement heifers, a dead cow was assumed to have no value\(^{20}\).

The feeding regime assumed was that of cattle grazing unimproved natural pastures. It was assumed that feed was available throughout the year for grazing, and no supplementary feed was provided. It was also assumed that seasonal effects had no influence on quality and quantity of natural pastures. This means that seasonal effects had no influence on animal performance. Although there is presently no cost associated with natural grazing pastures, because farmers do not cultivate or improve these pastures, food cost was assumed in this work because it is anticipated that in future farmers would have to cultivate pastures, and/or improve the natural grazing pastures.

Labour was provided by the Fulani herdsman, whose main duty is to graze cattle, build the kraal and assist in handling animals in case of any veterinary interventions. The labour cost of the Fulani herdsman (adjusted for average herd size in Southern Ghana) was considered fixed, since it was assumed that he is paid cash, equivalent to the value of one marketed heifer each year, whether he works or not. Vaccination of cattle and some veterinary assistance against, for example, traumatic injury and minor diseases were assumed to take place. The costs associated with the marketing of cattle were also assumed to be born by the farmer. These include transportation, loading fees, local levies and taxes involved in meat inspection. Information on these were provided by the Animal Production Department (APD), Ministry of Agriculture, Ghana.

**Identification of the sources of income and expense in production system**

Here, the profit (P) in the smallholder herd was expressed as a function of income (I) and cost (C):

\[ P = I - C \]

The profit equation was expressed by grouping terms by classes of cattle and calculating returns and expenses in one-year yields as:

\[ P = P_{bullocks} + P_{heifers} + P_{cow} \]

where Pbullocks, Pheifers and Pcow are profits from bullocks, surplus heifers and culled cow respectively in the complete life cycle of the breeding cow.

Income was derived from the sum of products of number of sale animals in each class of cattle (bullocks, heifers and culled cow) and the values per individual as follows:

- bullocks x value per individual
- surplus heifers x value per individual
- culled cow x value per cow.

Expenses were derived from food, husbandry, marketing and fixed costs as follows:

- heifers' food intake x cost per kg
- bullocks' food intake x cost per kg
- cows' food intake x cost per kg
- heifers' husbandry cost
- bullocks' husbandry cost
- cows' husbandry cost
- bullocks x marketing cost per individual
- surplus heifers x marketing cost per individual
- culled cow x marketing cost per individual
- labour cost
- initial cost for establishment of business
- interest on investment
The last three items are termed as fixed costs, because they are independent of the level of output. All other costs are known as variable costs because they change with the level of output. The price of beef was assumed at 2600 Cedis per kilogramme for all classes of stock. This information was provided by the Animal Production Department (APD), Ministry of Agriculture, Ghana, and represented the average prices of beef from nine major markets in Accra, the Ghanaian capital. The Cedi is a unit of the Ghanaian currency. Food costs for all classes of cattle were assumed to be the same. This was calculated from information provided by APD, Ghana, on current cost of establishing and maintaining pasture, and dry matter yields of several grass and legume species in Ghana. The latter were obtained from the literature\(^{21,22}\). Daily dry matter (DM) feed requirements were calculated for different classes and breeds based on values obtained from ARC\(^{23}\). The dry matter intake of N'dama and Zebu (figures in brackets) were assumed at 4.7 (5.2); 5.0 (5.5); 6.3 (7.1) kg/day for heifers, bullocks and cows respectively. It was assumed that the feed requirements of the breeding cow covered those needed for maintenance, growth, reproduction and lactation.

The feed intake of heifers and bullocks included that occurring between birth to weaning and weaning to maturity. Intake given above covers the post-weaning period, and the pre-weaning intake was assumed to be equal to half of the post-weaning food intake. Intake of the breeding cow was also assumed to include the pre-cow (from birth to first calving) intake and the active productive life intake. The pre-weaning feed intake of calves was assumed to begin actively in 61 days (2 months) after birth\(^{24}\), since very young calves consume insignificant quantities of forage as they cannot digest a greater intake.

Husbandry costs included castration, drenching, deticking and wound treatment. Information on husbandry costs were provided by the Veterinary Services Department (VSD), Ministry of Agriculture, Ghana (Table 2). The husbandry cost of Zebu cattle was double that of N'dama, because of the susceptibility of the former to trypanosomiasis.

Marketing cost was based on mature saleable weight, assumed to be about 20 Cedis per kilogramme liveweight for all breeds. The pre-weaning husbandry and feed requirements assumed that animals which died did so at the end of the pre-weaning period. Similarly, animals which died at the post-weaning period were counted at the end of this period.

Housing was not costed as the kraal is built of cheap, locally available materials mobilised by the Fulani herdsman. Since the cow was considered a calf from day 1 of birth (when the investment started), the cost of the calf (fixed) and interest on this cost (fixed) were all ignored in the calculations because the costs of a calf relative to that of a heifer or a cow is negligible. The only fixed cost item identified was that of labour.

Economic efficiency was defined as total returns (Cedis) divided by total enterprise costs (Cedis). Biological efficiency was defined in two ways, viz: (1) product output (kg) divided by feed input (kg) and (2) body weight of offspring sold in a year (kg) divided by body weight of the cow (kg).

**Table 1. Distribution of weights (kg) by age for male and female N'dama and Zebu cattle**

<table>
<thead>
<tr>
<th>Trait</th>
<th>N'dama</th>
<th>Zebu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Birth weight</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>6 months weight</td>
<td>94</td>
<td>85</td>
</tr>
<tr>
<td>Mature weight</td>
<td>239</td>
<td>221</td>
</tr>
</tbody>
</table>

Adapted from: (41, 42 & 43)

**Table 2. Value of expenses (Cedis) for production systems**

<table>
<thead>
<tr>
<th>Expense**</th>
<th>Heifers</th>
<th>Bullocks</th>
<th>Cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed (Cedis/kgDM)</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Husbandry (per head per year)</td>
<td>5100</td>
<td>5500</td>
<td>6000</td>
</tr>
<tr>
<td>Marketing (per head)</td>
<td>4500</td>
<td>5000</td>
<td>4000</td>
</tr>
<tr>
<td>(per head)</td>
<td>(6500)</td>
<td>(7500)</td>
<td>(6000)</td>
</tr>
</tbody>
</table>

** = Figuras in brackets and open represent values for N'dama and Zebu respectively.
Results
When the difference between returns and costs was used as an indicator of economic evaluation, the N'dama production system produced more profit per cow per year than Zebu (Fig. 1). The profit per cow per year for N'dama was on average 17% more than that for the Zebu production system. When the price of feed was set to zero (F = 0), profit per cow per year was almost doubled for both breeds (Fig. 1). However, profit per cow per year for the N'dama production system was only about 7% more than that of the Zebu, with the removal of food intake from the objective.

Figure 1. Profit per cow per year in N’dama and Zebu cattle production systems

In terms of economic efficiency, defined as total returns divided by total enterprise cost, the N’dama production system was more efficient than that of the Zebu (Table 3). The economic efficiency for N’dama and Zebu were 31 and 24% respectively. This supports the argument above that the N’dama performs better in economic terms than the Zebu. Biological efficiency, defined as the ratio of product output (kg) to feed input (kg) was just about 2% for both N’dama and Zebu. Biological efficiency was again evaluated based on the amount of body weight of offspring sold, generated by the breeding cow. The N’dama and Zebu cows were capable of generating only about 0.4 and 0.3, respectively, of their body weight in progeny each year (Table 3).

Table 3. Efficiency of N'dama and Zebu cattle production systems

<table>
<thead>
<tr>
<th>Type of Efficiency</th>
<th>N’dama</th>
<th>Zebu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Efficiency</td>
<td>0.31</td>
<td>0.24</td>
</tr>
<tr>
<td>Biological Efficiency¹</td>
<td>0.21</td>
<td>0.22</td>
</tr>
<tr>
<td>Biological Efficiency²</td>
<td>0.38</td>
<td>0.30</td>
</tr>
</tbody>
</table>

¹ = Product output (kg) / Feed input (kg)
² = Weight of offspring sold in a year (kg) / Weight of cow (kg)

Discussions
It can be deduced from the results that although the Zebu is quite larger than the local N’dama cattle, the N’dama performed better in economic terms than the Zebu. The difference in profit between the two breeds regressed towards zero when the price of feed was set to zero. This probably explains why farmers in Ghana prefer the Zebu to the local cattle, although adaptation (survival), which is higher in the local cattle, contributes enormously to the overall profitability of the beef cattle enterprise in Ghana. Presently, most farmers in Ghana do not cultivate pasture, but depend on free natural grazing pastures which are not even maintained i.e. if feed cost is ignored, Zebu cattle appears to look similar to N’dama for profit.

The low biological efficiency (ratio of product output to feed input) values obtained for both breeds show the poor efficiency with which ruminants convert forage into meat. However, it should be recognised that this forage cannot otherwise be used by humans. The validity of biological efficiency as an indicator of efficiency in animal production has recently been questioned.

It was demonstrated that marked differences between systems in the value of the carcass produced and/or feed consumed can lead to poor correlation between the efficiency of ranking systems by biological and economic criteria. In most cases, biological efficiency is
reduced when expressed per unit of a breeding population, (as done here) since the feed required to support breeding females have to be included and for the whole time, not merely when they are being productive. This has been demonstrated in sheep in South Africa. The results of studies conducted illustrated the huge cost (at least 81 to 94% of total food intake depending on reproductive rate of the different genotypes used) of maintaining a ewe flock and indicated that the efficiency of food utilisation of lamb was relatively unimportant when the total amount of food consumed by the ewe-lamb unit is considered. It has also been reported that about 50 – 70% of the total herd food intake is required by the breeding cow herd. In the present study, cow’s food cost accounted for 54 and 57% of total enterprise food cost of N’dama and Zebu respectively. In addition to the reasons given above, assessment of the efficiency with which feed is used by the animal population has to take into account the feed used to produce replacement breeding stock and losses of animals due to diseases. All of these lead to reduction in efficiency. Even where efficiency is used as the basis for assessing breeding objectives studies have warned that although the effect of genetic changes in performance on biological efficiency can be used as the basis, the breeding objectives must be determined finally by effects on economic efficiency.

The 0.4 and 0.3 biological efficiency values (amount of body weight of offspring sold, generated by the breeding cow) obtained for N’dama and Zebu cattle respectively are also low compared to the 0.7 reported by Speeding. This reflects the results of relatively low reproduction and survival rates of the breeds of cattle evaluated, and the conversion of grass to meat (calf) with the loss of energy at each stage of the process. Measures of biological efficiency which relate meat production to dam liveweight assumes a constant relationship between dam liveweight and input costs, of which the most important are commonly feed costs. Biological efficiency measured in this way is therefore known not to be useful when comparisons are made across species, and may also be questionable when comparisons are made between systems within species.

The superiority of N’dama cattle to the Zebu raises the question why farmers and scientists alike are looking for bigger breeds in the tropics. Breeding cattle in the tropics has always focused attention on growth traits (e.g. 36). Surprisingly, this work has demonstrated that the size of the animal per se may not be an important determinant of profit or efficiency. This is supported by the work done recently by. This work demonstrated that in terms of economic units, survival is the most important trait in beef cattle herds in Southern Ghana, followed by reproduction, with growth rate ranking the least important. Similar results to this work in small ruminants have been obtained in Nigeria and South Africa.

Conclusion

This work has demonstrated that the performance of N’dama in economic units is better than that of the Zebu in a tsetse infested zone. Since it is very expensive to control trypanosomiasis, increasing the numbers and performance of cattle which are naturally resistant to the effects of trypanosome infection would provide an alternative and sustainable potential control option for the disease. This is consistent with the view of some proponents that breeding programmes in the tropics will only be successful when stresses are controlled (e.g. 38,39,40). It is therefore reasonable to suggest that consideration should be given to the use of trypanotolerant breeds of cattle in tsetse-infested areas of Africa.

References


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SHORT COMMUNICATION

NEWCASTLE DISEASE IN BOTSWANA, 1989 – 1993

M.G. BINTA, E.K. ADOM and E.Z. MUSHI
National Veterinary Laboratory Private Bag 0035, Gaborone Botswana.

A total of 97 outbreaks of Newcastle Disease (ND) were reported to the National Veterinary Laboratory in the period between 1989 and 1993. A major outbreak of this disease was noted in 1993.

Newcastle is the commonest disease of chickens. It is also the most feared because it has a mortality of 100% in affected flocks\(^2\). This disease has been reported in Botswana before\(^5\).

The objective of this study was to monitor subsequent outbreaks by virus isolation from the affected chickens between 1983 and 1993. Also, the postmortem lesions and clinical signs observed in the chickens presented to the National Veterinary Laboratory were studied.

Virus isolation was done as described before\(^6\). A total of 97 outbreaks of ND were reported from 1989 to 1993 of which 42.3\% (n = 41) were recorded in 1993 alone (Table 1). The monthly mean was 8.1 \pm 1.6 cases. The mean number of outbreaks for the five-year period was 19.4 \pm 3.3. A major outbreak of this disease was noted in 1993, involving mostly backyard flocks. Progression of the outbreaks was from the old endemic foci, namely the districts of Gaborone, Mochudi, Kanye, Lobatse and Molepolole to new areas. The new foci included Palapye, Mahalapye, Francistown and Tsabong districts (Table 2). The districts of Orapa, Maun and Ghanzi were spared (see map).

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Table 1. Seasonal distribution of Newcastle Disease cases 1989 – 1993

<table>
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<td>1</td>
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<td>June</td>
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<td>1</td>
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<td>7</td>
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<td>0</td>
<td>0</td>
<td>7</td>
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<tr>
<td>Total</td>
<td>23</td>
<td>21</td>
<td>9</td>
<td>3</td>
<td>41</td>
<td>97</td>
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<tr>
<td>% Year Total</td>
<td>23.7</td>
<td>21.6</td>
<td>9.3</td>
<td>3.1</td>
<td>42.3</td>
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</tbody>
</table>
The seasonal distribution pattern showed a higher prevalence during the warm months of September to October (Figure 1) for the 5-year period.

Figure 1. Seasonal distribution of Newcastle disease cases 1989 – 1993

The most consistent clinical signs were those pertaining to the nervous system, namely paralysis of the wings and legs, convulsions and torticollis. A greenish diarrhoea, proventricular and intestinal haemorrhages were common findings.

The reasons for the outbreak of this disease were various. It is possible that the virulent (velogenic) strain of ND was in circulation among scavenging unvaccinated backyard flocks. These formed a susceptible population of chickens.

This observation has been reported before\(^4\). Aerosol and mechanical transmission of the virus could have assisted in dissemination of the virus along the railway line to the northern town of Francistown. The ND virus has been known to persist among immunised groups of chickens\(^5\). Also free-flying birds and ducks can spread the virus to susceptible populations of chickens. Considering that most indigenous birds are not vaccinated, the above mode of virus spread in this study could not be ruled out.

In this study, most of the outbreaks were recorded during the warmer months September – October, (See Table 1) thus concurring with the observations of other workers\(^6\).

It is therefore suggested that vaccination of backyard flocks and restricted movement of chickens during outbreaks are imperative in curbing the spread of the disease. Also the possibility of serological monitoring of flocks to assess the bird’s antibody levels to ND virus should be explored.

Acknowledgement

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References

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Studies of *Toxocara vitulorum* in domestic bufallo have been carried out fairly extensively in Asia but research into *Toxocara spp.* in cattle has been limited. Reports have been made in Australia\(^1\), Nigeria\(^2\), Zimbabwe\(^3\), Kenya\(^4\) and Tanzania\(^5\). It is claimed that *T. vitulorum* infections are responsible for serious economic losses in Nigeria\(^6\) while a study in Tanzania\(^6\) revealed mortalities ranging from 21 – 50% in suckling calves.

Some authorities maintain that the transmammary route is the most important for transmission with little evidence of uterine transmission\(^7\). It has been shown that transmission does not occur among calves reared away from their mothers\(^1\). Other authors\(^8,9,10\) have indicated that uterine infections occur and hence the need for further study on the route(s) of transmission.

Faecal materials were collected from calves under 3 months of age in various herds spread through Kajiado District on the wind-ward and lee-ward sides of Ngong Hills (Figure 1). The wind-ward side is the wettest and most humid and has an annual rainfall of 510 – 760 mm while the other areas are drier with 255 – 510 mm. In all areas, young calves were tethered near the homestead during the day when mature cattle were driven out into open bushes to graze. The calves suckled their dams and never grazed. Faecal samples were analysed for *Toxocara vitulorum* by the McMaster method.

About 500 ml of milk was collected from udders of cows within 3 weeks of calving and analysed using a method modified from Roberts *et al*\(^11\). This modification allowed for larger volumes of milk to be processed while still fresh and at a faster rate. Thus, the sedimentation stage in phosphate buffered saline of Roberts *et al*\(^11\) was bypassed and the aperture size of the filters increased. Hence, the milk samples were directly strained through 250 μm aperture sieve and the filtrate (material left on the filters) was washed into a clean petri-dish using distilled water which had previously been filtered through 25 μm sieves. This material was then examined under a microscope at X 10 and X 40 objectives for the presence of larvae, a process that was facilitated by the motility of the live larvae.

Figure 1. Vitulorum: Map of Kenya showing the area of study in Kajiado District

Point prevalence rates and infection levels of *Toxocara vitulorum* in calves are presented in Table 1. *T. vitulorum* eggs were encountered in all areas surveyed and were commonest (36.6%) among herds on the wetter wind-ward side of Ngong Hills. The levels of infection followed a trend similar to that of prevalence rates so that the highest eggs per gram (E.P.G.) value was 34,000 recorded from a herd on the wind-ward side compared to an E.P.G. of 800 from a herd on the lee-ward side.
Table 1. Prevalence rate and infection levels of *T. vitulorum* in calves faecal samples

<table>
<thead>
<tr>
<th>Area</th>
<th>Number sampled</th>
<th><em>Toxocara vitulorum</em></th>
<th>per cent positive (EPG Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ngong Hills</td>
<td>72</td>
<td>2</td>
<td>(2.8%) (0-800)</td>
</tr>
<tr>
<td>Leeward</td>
<td>41</td>
<td>15</td>
<td>(36.6%) (0-34,000)</td>
</tr>
<tr>
<td>Windward</td>
<td>50</td>
<td>2</td>
<td>(4%) (0-2,200)</td>
</tr>
<tr>
<td>Central</td>
<td></td>
<td>1</td>
<td>(3.3%) (0-700)</td>
</tr>
<tr>
<td>Kaj iado</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Isinya</td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

A total of 52 colostral milk samples were examined nine of which were from the windward side of Ngong Hills where 33.3% were positive for infective larval stage 3 (L3). Samples from the other regions of the district were negative and the overall prevalence rate was 5.8%. Samples that yielded larvae were 2 - 5 days post-partum. The larvae were alive and quite active within the first 24 hours after sample collection during which the analysis was carried out.

Occurrence of *Toxocara vitulorum* infection in calves has been shown in many parts of Kajiado District of Kenya. The prevalence rate and geographical distribution agrees with earlier work\(^{(4)}\) whereby the more humid windward side of Ngong Hills have higher prevalence rates and infection levels than the drier areas. However, the district had been quite dry for the period that the survey was conducted and so prevalence rates may be higher during the wetter and cooler seasons.

An interesting aspect of this work was the isolation of *Toxocara* larvae from early postpartum milk samples. This finding is important in that it establishes the fact that calves acquire infection with L3 transmammarily as they suckle their dams in the early days after birth. Reports have been made regarding the presence of larvae in buffalo milk\(^{(1)}\). The current observation gives support to the observations made from Australian calves\(^{(1)}\) and is the first to be made among cattle in Africa as other workers\(^{(2)}\) failed to observe larvae in milk from cattle in Zimbabwe. They insinuated the *in utero* route of infection. Other reports among cattle are suggestive of the transplacental route without offering enough proof\(^{(3)}\). The current work strongly points to the transmammary route of infection though it does not preclude the transplacental one. The possibilities of developing visceral larval migrans by humans has been discussed\(^{(13)}\) and appears unlikely. The method of larval isolation adopted here is simple and allows for the screening of large samples of milk as opposed to the method previously described.

Acknowledgments

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References


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SHORT COMMUNICATION

EXPERIMENTAL INFECTION OF RABBITS (ORCYTOLAGUS CUNICULUS) WITH TOXOCARA VITULORUM FROM CALVES.

University of Nairobi Department of Veterinary Pathology and Microbiology, P.O Box 29053
Kabete Via Nairobi Kenya.

Use of laboratory animal models for the study of infection with Toxocara vitulorum are limited. Rabbits have been used to study T. vitulorum from buffaloes(1) but with T. vitulorum from cattle, work is limited to two studies(2,3) both of which utilised guinea pigs. It would be useful to establish whether the locally available cheap rabbits can be infected with T. vitulorum from cattle, results of which can be useful for further studies.

Faecal samples were collected per rectum from calves under three months of age from various herds spread through Kajiado District of Kenya. This area is occupied by pastoral communities, and Toxocara vitulorum has been shown to be endemic among cattle(4). The faecal samples were analysed in the laboratory and all positive samples processed to concentrate and obtain T. vitulorum eggs.

Clean eggs were incubated in Petri-dishes with clean water at 28°C. They were constantly aerated and development of the larvae monitored microscopically. Within a period of two weeks the larvae had fully developed as evidenced by their clear outline and movements in the egg shell, they were enumerated using the McMaster chambers and used to infect rabbits orally.

Twelve (12) female rabbits (Orcytolagus cuniculus) of about six months of age were obtained from individuals within the locality of the Veterinary College, Kabete. They were housed indoors in individual cages, maintained on rabbit pellets (Unga Feeds, Kenya Ltd.) and given water ad libitum. They were screened for any faecal parasites, some were found infected with coccidian parasites (Eimeria spp.) for which they were successfully treated using furazolidone.

They were divided into two groups of eight and four each in the first group was infected orally with 25,000 embryonated (larvated) eggs of T. vitulorum by use of a blunt needle and syringe. This dosage is equivalent to 25 eggs/gram body weight. They were then killed for postmortem examination in pairs on day 5, 15, 30 and 40 post-infection (P.I). A similar interval was used for the four uninfected controls which were killed singly.

At postmortem, all body organs were examined for pathological changes and small tissue sections also preserved in 10% buffered formalin for histopathology. The remaining tissues were separately subjected to acid-pepsin digestion. After digestion, each organ material was filtered and larvae looked for from the sediment microscopically at x10 objective.

Grossly, most organs from infected rabbits appeared normal at postmortem. However, at day 30 post-infection, the apical lobes of the lungs exhibited hemorrhagic changes, both the liver and the kidney had tiny milky spots but no masses were felt on palpation.

Positive results of larvae recovery were yielded from the following organs: liver, uterus, lungs, kidneys, spleen and the diaphragm. The larvae were long and slender and often motile. No pathological changes were noted among uninfected rabbit organs.

Histopathologically, no dramatic changes or larval sections were seen among all organs examined. However, certain changes were observed among infected rabbit organs and they may be related to the presence of the migratory effects of the larvae. At day 5 P.I the liver showed mononuclear cell infiltration comprising macrophages, lymphocytes and
eosinophils. This change was observed in the lungs also on day 15 and 30 P.I. The heart also had mononuclear cell infiltration on day 15 P.I. At day 40 P.I, there was slight congestion of the psoas muscles and the kidneys. None of these changes were observed in organs of the control rabbits.

Further observations made during this study are that infections with *T. vitulorum* were possible in rabbits without the need to hatch L₃ from the egg shell and that, oral infections were successful, making stomach intubation unwarranted. Previous experimental infections in rabbits recorded larvae from the liver, lungs and muscles including the heart²¹. The current findings report the presence of larvae in all organs mentioned above¹ and in addition, the uterus, the kidney and the spleen. Thus, larvae are distributed in a wide range of organs and this gives support to the work conducted in guinea pigs²,³. Invasion of the liver appears to be quite rapid, being accomplished within day 5 P.I and this agrees with the report made earlier¹⁰ using *T. vitulorum* isolated from buffaloes. Measurements of the larval sizes were not taken but there was an indication of growth in rabbit tissues in comparison to the L₃ hatched from eggs in vitro. This would agree with the earlier report¹ which recorded larval growth throughout the first infection of rabbits with *T. vitulorum* of buffalo origin. Experimentally, adult female rabbits may therefore serve as “intermediate hosts” in a manner similar to that of cattle where by the neonates get infection by suckling their mothers.

Conclusive evidence to this possibility could be established if infected female rabbits could be mated and resultant bunnies examined for *Toxocara* infestation acquired in utero or transmammarily.

Little work has been conducted on the pathological changes in tissues of laboratory animals infected with *T. vitulorum*. However, pulmonary hemorrhages in mice infected orally with 200 eggs of *Ascaris suum* were recorded⁵. That observation is in agreement with the current findings. Generally, it would appear that the degree of pathogenicity is low in rabbits when infected with L₃ thereby suggesting a successful utilisation of an "intermediate host" to help the parasite reach the final host.

Acknowledgments

The authors are very grateful to DANIDA through the Royal Veterinary and Agricultural College, Copenhagen, for the financial support, and the University of Nairobi, College of Veterinary Medicine, for providing laboratory facilities. Finally Mrs. Ngaii for typing the manuscript.

References


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SHORT COMMUNICATION

MUELLERIUS CAPILLANS INFECTION IN IMPALA (AEPYCEROS MELAMPUS) IN LAKE MBURO AREA IN MBARARA DISTRICT IN WESTERN UGANDA

M. OCAIDO, L. SIEFERT AND S.K. ARUO
Faculty of Veterinary Medicine, Makerere University, P.O Box 7062 Kampala, Uganda

This study was done in Lake Mbuuro Area comprising Lake Mbuuro National Park and ranches adjacent to it. The study area is located in Mbarara district in western Uganda. By 1992, Lake Mbuuro National Park had impala population of 16,185[1]. This is the only park containing Uganda's population of impala. In the ranches adjacent to this park, impala are seen freely grazing and browsing with livestock, especially Ankole cattle and goats. It was against this background that a study was initiated with the major aim being to study transmission of diseases between livestock and impala. But when preliminary investigations were being done, a postmortem was done on a dead impala, which revealed that it had verminous pneumonia due to heavy infestation with Muellerius capillaris. It was therefore decided to carry out a short-term study with the major objective being to determine the prevalence of this lungworm infection in impala.

The study consisted of two parts, namely: detection of first stage larvae (L1) of the lungworms in faecal droppings of impala, and carrying out postmortem examination on impala shot or found dead. The study lasted 12 months. For purposes of collecting fresh faecal droppings of impala from the rangeland, seven study sites with a radius of 150 meters were systematically identified according to animal utilisation patterns. About 2 – 3 fresh faecal samples were collected per study site once every 4 weeks for a period of 12 months. A total of 178 faecal samples were collected. Faecal samples were collected in polythene bags, labelled using adhesive labels and cooled at 4°C using a portable fridge powered by a car cigarette lighter (12 V battery). The samples were then transported to the laboratory and the larvae recovered through the Baerman procedure as described[2]. A drop of iodine was added to kill and stain the larvae. The larvae were identified with the aid of a microscope (x 10 objective) using keys developed by Anonymous[3].

Postmortem examination was done on 16 impala of which 7 were shot and 9 were found dead. Samples of granulomatous lesions of the lungs were removed and preserved in 10% formal saline for histopathological sections. The nodular lesions were incised and impression smears made. The smears were stained with Ziehl-Neelsen's carbol fuchsins and counter stained with 1% aqueous methylene blue for acid fast bacilli. The lungs were systematically opened to recover any adult lungworm.

The results were analysed statistically using z test for proportion.

Lungworm larvae (L1) of the genera Muellerius, Dictyocaulus and Protostrongylus were recovered from impala faecal samples. Details of the results are shown in Table 1. A total of 178 fresh faecal samples were examined in which 61.8% (110) of the faecal samples had lungworm larvae. Muellerius, Protostrongylus and Dictyocaulus larvae were detected in 51.7% (92), 6.2% (11) and 6.7% (12) respectively of the faecal samples examined. There was a very highly significant difference (P<0.003, z=3.12) in prevalence of MuelleriusL1, in faecal droppings of impala than that of Protostrongylus and Dictyocaulus.

The monthly variation of prevalence of lungworm larvae in faecal samples of impala is shown in Figure 1. There was peak prevalence of lungworm L1, in faeces of impala in the April-May and November-October periods. This coincides with the periods of high rainfall (see Figure 1).
Table 1. Results of impala faecal samples to Baerman test for lungworm larvae

<table>
<thead>
<tr>
<th>Month</th>
<th>No. of samples examined</th>
<th>No. with lungworm larvae</th>
<th>No. with Muellerius larvae</th>
<th>No. with Protostrongylus larvae</th>
<th>No. with Dictyocaulus larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>13</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>March</td>
<td>19</td>
<td>16</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>April</td>
<td>16</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>May</td>
<td>17</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>June</td>
<td>10</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>16</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>15</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>September</td>
<td>17</td>
<td>10</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>16</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>November</td>
<td>13</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>December</td>
<td>14</td>
<td>12</td>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Key
No. Number

Figure 1. Monthly variation of prevalence of lungworm larvae in impala faecal samples with mean monthly rainfall (mm) in Lake Mburo Area

Out of 16 impala examined on postmortem, 93.7% (15) of them had verminous pneumonia due to *Muellerius capillaris*. Only one young impala (about 3 months old) found dead was negative. All impala shot were positive, despite some being in a very good condition. The lungs had multifocal subpleural nodular lesions. Some of the lesions showed some degree of calcification when incised. Histopathological sections revealed lungworms lodged in alveolar sacs. In most cases alveolar sacs contained 3 stages of the parasite namely: adults, eggs and larvae. There were foci of marked eosinophilic reaction. Some subpleural alveoli with parasites showed granulomatous reaction. A few areas appeared atelectatic while others were emphysematous with ruptured alveoli. A number of sections had alveoli filled with fibrinous exudate. Necrotic and calcified foci were also seen. Adult worms of the genus *Protostrongylus* were seen in the small bronchioles. The degree of severity of these lesions varied from section to section and from animal to animal.

The adults of *Dictyocaulus* were recovered on the mucosa of the trachea and bronchi in
12.5%\(^{(2)}\) of the impala examined on postmortem. They measured between 8 to 10 cm in length. The prevalence of lungworm infection of impala revealed by postmortem examination was significantly more different (P < 0.01, z=2.52) from the results got when using the Baerman test.

No acid fast bacilli were detected in the impression smears.

This study has shown that impala in Lake Mburo area are infected by three genera of lungworms: *Muellerius*, *Protostrongylus* and *Dictyocaulus*. Both postmortem and Baerman test results have shown that *Muellerius* is the most common lungworm of impala in this area. These results confirm what was reported by Bwagamoi et al\(^{(3)}\) that this worm is prevalent in goats in this area. Both tests show that there were significantly more impala affected with lungworms than those which were non-infected. Postmortem results show that almost all impala are infected with *Muellerius capillaris* with the exception of the young ones (below 3 months old). A similar report has been made by Hammond and Sewell\(^{(4)}\) about this lungworm and impala in South African game parks. Even in Britain, Dunn\(^{(5)}\) reported a high incidence of 98 % of this worm in sheep. Also in Britain in sheep, Jubb and Kennedy\(^{(6)}\) reported that the infection by this worm in young lambs below the age of 6 months is seldomly observed. This is because the infection is gradually acquired when the animals start to graze after being weaned.

The high prevalence of this lungworm infection in susceptible hosts in areas it exists has been attributed to the wide range of intermediate hosts (I.H) which are mainly snails and slugs\(^{(6,6)}\). In this area, on the contrary, land snails and slugs are rare, but preliminary investigations\(^{(7)}\) show that beetles may be playing a major role as intermediate hosts.

This study has shown that peak prevalence of lungworm larvae in impala faeces occurs in April to May and November to December. This coincides with the period of high rainfall. This could be so because rainfall is most likely to be positively influencing the abundance of the intermediate hosts (beetles). Also this time coincides with calving peaks of impala in this area\(^{(8)}\) such that the dams become stressed hence losing their immunity so that encapsulated adults become active and thus laying more eggs which hatch to L\(_1\). From June to August, there was least shading of lungworm larvae in the environment. This could be attributed to the seasonal strong immunity built by the animals thereby encapsulating the worms in the granulomatous tissue. This mechanism may therefore explain the difference of prevalence of lungworm infection in impala given by postmortem and the Baerman test. This is so because the infected animals in a very good body condition do not shed the larvae in their droppings.

The pathogenicity of this infection is unknown. Earlier reports\(^{(5,6)}\) on sheep in Britain say that this worm does not cause clinical disease but diminished weights had been observed. The predisposing effect of infestation of this worm in impala to bacterial and viral infections in this area, should not be overlooked. Further studies are necessary to determine the pathogenic and economic effects of this infestation in impala, goats and sheep in this geographical location.

From the present study and a previous one by Bwagamoi et al\(^{(3)}\), it becomes apparent that, in this area, there is risk of cross-infection of this helminth between impala and goats. This means that if mixed game and livestock ranching is developed in this area, impala will act as a reservoir of this infection to livestock especially goats and sheep. Control measures should therefore be put in place on how to break the transmission cycle either at the I.H or the final host. Further studies are therefore needed to establish the life cycle of this parasite in this place.

**Acknowledgments**

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References


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SHORT COMMUNICATION

MOLLUSCUM CONTAGIOSUM IN THREE HORSES IN ZAMBIA

M.M. MUSONDA¹, R.N. SHARMA¹, G.S. PANDEY¹, J.O. OMAMEGBE¹, A.M. MWANZA¹, E.M. MPABALWANI², Y. NOMURA³, and A. SHIGA³

¹School of Veterinary Medicine, University of Zambia, Lusaka, Zambia
²School of Medicine, University of Zambia, Lusaka, Zambia
³School of Veterinary Medicine, Azabu University, Sagamihara City, Japan

A form of proliferative pox virus lesion similar to human molluscum contagiosum has been reported in the horse[9]. In Zambia the disease was first diagnosed in 3 horses in Chingola District of Copperbelt Province[9]. The condition has since been observed in Kafue District of Lusaka Province (two horses) and Choma district of Southern Province (one horse) very far from the first recorded cases in the country. This paper presents the observations on naturally infected horses in Kafue and Choma districts.

Out of a total of eight horses on a farm in Kafue District, two were affected. One was a six-year old dark grey stallion, (Case 1) and the other was a three-and-a-half-year old chestnut mare (Case 2). The stallion had the condition for seven months whereas the mare had the condition for five months. One of ten horses on a farm in Choma District, a two-year old thoroughbred stallion, was affected (Case 3). The horse had skin lesions for about four months. On both farms there was an adjoining Game Ranch.

In all three cases, the lesions were seen all over the body but were more pronounced on the chest, shoulders, neck and limbs (Fig. 1).

The early skin lesions reported by the owners were small elevated plaques with raised hairs. At the time of examination of horses, the lesions were in an advanced stage; appearing as multiple gray white papules of 1 cm to 3 cm in diameter. Some of the papules were alopecic and covered with gray white keratinised scales.
Skin biopsy samples obtained from all the three horses were fixed in 10% phosphate-buffered formalin, embedded in paraffin, sectioned at 4 μm and stained with Haematoxylin and Eosin, Giemsa's stain and PAS. The samples were also processed for electron microscopy.

Microscopically, lesions were characterised by well demarcated areas of hyperplasia and hypertrophy of cells in the stratum spinosum showing, at places, downward projections into the dermis. The hypertrophied cells contained large intracytoplasmic inclusions, molluscum bodies. The nuclei of the affected cells were pyknotic and centric in location. Inflammatory reaction in the dermis was minimal.

Electron microscopy of the biopsy material revealed viral particles that had typical orthopox virus morphology (Fig. 3). Viral particles of similar morphology have been reported in equine molluscum contagiosum(1,5,6,7).

Gross and microscopic lesions observed in the three horses resembled equine molluscum contagiosum described by earlier workers(3,5,8) and are similar to a skin condition of horses in Kenya called Uasin Gishu skin disease(6,8). The variation in the distribution and gross appearance of the lesions by various workers could be due to age of the lesions at the time of the examination.

Fenner et al(2) have pointed out that orthopoxvirus infection in horses is presumably from a wildlife reservoir. Identification of a natural reservoir of the virus would aid understanding the epidemiology of horse molluscum contagiosum.

References


Figure 3. Typical Pox Virus particles in the cytoplasm of Stratum Spinosum cell X 80,000

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SHORT COMMUNICATION

ABORTIONS DUE TO MALNUTRITION IN CAPRINE IN ZARIA AREA OF NORTHERN NIGERIA

BABAGANA AHMADU*
Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria-Nigeria

The average annual animal protein intake in Nigerian household is about 9.4 kg meat per head which is grossly below the minimum WHO recommendation of 45 kg\(^1\). This shortage is in spite of the country owning about 13 million cattle, over 22 million sheep and about 34 million goats\(^2\). Goats are mainly kept for meat in Nigeria and the goat meat is expected to contribute about 25% of the country’s meat supply by the end of the century. This calls for an increase of greater attention to the country’s goat industry.

Reproductive wastage through abortions due to malnutrition appears to play an important role in decreasing the efficiency of the goat industry in the Zaria area of Northern Nigeria. Malnutrition has for long been recognised as a cause of abortion in goats and it occurs when an animal receives a sub-maintenance ration. Intake of an inadequate or faulty diet may also lead to malnutrition — which may further lead to reproduction failure. This is especially likely with livestock on the Savanna and Sahelian areas of Northern Nigerian pastures where marked seasonality of rainfall results in extremely low marked content of herbage during the dry season. The poor performance of small ruminants in Nigeria, especially during the dry season (November – March) and periods of scarcity has been attributed to inadequate minerals, low protein feeding and total lack of concentration supplementation\(^3\). In 1981, the Nutrition Research Council\(^4\) (NRC) published a report indicating that the goat is more susceptible to abortion than other species of livestock. Studies by Ojo\(^5\) indicated that abortions and stillbirths were higher in goats than sheep and cattle, he suspected poor nutrition as being responsible. Abortions due to malnutrition in goats have been documented to cause significant losses to the goat production industry due to infertility, kid losses and prolonged breeding periods\(^6\).

A lot of research studies relating to abortion in goats has been done with Angora goats in South Africa\(^6,7,8\). These studies associated malnutrition of the foetus with abortions. More recent studies on abortion in West African Dwarf goats associated adverse nutritional conditions with “stormy” abortion in 52 experimental does\(^6\). Generally, the study of abortion in Nigerian livestock appears to receive very little attention. As a result, very little or no data is available on the incidence of nutritional abortions in caprine in the Savanna and Sahelian areas of Nigeria. The objective of this study is, therefore, to conduct a survey through necropsy and clinical case records so as to establish the preliminary information on the incidence of abortions in goats as a result of malnutrition in the Savanna and Sahelian grazing areas of Northern Nigeria. Possible ways of prevention and control of the losses due to this condition will be suggested from the information gathered.

The data utilised in this study were obtained from necropsy records of the postmortem: room of the Department of Veterinary Pathology and Microbiology, Faculty of Medicine and the Veterinary Teaching Hospital. Ahmadu Bello University, Zaria. Oral interviews and discussions were also held with the staff of the Veterinary Clinic, Zaria City, and some veterinary clinicians at the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria, as well as the National Animal Production Research Institute (NAPRI) Zaria.

*Present Address: University of Zambia, School of Veterinary Medicine, P.O. Box 32379, Lusaka, Zambia.
The records from January 1977 to December 1993 showed that about 7,207 animals were presented for postmortem examination, out of this number, about 744 (12%) were goats. More than 25% of the goats were reported to have died of nutritional diseases: either some form of tumor or unspecified conditions. The record showed that deaths due to nutritional diseases were more or highest during the months of November to March. The highest incidence was during the year 1977 while the lowest incidence occurred in 1981. Cases of decomposed and experimental animals as well as inconclusive diagnosis were not included. The results or outcome of the oral interviews with the veterinary field officers appeared not to be very reliable as records were poorly kept at both clinics and the officers in charge could not recall precisely how many cases were encountered during the period under study.

Records from January 1977 to December 1993 showed that of the 7,207 goats presented for postmortem examination, 744 (about 12%) were goats and about 25% of this number were diagnosed to have died of nutritional diseases, some form of tumor, and unspecified conditions. The monthly incidence of the death due to nutritional diseases revealed that many cases of death due to conditions associated with starvation were encountered during the periods of November to March – which corresponds to the period of feed scarcity in the dry season. Although cases of abortions were low, it is widely believed that most cases were not reported as most experts within the area under study concurred that abortion and stillbirths were responsible for the poor reproductive performance in small ruminants, especially goats. The same author commented that nutritional abortion of goats are insidious and are significant in animal production in the Savanna and Sahelian grazing areas of Northern Nigeria. Many cases of abortion in sheep, goats and cattle were reported from several districts of the former north western States during the early 1970 but the immediate causes were not documented. Undernourishment was, however, among the major conditions suspected. The insidious occurrence of nutritional abortion in the area could be attributed to the unscientific approach to animal feeding especially during pregnancy which may lead to reproductive wastage resulting from either dystocia due to absolute foetal oversize as a result of a high level of feeding throughout gestation or from abortion and neonatal death due to low birth weight resulting from malnutrition during pregnancy. The Zaria area of Northern Nigeria experiences seasonal fluctuations in both quantity and quality of feed. In the rainy season, there is abundance of high quality feed/forage but since this is not preserved there are dry season deficiencies. Though goats are well adapted to survive under dry situations mainly by browsing, the forage available is of low quality during the dry season and hence cannot meet their maintenance requirements especially during pregnancy and lactation.

Conclusion

At the present level of animal husbandry and management in Zaria, Nigeria, poor nutrition plays a leading role in the incidence of abortions and stillbirths in small ruminants, especially goats; but most cases appear to be unrecorded or unattended to by qualified personnel. There is need to document all cases of abortions presented to our clinics in the area under study so that more precise and fairly accurate data could be generated in future on the nutritional causes of abortion in goats under the area considered. The goat industry in Nigeria would benefit if does receive the optimum nutrition leading neither to abortion nor foetal oversize.

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SHORT COMMUNICATION

FOETAL WASTAGE THROUGH SLAUGHTER OF GRAVID SHEEP AND GOATS IN NIGERIA

A. O. OKUBANJO

Meat Science Laboratory, Department of Animal Science, University of Ibadan, Ibadan, Nigeria

The population figures for sheep and goats in Nigeria for 1983 were 12.85 and 26.30 million respectively\(^1\) with both species combined supplying 176 thousand tonnes of meat. Over the past few years, there has been a declining trend in per capita meat consumption as increase in human population greatly outstrips that of livestock, particularly of sheep and goat which supplies about 50% of all meat consumed in the humid zone of Nigeria.

Of the many constraints to small ruminant production for meat in West Africa\(^2,3,4\), foetal wastage through slaughter of gravid small ruminants appears to be one not often noticed even though the potential number of young animals and the resulting income lost to the farmers are immense.

In this study at Bodija Abattoir, Ibadan, Nigeria foetal sample collection was carried out between 6.00 am and 11.30 am for 16 days which were selected at random over the period from January to May, 1985. Following the traditional methods of dressing sheep and goat carcasses, the number of gravid animals were obtained through visual observation and palpation of the excised uteri. Data was collected on the total number of both species slaughtered on the collection days. Slaughter data were also collected for the years 1983 to 1985 through records kept by the veterinary staff at the abattoir.

The foetus was separated from every third gravid uterus. Foetal age was determined by reference to the developmental horizons as outlined by Cloette\(^5\) taking into consideration that the gestation periods in both animal species are similar\(^6\).

Virtually all sheep and goats slaughtered at the abattoir are of the Yankassa and Ouda breeds of sheep and Red Sokoto breed of goats. The total number of these animals slaughtered daily is affected by the total arrival figures for sheep and goats at the adjoining stock yard from the northern states where about 75% of the national sheep and goat population is concentrated\(^7\). Slaughter figures for both species inclusive for 1983, 1984 and 1985 were 34,504, 23,884, and 67,328. For the same periods, slaughter figures for sheep accounted for 12.80%, 23.60% and 21.49% respectively while those for goats were 87.20%, 76.40% and 78.51%. Mean values for the three-year period were 19.30% and 80.70% or a ratio of 1:4 for sheep and goats. The sharp contrast to the national sheep to goat population of 1:2 indicates a strong preference for goat meat in this part of Nigeria.

Daily slaughter of both species during the 16 sampling days varied from 154 to 214 with the percentage of observed gravid animals varying from 8.04% to 12.43%. Of the total slaughter figure of 3,063 animals during the sampling period, 304 or 9.92% were observed to be gravid. When the observed wastage was partitioned into four quarters over the full gestation period, 13.95% of the observed wastage occurred during the first quarter while the highest wastage of 39.53% occurred during the third quarter. Both second and fourth quarters showed a wastage of 23.26% each.

A foetal wastage equivalent of 9.92% of the slaughter stock was however only apparent as some animals in their first quarter of the gestation period must have escaped detection as a result of the mode of collection and general conditions at the abattoir. Appreciable weight changes in the foetus and associated membranes and fluids during gestation of single lambs occurs.
only after the second trimester\(^{(6)}\), while two thirds of foetal growth takes place during the third trimester\(^{(9)}\). Visual antemortem detection of pregnancy should therefore be more definitive during the third and fourth quarter gestation periods. Yet 63\% of the observed wastage occurred during these periods.

Based on slaughter data for 1985, a total of 6,690 animals of both species were gravid resulting in the loss of an equal number of potential single lambs and kids. Correcting for an average litter size of 1.43 in the West African breeds\(^{(10)}\) and the fact that an additional equivalent of 25\% of the official slaughter data for small stocks in government abattoirs are slaughtered in private households\(^{(11)}\), the foetal wastage for 1985 alone at Ibadan approached almost 12,000 potential young. Apparent wastage nationwide must therefore assume great proportions.

Other losses involve drastic reduction in the dressing percentage of gravid animals, loss of feed utilised in the formation of the foetus and associated membranes, loss of quality in the meat, loss of monetary value for the tissue so discarded from the gravid animals and the loss of the traditional role of such potential young animals as investment against crop failure. Improved surveillance at local sheep and goat markets and of ante-mortem inspection could reduce the observed wastage. Additionally, detected gravid animals could be saved and maintained until after parturition and weaning.

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RECOMMANDATIONS AUX AUTEURS

Objet
Le Bulletin de la Santé et de la Production animales en Afrique contient des articles de recherches originales traitant d'activités en matière de santé et de production animales visant à assurer le développement de l'industrie animale et une meilleure utilisation des ressources du bétail en Afrique. Le Bulletin est un périodique trimestriel.

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

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

Genres d’articles publiés dans le Bulletin
— des communications originales
— des brèves communications
— analyse des articles proposée par le Rédacteur
— des éditoriaux
— le courrier des lecteurs
— analyse d’ouvrages
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Format des articles
Les manuscrits doivent respecter les conditions suivantes :
Le titre doit être concis et ne pas dépasser plus de 15 mots, il est suivi du (des) nom(s) de l’auteur (ou des auteurs) et des établissements ou le travail a été effectué, ainsi que de l’adresse pour les correspondances si elle n’est pas la même.
Le résumé ne doit pas excéder 200 mots. Son texte bref et concis comprendra les principaux résultats et la (les) conclusion(s) de l’étude.
L’introduction expose le but de la recherche.
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