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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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# ORIGINAL ARTICLES

1. Survey of Zoophilic Dermatophytes from Symptomatic and Asymptomatic Horses in Nigeria — C.A.O. ADEYEFA ........................................... 219
2. Clinical and Pathological Studies on Lumpy Skin Disease Firstly Recorded in Egypt — M.A.M. HAFEZ, A.M. TAWFIK, MAYSA, H.M. SHAKER & N.A. EL-DANAF ................................................................. 225
3. Observation of the Pathology of Natural Eimeria Infections in Kids in Kenya — S.M. GITHIGIA, W.K. MUNYUA & P.W.N. KANYARI ......................................................... 235
4. Sarcoptic Mange Infestation in Goats — D.M. KAMBARAGE .................................................. 239
5. An Investigation into the Heat Stress Suffered by Imported Holstein-Friesian cows in the Humid Tropics — J.D. KABUGA & K. AGYEMANG .................................................. 245
6. Effect of Supplementary Phosphorus and the Source of Nitrogen on Food Intake and Growth Performance of Wether Sheep — J.P. ALAWA .................................................. 253
7. Forage Utilization by Dairy Goats — M.S. BADAMANA .................................................. 259
8. Some Factors Affecting Diet Digestibility in Goats — M.S. BADAMANA .................................................. 267

# SHORT COMMUNICATIONS

10. Ectoparasites of Pigs in Tanzania — D.M. KAMBARAGE .................................................. 281
11. Prevalence of Eimeria Species in Goats from Parts of Central Kenya — S.M. GITHIGIA, W.K. MUNYUA & P.W. KANYARI .................................................. 283
SURVEY OF ZOOPHILIC DERMATOPHYTES FROM SYMPTOMATIC AND ASYMPTOMATIC HORSES IN NIGERIA

C.A.O. ADEYefa
Department of Veterinary Medicine, University of Ibadan, Ibadan, Nigeria

ETUDE DES DERMATOPHYTES ZOOPHILTIQUES DES CHEVAUX SYMPTOMATIC ET ASYMPTOMATIC AU NIGERIA

Résumé

On a fait état d’une étude des dermatophytes zoophiliques affectant les chevaux au Nigeria. Treize espèces de dermatophytes ont été isolées des éraflures de peau entamés des chevaux symptomatiques et asymptomatiques. L’isolement de Epidermophyton floccosum et Blastomyces dermatitidis de la peau des chevaux a été signalé pour la première fois au Nigeria. Les conséquences dans les domaines vétérinaire, médical et économique des dermatophytes zoophiliques provoquant la dermatomycose chez l’homme et les animaux sont discutées.

Summary

The results of a survey of Zoophilic dermatophytes affecting horses in Nigeria are reported. Thirteen species of dermatophytes were isolated from skin scrapings taken from symptomatic and asymptomatic horses. The isolation of Epidermophyton floccosum and Blastomyces dermatitidis from the skin horses is being reported for the first time in Nigeria. The Veterinary, medical and economic importance of zoophilic dermatophytes causing dermatomycoses in man and animals are discussed.

INTRODUCTION

Dermatomycoses are among the oldest and best recognised mycoses. The causative fungi, the dermatophytes are keratinophilic, parasitising the keratinized epithelium, hair, nails of man and hoofs of animals[1].

The Zoophilic dermatophytes affect animals while the anthropophilic species affect man but some members of genera Trichophyton and Microsporum are zoonotic affecting animals and man[2,3].

There has recently been a notable awareness among Polo horse owners and handlers of the increase in the incidence of dermatomycoses or ringworm infections particularly during Polo tournaments when horses from different parts of the country congregate for a week or more. The increase in incidence of dermatomycoses gave some horse owners concern over their valuable animals particularly in case of recurrent infections.

The purpose of this study is to document the incidence of dermatomycoses as well as the species of dermatophytes involved among the established horse populations in Nigeria.

Materials and Methods

Over a 3 year period in January 1989, 1990 and 1991 during the annual Ibadan Polo tournament horses from Lagos, Kaduna, Kano, Jos as well as resident horses were examined for evidence of dermatomycoses. These comprised 210, 230 and 286 horses in 1989, 1990 and 1991 respectively. Similarly during a 6 week stay in the north of the country in May - June 1991 equine establishments and private stables were visited in Kaduna, Kano, Jos, Abuja and Maiduguri. Prior to this, resident horses at Ibadan Polo Club stables, Lagos Polo Club stables and Nigerian Police Mounted Troop stables at Ikeja and Obalende in Lagos were also examined in March 1991.
A total of 946 horses were examined in Ibadan during 1989, 1990 and 1991 tournaments while 807 horses from 7 different towns were examined from March - June 1991. The horses were predominantly males, their ages ranged from 2 months to 23 years and consisted of Dongola, Sudanese, Arab, Chadian, Argentine, Thoroughbred, crossbreds and some unidentified breeds.

Of all the animals showing evidence of dermatomycoses skin scrapings were taken from only 10 horses showing active lesions of dermatomycoses from 2 recovered cases and from 5 asymptomatic horses for direct microscopic examination with 10% KOH and lactophenol cotton blue and for culture. The methods of examination and culture have been previously reported\(^4,5\). Briefly, the skin scrapings were inoculated into sterile petri dishes containing potato dextrose agar and incubated at 35°C for 5-7 days. Primary isolates were then obtained by subculturing the organisms in malt extract agar and Czapek dox agar. Identification of the organisms was based on colonial morphology and the characteristics of their macro and micro-conidia as previously described\(^1,2,3,6\).

Photomicroscopy was done with Carl Zeiss Jeriaval Research Microscope (W.

Germany) with mf — AKS Photomicrographic equipment using Agfa 40 ASA Din 20 film.

**Results**

In 1989, 1990 and 1991 only 24, 15 and 33 horses respectively showed lesions of dermatomycoses out of the 210, 230 and 286 horses examined in Ibadan during the annual tournaments in those years, indicating an incidence of 11.4%, 6.5% and 11.57% respectively. However, of the 807 horses clinically examined between March and June 1991 in the various equine establishments visited only 108 (13.4%) were infected (Table 1). The highest number of infected horses came from Lagos probably due to the larger number of horses examined there (over 50%). However, highest incidence of 36.2% was seen in Ibadan. This was followed by horses from Lagos with incidence of 8.9% and the least incidence of 5.05% was recorded in horses from Maiduguri.

Eight of the 10 skin scrapings from clinically infected horses were positive for fungal elements by direct microscopic examination while all the scrapings from clinical and asymptomatic cases were positive for one fungal organism or the other on culture. No growth was found in

### Table 1: Total number of horses examined, number with mycotic lesions and the equiestrian establishments visited in March-June, 1991.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Total No.</th>
<th>No. with skin Lesions</th>
<th>% incidence</th>
<th>Polo clubs</th>
<th>NPF mounted Troop</th>
<th>Nig. Army NDA</th>
<th>Race Course</th>
<th>Private University stables</th>
<th>Vet. Teach. Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lagos</td>
<td>414</td>
<td>37</td>
<td>8.9</td>
<td>353</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Ibadan</td>
<td>69</td>
<td>25</td>
<td>36.2</td>
<td>49</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Kaduna</td>
<td>139</td>
<td>8</td>
<td>5.8</td>
<td>79</td>
<td>35</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Kano</td>
<td>251</td>
<td>14</td>
<td>5.6</td>
<td>65</td>
<td>26</td>
<td>1.5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Jos</td>
<td>160</td>
<td>13</td>
<td>8</td>
<td>40</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Maiduguri</td>
<td>178</td>
<td>9</td>
<td></td>
<td>138</td>
<td></td>
<td></td>
<td></td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>7. Abuja</td>
<td>26</td>
<td>2</td>
<td>7.7</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
M. nanum, M. audouini, Epidermophyton floccosum, Keratinomyces ajelloi, Blastomyces dermatitidis, Aspergillus fumigatus, A. flavus and Candida albicans. It is note worthy that the isolation of Epidermophyton floccosum and Blastomyces dermatitidis from infected horses is being reported for the first time in Nigeria. Figure 2 shows the macroconidia of E. floccosum while Fig. 3 shows the double cell of the final stage of budding in the yeast form of B. dermatitidis. Fig. 1 shows the typical lesions of dermatomycoses as previously reported(4). T. mentagrophyte, T. equinum, M. canis and Aspergillus species were isolated from all the skin scrapings. A few mites identified as Psoroptes equi and lice identified as Haematopinus equi and Damanila equi were also encountered in the direct microscopic examination of skin scrapings. Other cases observed were streptothricosis (one), photosensitisation (five), papillomatosis (three), cutaneous habronemiasis (two) and several harness sores.

Discussion

The above results showed an incidence of 13.4% in the horses examined between March and June 1991 with a range of 5.0-36.2% incidence in the various equine populations visited. Lesions were found on animals of all ages, breeds and sex. In man sex, age, race and occupation have little or no differential influence on the frequency, occurrence or distribution of dermatophytosis(6) as observed in the present studies, although the animals examined were predominantly males.

Dermatomycosis is one of the commonest skin disorders of horses which may bar them from equestrian activities such as competitions, sales and pleasure rides. This may result in serious economic losses in terms of revenue and pleasure derived from such activities(4). Dermatomycoses also occur in man and animals(1,2,7,8) and in Nigeria, Shrank and Harman(9) and Adetosoye(7) have reported the isolation of several species of

Figure 1: Lesions of dermatomycoses on the skin of a horse.

Figure II: Macroconidia of Epidermophyton floccosum x 100.

Figure III: The double cell of the final stage of budding in the yeast form of Blastomyces dermatitidis x 100.

the scrapings from treated and the recovered animals.

A total of 13 species of dermatophytes were isolated. These include Trichophyton mentagrophyte, T. equinum, T. rubrum, Microsporum canis, M. gypseum,
zoophilic dermatophytes from human patients including *Trichophyton, Microsporum* and *Epidermophyton* species. The infection is thus of veterinary, medical and economic importance. In view of this it is reasonable to suggest a coordinated veterinary, medical and economic survey to establish the extent of this problem in the country with a view to improving the methods of its treatment and control and to enhance the usefulness of valuable animals. The disease is spread by direct contact while close proximity between man and companion animals (horses, dogs and cats) highlights the zoonotic importance of the infection. Of the 13 species isolated in the present study at least 6 species(7) have been reportedly isolated from human patients in the low economic groups who kept dogs and cats at home as did the horse handlers in the stable blocks where they live. This fits into the epidemiology of the infection whose rapid spread is further enhanced by warmth, high humidity, sweating(7), dirty environment and favourable nitrogen nutrient sources in the skin of patients(6) all of which are not only adequately present but also play a significant role in the epidemiology of this infection in Nigeria. This is particularly the case in Ibadan Polo stables where the incidence is highest. Cleanliness and high standard of hygiene in man and animals are thus of paramount importance in the control of the infection.

It is noteworthy that *Epidermophyton floccosum* and *Blastomyces dermatitidis* were isolated from infected horses in this study. This to the author’s knowledge is the first time these species would be reported in horses in this country. *E. floccosum* is essentially an anthropophilic dermatophyte that infects toenails and hairless areas in man and it is not known to infect domestic animals(11). The isolation of this species in the horse is very significant and further reinforces the danger of close contact between horses and man. *B. dermatitidis* on the other hand lives saprophytically in the soil and causes a chronic granulomatous disease frequently involving the lungs with subsequent spread to the skin and other visceral organs(1,2). It is probable that isolation of this organism from the skin of the horse may be due to the animal lying down on the ground and beddings. *Candida* and *Aspergillus* species have also been isolated and incriminated in diseases of animals(10,11).

The number of horses examined in this study does not reflect the exact populations of horses in Nigeria. They represent only the animals to which access was granted. Also the list of organisms isolated is by no means exhaustive. Other species especially the ascomycetous stages of *Trichophyton* and *Microsporum* species could be present in the cultures and inability to identify them may be due to mutations whereby the new mutants lack the basic characteristics of the original species. Further studies may be necessary to fully document the species of zoophilic and anthropophilic dermatophytes affecting animals and man in Nigeria.

**Acknowledgements**

The author is grateful to Dr. Wale Ogundeko formerly of Department of Botany and Microbiology, University of Ibadan now in Ogun State University Ago-Iwoye for assistance in culturing the organism, to Prof. A.I. Adetosoye of Department of Veterinary Microbiology and Parasitology, University of Ibadan for assistance in identifying some of the dermatophytes, to Dr. N.O. Funsho, Novat Animal Hospital, Kano, Dr. Adedokun, Nigerian Defence Academy Equestrian Unit, Kaduna, Dr. Hart, Nigerian Police Mounted Troop, Maiduguri, Mr. F. Alagba, Nigerian Police Mounted Troop, Abuja for arranging access to horses in some of the equine establishments visited in the North.

**References**

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CLINICAL AND PATHOLOGICAL STUDIES ON LUMPY SKIN DISEASE FIRSTLY RECORDED IN EGYPT

M.A.M. HAFEZ, A.M. TAWFIK, MAYS A, H.M. SHAKER and N.A. EL-DANAF
Animal Health Research Institute, Dokki, Egypt

ETUDES CLINIQUES ET PATHOLOGIQUES CONDUITES POUR LA PREMIERE FOIS EN EGYpte SUR LA DERMATOSE NODULAIRE CONTAGIEUSE BOVINE

Résumé

Dès signes caractéristiques de la dermatose nodulaire contagieuse bovine sont apparus chez les Holstein-Friesian dans une ferme d’engraissement dans le Gouvernorat de Suez et chez les bovins indigènes appartenant à des exploitants agricoles dans le Gouvernorat d’Ismailia. Les symptômes étaient plus apparents chez les veaux nouveau-nés. Le taux de morbidité variait entre 7,22 et 16,93% sans aucun cas de mortalité. Des nodules cutanés étaient répandus sur tout le corps, affectant les tissus mous comme la mamelle, la vulve et le scrotum.

Trois bovins: un Holstein-Friesian et deux bovins indigènes, ont été abattus d’urgence. Par ailleurs, on a effectué la biopsie de la peau d’un veau malade ayant la fièvre aux fins d’examen histopathologique. Les changements histologiques observés pour la peau, le nodule intradermique, les ganglions lymphatiques, la rate, le foie et les reins ont été analysés. On a aperçu l’inclusion éosinophile intracytoplas- mique dans l’épiderme de l’un des quatre cas examinés.

Les signes cliniques et pathologiques de la dermatose nodulaire contagieuse bovine sont exposés et discutés. Il s’agit du premier cas de cette maladie constaté en Egypte.

Summary

Typical signs characteristic of lumpy skin disease (LSD) appeared on Holstein Friesian cattle in a fattening farm at Suez Governorate and in native breed cattle belonging to farmers at Ismailia Governorate. The clinical picture was more severe on newly-born calves. The morbidity rate changed between 7.22 and 16.93 without mortality. Skin nodules were scattered all over the body, affecting soft tissues such as udder, vulva and scrotum.

Three cattle, one Holstein Friesian and two native breed cattle, were emergency slaughtered. In addition, a skin biopsy was taken from a diseased febrile calf for histopathological studies. The histological changes in skin, intradermal nodule, lymph nodes, spleen, liver and kidneys were studied. Eosinophilic intracytoplastic inclusion bodies were seen in the epidermis of one out of the four examined cases.

The clinical and pathological picture of the disease are illustrated and discussed. This is considered to be the first record of the disease in Egypt.

INTRODUCTION

Lumpy skin disease is caused by a capripoxvirus affecting cattle. The disease is characterized by fever and large numbers of intradermal nodules of varying size which later undergo necrosis. In severe cases, skin lesions can be accompanied by superficial lymphangitis, lymphadenitis and oedema of the legs (Losos, 1986).

The disease was first recognized in Northern Rhodesia (Zambia) in 1929. It was called “Pseudo-urticaria” and was believed to be caused by insect bite. Despite rigid quarantine measures, by 1956 it had spread over most Southern and Central Africa (Henning, 1956). Its spread throughout South Africa was recently discussed by Davies (1981). There is a strong indication that the capripoxvirus may be vectorborne. Thes disease may also spread by direct contact. The morbidity in Southern Africa was usually 50 to 100%, mortality was usually 1% but occasionally could reach 75% (Diesel, 1949).

The post-mortem lesions and the
pathological picture were described by Haig (1957), Weiss (1968), Young et al. (1970) and Schicmann et al. (1971) either in naturally or experimentally infected cattle. Ali and Obeidi (1977) investigated and described the disease in the first outbreaks in Sudan.

Until 1988, lumpy skin disease was not recorded in Egypt. Hence the present study deals with the clinical and pathological aspects of the disease first recorded in Egypt.

Materials and Methods

Clinical signs suggestive of lumpy skin disease appeared on Holstein Friesian cattle in a fattening farm at Suez Governorate as well as on native breed cattle belonging to farmers at El-Tal-El-Kebeer, Ismailia Governorate. The clinical manifestations characteristic of this disease were noted. The causative agent virus isolated at the Animal Health Research Institute (Dokki, Egypt) was confirmed by serology and pathogenicity by Dr. J.A. House at the Foreign Animal Disease Diagnostic Laboratory at the Plum Island Animal Disease Centre, Greenport, N.Y., U.S.A.

Three cattle, one Holstein Friesian and another two native breed, were emergency slaughtered. The post-mortem examination was done and representative samples from cutaneous nodule, lymph nodes, spleen, liver, kidneys and heart were taken and preserved in 10% formol saline.

After 31 days, the diseased native breed cattle at El-Tal-Kebeer were re-examined to follow up the clinical status of the animals. A biopsy sample from a skin nodule of a calf showing severe clinical manifestation with febrile condition was taken for histopathological studies.

The samples obtained were fixed in 10% formol saline and embedded in paraffin, sectioned at 5-6 μ thickness and stained with haematoxylin and eosine (H & E). Tissue sections were also stained by phloxin tartrazin for inclusion bodies, and trichrome stain for collagen fibres according to the procedure adopted by Clayden (1971).

Results

1. Clinical findings:

The data collected during the period from June to November 1988 revealed that lumpy skin disease was accompanied with a morbidity rate of up to 17% with no mortalities among Holstein Friesian and native breed cattle. The disease had no age specificity. The morbidity rate reached 7.22% in Holstein Friesian and 16.93% in native breed cattle (Table I).

The clinical signs included temperature

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Species</th>
<th>Total No. of animals</th>
<th>No. of isolated cases</th>
<th>No. of dead animals</th>
<th>Morbidity rate</th>
<th>Mortality rate</th>
<th>No. of cases subjected to pathological studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suez (Fattening farm)</td>
<td>Holstein Friesian cattle</td>
<td>194</td>
<td>14</td>
<td>0</td>
<td>7.22</td>
<td>0</td>
<td>One cattle emergency slaughtered</td>
</tr>
<tr>
<td>Ismailia (El-Tal-El-Kebeer) (at farmers)</td>
<td>Native breed cattle</td>
<td>1500*</td>
<td>245</td>
<td>0</td>
<td>16.93</td>
<td>0</td>
<td>Two cattle emergency slaughtered</td>
</tr>
<tr>
<td>Ismailia Re-examination 30/11/88</td>
<td>Native breed cattle</td>
<td>1500</td>
<td>245</td>
<td>0</td>
<td>16.93</td>
<td>0</td>
<td>Skin biopsy from a calf</td>
</tr>
</tbody>
</table>

*This number includes the total animals in five closely adjacent villages.
Figure 1: Cow showing subcutaneous nodules scattered all over the body.

Figure 2: Showing circumscribed reddened nodules on the mammary gland and perineal region.
rise to 41°C and some cases suffered from mild respiratory manifestations with serious nasal discharge. In the early stage of the disease, subcutaneous oedema on the limbs and dewlap was seen. The pre-scapular and prefermoral lymph nodes were enlarged. The skin in some areas was thickened and during the developmental stage of the disease cutaneous nodules measuring 1-3 cm in diameter were noted. The nodules were scattered all over the body (Fig. 1). On mammary glands as well as scrotum circumscribed reddened areas were seen (Figs. 2 & 3). The same clinical picture was seen in calves but in a more severe form (Fig. 4).

The animals were symptomatically treated with long acting terramycin then followed by a course of streptopenicillin. In addition, animals suffering from oedema of limbs were treated with 4% iodine ointment. Some cattle were injected with Devidrine Forte (AD3E). Some cases were given Arrhenal for blood parasites and catarin injections for nematodes.

Re-examination of native breed cattle, 31 days after the first examination, revealed the following: in some cases, the subcutaneous nodules had resolved while the skin was still intact. In other cases, the central area of skin underlying nodules were scuffed from the surrounding tissue leaving hypraemic edges with late scar formation (Fig. 5). In few cases, the nodules had a purulent discharge.

2. Post-mortem examination:

Post-mortem examination of both Holstein Friesian and native breed cattle showed thickening of the skin with nodular formation scattered all over the body. The size of the skin nodules ranged from 1 to 3 cm in diameter and were either firm, tender or soft in consistency. Oedema and congestion of the adjacent tissue was noticed. The hair over the central portion of the nodules was erect and the skin at the centre became depressed. The lesions affecting soft tissue such as vulva,
Figure 4: Calve showing cutaneous nodules scattered all over the body.

Figure 5: Cow showing sloughed nodule, scar formation and in some areas nodules have a purulent discharge.
Figure 6: Section of the skin showing degenerative changes in the prickle cell layer stratum basalis is intact (H & E 200 X).

Figure 7: The epidermis showing eosinophilic intracytoplasmic inclusions. (Phloxin tartrazine, 400).
Figure 8: Section of the skin showing oedema and mild diffuse infiltration of inflammatory cell reaction.

(H & E, 40 X).

Figure 9: Blood vessels in the superficial area of the dermis. Hypertrophy of endothelial lining, thickening of adventitia and perivascular cuffing.

(H & E, 200 X).
ration was seen in the deep part of the epidermis near the basal layer. In the dermis, focal and diffuse infiltration by mononuclear cells in the dermal papillae were found (Fig. 8). Oedema as well as degeneration of collagen fibres were also noticed. In the subcutis, there was diffuse and/or focal infiltration by mononuclear cells. Congestion and haemorrhages were evident. The muscle fibres in some areas were necrotized. Vascular degenerative changes and thickening of adventitia as well as perivascular infiltration by lymphocytes and histiocytes were seen (Fig. 9).

The cutaneous nodule was surrounded by dense fibrous connective tissue infiltrated by mononuclear cells. The matrix of the nodule contained inflammatory exudate with massive infiltration by mononuclear cells mainly lymphocytes, histiocytes and plasma cells (Fig. 10). Some areas had focal aggregations with lymphocytes and few neutrophils surrounded with thin fibrous tissue capsule.

The lymph nodes had capsular thickening, hyperplasia of lymphoid follicles and blood vessels were dilated and engorged with blood.

In the spleen, trabeculae were thickened and diffusely infiltrated with mononuclear cells. The trabecular artery was thickened with thrombus formation. Oedema, haemorrhages and slight haemosiderosis occurred around the trabeculae.

In the liver, congestion, haemorrhages and degenerative changes in some hepatic cells as well as mononuclear infiltration were seen.

In kidneys, some glomeruli had capillary congestion. Degenerative changes in the epithelium lining of some renal tubules and haemorrhages were seen.

In the heart, some cardiac muscle fibres occasionally had degenerative changes with intramuscular haemorrhages.

**Discussion**

Lumpy skin disease appeared recently in Egypt in 1988. The clinical signs manifested on Holstein Friesian and native
breed cattle closely resembled those which appeared in cattle during outbreaks in different countries in Africa including Sudan (Ali and Obeidi, 1977). In Egypt, all ages of cattle were susceptible to the infection with a significant morbidity rate.

In the present work, the pathological studies revealed the occurrence of cutaneous nodules on all parts of the body as well as nodular lesions on the udder and scrotum. The gross and histopathological findings in the skin and intradermal nodules were characteristic of lumpy skin disease and were similar to those reported by Ayre-Smith (1960), Jones and Hunt (1983), Yager and Scott (1985) and Losos (1986). Although eosinophilic intracytoplasmic inclusions usually present in epidermis and smooth muscle cells, they did not occur in all lesions or in all affected cattle (Burdin, 1959).

Re-examination of the diseased cattle after a month revealed that the nodules disappeared in many cases from some areas on the body, while others persisted as hard lumps. Some nodules became soft, necrotic and sloughed. The others had purulent discharge. These lesions represented the late stage of the disease as a result of vascular changes. These changes caused necrosis in the epidermis at the top of nodule and as separation proceeded secondary infection of the exposed dermis or subcutaneous tissue might occur (Ayre-Smith, 1960).

The observed petechial haemorrhages in the epicardium as well as petechial haemorrhages and degenerative changes in the liver and kidneys also have been described by Weiss (1963) in association with lumpy skin disease. These lesions usually accompanied the febrile phase of the disease.

Acknowledgement

The authors wish to express their cordial gratitude to Dr. James A. House, for his continuous efforts for LSD confirmation. Also thanks to Dr. S.A. Deeb, for his advice.

References


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OBSERVATION OF THE PATHOLOGY OF NATURAL EIMERIA INFECTIONS IN KIDS IN KENYA

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EXAMEN DE LA PATHOLOGIE DES INFECTIONS NATURELLES PAR EIMERIA CHEZ LES CHEVREAUX AU KENYA

Résumé

Six chevreaux âgés de une à quatre semaines, confirmés comme souffrant d’une infection naturelle par Eimeria ont été euthanasiés et on a examiné les lésions macroscopiques et microscopiques. Les espèces d’Eimeria qui infectaient ces chevreaux étaient aussi identifiées après avoir effectué une culture et une sporulation.

Neuf espèces d’Eimeria ont été identifiées chez les chevreaux. Eimeria arloingi était l’espèce la plus prévalente et constituait 45% de tous les oocystes sporulés. Eimeria caprina et Eimeria apsheronica étaient les moins fréquentes.


Summary

Six kids aged one to four weeks confirmed infected naturally with Eimeria species were euthanised and macroscopic and microscopic lesions observed. The species of Eimeria infecting these kids were also identified after culture and sporulation.

Nine species of Eimeria were identified in these kids. Eimeria arloingi was the most prevalent species and composed 45% of all the sporulated oocysts. Eimeria caprina and Eimeria apsheronica were the least prevalent.

Macroscopic lesions were observed in the whole of the small intestines. The lesions included congestion, mucosal haemorrhages and greyish-white nodular lesions. These were more numerous in the jejunum.

Microscopic lesions were distributed throughout the small intestines, caecum and colon. They included subacute enteritis, submucosal edema, hypertrophy and hyperplasia of the villi. Various endogenous stages were observed mainly macrogametes, microgametes and developing oocysts.

INTRODUCTION

Caprine coccidiosis has gained interest among researchers especially with changing patterns of husbandry. The disease mainly affects those under 12 months of age\(^1\) especially if kept in congested unsanitary conditions\(^2\). Several researchers have confirmed that coccidiosis in goats is caused by members of the genus Eimeria\(^{3,4,5,6}\). Among these E. ninakohiyakimovae is the most pathogenic\(^{3,7}\) but E. arloingi is responsible for most outbreaks\(^{3,8}\).

Several researchers have also reported on the pathology caused by these Eimeria species under experimental and natural infections\(^{1,2,3,4,5}\).

This study was undertaken to study the pathology caused by natural Eimeria infections in kids and compare to the available reports.

Materials and Methods

Six kids aged between 1 and 4 weeks were purchased from small-scale farmers
at Ongata-Rongai Kajiado district. They were brought to the animal compound Kabete Campus. They were fed on cows milk for two weeks during which time they were weaned to hay and concentrates. Daily rectal faecal samples were collected individually for oocysts per gram of faeces (OPG) analysis and identification of the *Eimeria* species affecting the kids. This was done as described by earlier workers\(^4,6,9,10\). This was done for three weeks and the data recorded for each kid. They were then euthanised one daily and a full postmortem carried out on the intestinal tract from the duodenum to the colon. Macroscopic lesions were noted in relation to location size and distribution. Histological samples were taken after every 30 centimeters starting from the duodenum up to the colon. These were fixed in formalin, trimmed and processed for histology in paraffin wax. They were then sectioned at 5 microns and stained with haematoxylin and eosin (H & E). These were observed under a light microscope.

**Results**

All the kids were shedding *Eimeria* oocysts. The youngest kid (1 week) had a value of 50,000 while the oldest (4 weeks) had a value of 3,600 at the time of first sampling. They were all infected by a mixture of *Eimeria* species. Nine species were identified.

The most prevalent species was *E. arloingi* which composed 45% of the 360 oocysts considered. The other species identified and their prevalence were: *E. ninakohlyakimovaie* 15%, *E. hirci* 15%, *E. alijevi* 10%, *E. jolchijevi*, *E. christensenii* 10% and *caprovina* 3%. *E. jolchijevi*, *E. caprina* and *E. apsheronica* composed 2% of the species identified.

Macroscopic lesions consisted of generalised congestion of the serosa, mucosal haemorrhages and circumscribed greyish-white nodular lesions. These were distributed throughout the small intestines and were more marked in the jejunum and least in the ileum. These lesion were visible on the mucosal surface. No visible macroscopic lesions were observed in the caecum and colon. The microscopic lesions included subacute enteritis which affected the whole of small intestines and parts of the colon.

There was marked congestion and submucosal edema especially in the jejunum. Hypertrophy and hyperplasia of the mucosal glandular epithelial cells occurred from the duodenum up to the colon. Some of these cells were laden with macrogametes, microgametes and developing oocysts.

The macrogametes appeared as orange-red globular bodies packing the glandular cells and arranged as a chain of beads around the inner margin of the glandular epithelial cell. They were encountered throughout the small intestines and parts of the colon. The variation in their sizes ranged from 10-22.5 microns in length by 10-17.5 microns wide (average 14.68 by 12.27 microns; n=42).

The microgametes were fewer in number and were found in all the regions of the small intestines and colon. Their sizes ranged from 12.5-13.75 microns in length by 8.75-12.5 microns wide (average 13 by 10 microns; n=15). Developing oocysts had retractile eosinophilic walls with pinkish-blue contents. They were distributed in the duodenum, ileum and colon. Their sizes varied in these regions from 15-27.5 microns in length by 12.5-17.5 microns in width (average 20 by 13.4; n=22).

Villi shortening occurred in the jejunum and ileum while marked villi erosion occurred in the distal ileum. There was marked lymphocytic infiltration of the lamina propria which also involved few plasma cells and eosinophils. This infiltration affected the small intestines and colon. Erosion of mucosa and infiltration with polymorphonuclear leucocytes occurred in the caecum and colon.

The greyish-white nodular lesions were hypertrophy glandular epithelial cells, fused villi, macrogametes and developing oocysts.
Natural coccidial infections cause pathology in young kids. Greyish lesions found in this study have been reported by other researchers[1,11] where they were numerous in the duodenum and less posteriorly as compared to this study where they were numerous in the jejunum. Similar results were reported in Nigeria[2] although there were no lesions in the duodenum in that study.

The microscopic lesions were distributed throughout the small intestines, caecum and colon with most been concentrated in the small intestines. In Nigeria[2] no lesions were found in the caecum and colon. Mature macrogametes and developing oocysts were encountered in caecum and colon. This was earlier reported in an *E. ninakohlyakimovae* infection[4]. Giant schizonts of *E. apsheronica* have been reported in an experimental infection in goats[5].

The dimensions of the macrogametes were in the ranges of those reported by earlier workers for various species of *Eimeria*. Macrogametes of *E. ninakohlyakimovae* were found to range in size from 9-18 x 13-17 microns[12] while those of *E. alijevi* ranged between 14-18 microns in length by 9-14 in width[13]. Macrogametes of *E. christensenii* were found to range between 19-35 microns in length by 13-25 in width with a mean of 26 x 19 microns[14] while those of *E. apsheronica* were found to be 24.7 x 18.5 microns[5].

It was concluded that natural coccidial infections cause pathology. This could explain the observed growth retardation in kids which shed large numbers of *Eimeria* oocysts.

References


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SARCOPTIC MANGE INFESTATION IN GOATS

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INFECTION DE GALE SARCOPTIQUE CHEZ LES CHEVRES

Résumé
L’examen clinique d’un troupeau caprin souffrant de lésions cutanées et de déman-geaisons a révélé des plaques d’alopecie croûteuses autour du museau s’étendant vers les yeux et autour des yeux; ces plaques enveloppaient aussi la partie externe des oreilles. Des lésions recouvreraient également le scrotum, la face médiane de la cuisse jusqu’au jarret, le poitrail et les creux axillaires. Les mêmes lésions ont été observées sur le côté ventral de l’abdomen chez les animaux gravement affectés par la maladie. Les lésions les plus fréquentes sont les lacerations, les petites papules rouges et l’épaississement de la peau avec des rides; ces derniers symptômes étant en général apparents sur le scrotum et parfois sur les oreilles. Un autre symptôme caractéristique était l’apparition de pellicules sur tout le corps, en particulier au niveau des parties très poilues. L’examen microscopique du grattage de la peau a révélé la présence de Sarcoptes scabiei, ce qui montre que ces parasites étaient responsables des lésions cutanées. L’on a observé, par ailleurs, qu’un seul traitement avec de l’ivermectine (Ivomec, MSD) a permis d’obtenir une guérison clinique totale.

Summary
Clinical examination of a herd of goats reported to be showing skin lesions and rubbing behaviour revealed crusty alopecic patches around the muzzle extending towards and around the eyes; and also involved outer aspects of ears. Lesions were also found on the scrotum, medial aspects of thighs extending to the hock joint, on the brisket and in the axilla region. Similar lesions were observed on the ventral abdomen in severely affected animals. Lacerations, small red papules and, thickening and wrinkling of skin, the latter commonly evident on the scrotum and sometimes on the ears were also common lesions. Another characteristic feature was dandruff on all parts of the body especially in those areas with lots of hair. Skin scrapings revealed the presence of Sarcoptes scabiei indicating that these mites were the cause of the observed skin lesions. It was further observed that a single treatment with ivermectin (Ivomec, MSD) resulted in complete clinical recovery.

INTRODUCTION
Mange mite infestation causes a major concern to all domestic animals\(^1\) and mites are one of the most important ectoparasites found in animals. Demodectic mange is rare in animals and it is often misdiagnosed as non-specific staphylococcal infection or passes unrecognised. These mites are known to infect hair follicles and sebaceous glands. Another commonly encountered mange is sarcoptic mange infestation which is well documented in pigs in which it is known to cause either an allergic disease or chronic form, the latter however is rare\(^2\). Porcine sarcoptic mange has been reported to be prevalent in major swine producing countries and recently, we have also shown that the disease is common among Tanzanian pigs\(^3\). Domestic animals are also susceptible to psoroptic and chorioptic mange mite infestation\(^4\).

The occurrence of ectoparasites in goats is well documented. For instance, Psoroptic and Demodex mange mites have been demonstrated to affect goats in Australia\(^5\). Demodectic mange has also been shown to be common in goats in India\(^6\). In other countries Sarcoptes scabiei, Demodex and Chorioptic mange mites are also known to infect goats. Other ectoparasites known to infest goats are lice and fleas which clinically cause
rubbing and/or scratching resulting in appreciable annoyance to animals. A disease was reported to have occurred in goats which had been purchased from different localities in Morogoro region. The main complaint was uneasiness and rubbing or scratching behaviour, presence of alopecic patches and poor general body condition. This study therefore describes clinical manifestation; type of skin lesions and their distribution and the results of treatment trial of the responsible skin disease.

Materials and Methods

All 25 goats in the herd were thoroughly clinically examined for the presence of clinical abnormality. Special attention was focused on the skin because of presence of skin lesions and evidence of rubbing and/or scratching behaviour. Clinical status of individual animals was noted especially in respect of type and distribution of skin lesions.

To aid in further diagnosis of the cause of skin lesions, skin scrapings were taken from affected parts using scraping spoons. Scrapped materials were immediately transferred to test tubes containing 3% potassium hydroxide solution. These were then stored at 40°C for 24 hours after which they were centrifuged at 1500 rpm for 15 minutes. After decanting the supernatants the remaining materials were suspended in a saturated sodium chloride/50% dextrose solution and microscopically examined for mites.

A treatment trial was also carried out to evaluate clinical efficacy of ivermectin in the treatment of caprine mange mite infestation. The drug was administered at a recommended dose rate of 1mg/5kg body weight i.m (intramuscular). Clinical evaluation was carried out a month later to assess whether animals had recovered from the disease.

Results

Clinical evaluation revealed a skin infection characterised by skin lesions on various parts of the body and the affected animals were observed to be rubbing themselves against walls. Lesions on the head included mainly light crusty materials on the muzzle extending to the area between the eyes and the nostrils. These materials were also present around the eyes; the region between the eyes and horns and also on the outer aspects of ears (Figure 1). Either partial or complete alopecia was observed on the affected parts. Crusty materials were also present in ears in some animals. Few isolated slightly crusty alopecic areas were also seen in the neck region in some animals (Figure 2).

Crusty and alopecic patches were also observed on the scrotum and the area around it, on the medial aspects of thighs, and the hock region or sometimes extending to cover the whole of scrotal-thigh-hock region (Figure 3). Few alopecic areas were found on the lateral aspects of the thigh and hock area in some animals. The degree of alopecia and amount of crusty materials varied from one leg to another with the medial aspects of the rear legs being affected to unequal degrees. Cracks and fissures were also evident among lesions at the hock joint. Alopecic patches were also evident in the axilla region, on the brisket in some animals and on the ventral abdomen in severely affected goats. A high degree of thickening and wrinkling of skin especially that of the scrotum (Figure 4) or on ears was also observed in few animals. Besides the presence of alopecic and crusty areas, dandruff was observed to cover the neck and abdominal areas including the scrotal-thigh-hock region. Heavy dandruff was evident in hairy areas which showed little evidence of alopecia and crusty materials. These scaly materials were mainly seen between the hair but small amounts were seen on top of hair. Small amounts of dandruff was seen on alopecic and crusty patches.

These clinical signs and type of skin lesions suggested mange infestation which was confirmed by positive demonstration of mites in skin scrapings.
Figure 1: Shows crusty alopecic areas around the muzzle, the eyes and on the ears.

Figure 2: Shows an alopecic patch in the neck region (indicated by an arrow).
Figure 3: Shows affected areas around the scrotum-thigh-hock region.

Figure 4: Shows thickened and wrinkled scrotal skin.
Mites demonstrated to be present in skin scrapings showed morphological features of *Sarcoptes scabiei* (Figure 5). Further evidence of the involvement of mite infestation was the clinical recovery evidenced a month after treatment using ivermectin. This shows that ivermectin is effective in the treatment of caprine sarcoptic mange infestation.

**Discussion**

Clinical evaluation and parasitological examination of skin scrapings showed that sarcoptic mange mite infestation was the cause of the skin lesions. Rubbing behaviour evident in most affected animals could be associated with either lice or flea or mange infestation\(^\text{[11]}\). It was apparent that a month earlier, animals had lice infestation which was treated effectively. This is supported by the observation that clinical evaluation carried out during this study did not reveal the presence of either lice or flea infestation. Therefore, the rubbing behaviour observed in this study seems to be due to *Sarcoptes scabiei* infestation.

The prevalence of mange mite infestation in pigs in Tanzania has been established and shown that sarcoptic mites are the most common ectoparasites infesting about 88% of pig herds\(^\text{[2]}\). Similar studies on mange infestation in other animals has never been studied. Although this study does not give indications on the disease status in goats, the available scanty information may be suggestive of the occurrence of sarcoptic mange infestations in goats in rural areas in Tanzania. This report gives the first documented evidence of sarcoptic mange mites are the only ones found in Tanzanian goats or that *Psoroptes, Demodex* and *Chorioptes* spp. all cause infestation in these animals, and *Chorioptes* spp. all cause infestation in these animals.

It was apparent that most of lesions due to *Sarcoptes scabiei* were located on the head, on the scrotal-thigh-hock regions and sometimes in the axilla and on ventral abdominal parts with little or no evidence of these lesions, with the exception
of dandruff, elsewhere. Lesions consisted mainly of alopecic crusty patches and generalised dandruff. This suggests that the distribution of skin lesions evident in this affected herd may be the representative distribution pattern of lesions of sarcoptic mange infestation in goats.

Various drugs have been shown to treat clinical cases of mange infestation in animals. For instance, ivermectin and phosmet (Porect, Beecham Animal Health) have all been shown to be effective in treating porcine sarcoptic mange\(^6,6\). The effectiveness of ivermectin has also been shown in the treatment of bovine psoroptic mange\(^7,9\). Similarly, the observation made in this study indicates that ivermectin is effective in treating caprine sarcoptic mange infestation.

In summary, the results indicate the occurrence of sarcoptic mange infestation in goats and these mites show some tendency to set up lesions mainly on the head, the scrotal-thigh-hock and axilla regions with generalised distribution of dandruff.

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References


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The morning (am) and afternoon (pm) rectal temperatures (RT), respiration rates (RR) and pulse rates (PR) of 17 Holstein-Friesian cows, previously imported from Canada, in 3rd lactation were studied to determine the degree of heat stress suffered by cows producing 0 (non-lactating), 1-10, 11-20 and 21-26 kg milk/day. The study also investigated the influence of pregnancy, month of observation, minimum and maximum ambient air temperatures and animals on these physiological responses. The physiological responses showed a diurnal pattern being lower in the morning than afternoon: 38.7 vs 39.0°C for RT, 51.0 vs 60.0 breaths/min. for RR and 56.0 vs 63.1 for PR. Non-lactating cows showed significantly (P<0.05) lower (38.8°C) rectal temperatures than other milk production groups (39.0°C) which were similar for this attribute. However, all milk yield groups were similar in am RT nd am and pm RR and PR. Pregnancy resulted in a significant (P<0.01) increase in pm RT and RR and am and pm PR. Month of observation was a significant source (P<0.01) of variation in all physiological responses. There was, however, no consistent trend of these attributes across months. All physiological responses except am RT increased (P<0.01) with increased minimum ambient temperature. However, only pm RT significantly (P<0.01) increased with increased maximum ambient temperature. Cows differed significantly (P<0.01) in all measures of physical responses except am RT.

It was concluded that under conditions of the experiment thermal conditions were not too stressful for cows producing up to 26 kg milk/day.
INTRODUCTION

Cattle under heat stress respond physiologically by elevation of rectal temperature, respiration rate and pulse rate\(^1\). Elevated body temperature, respiration rate and pulse rate are normally accompanied by declines in food intake and production\(^1,2\). These physiological responses have therefore been used as indices of heat tolerance of cattle\(^3\). Based on these indices exotic dairy cattle imported into the hot humid tropics are reported to be heat stressed for almost 24 h of the day\(^2,4\). Consequently the poor performance of exotic high yielding dairy cows in the humid tropics has partly been attributed to the prevailing high ambient temperatures and relative humidities and partly to poor nutrition, parasites and diseases\(^5,5\). Hence some authors\(^6\) have argued that on physiological grounds there is no place for the high yielding dairy cow in the humid tropics because these animals are unable to lose heat produced by digestion and metabolism.

However, several reports\(^7,8,9\) indicate that some exotic dairy cattle produced about 5,000 kg milk in 305 days of lactation in the humid tropics. How such animals responded in rectal temperature, respiration rate and pulse rate to the high environmental temperatures and humidities and yet produced satisfactorily has not been seriously studied. Previous studies on physiological responses of exotic dairy cattle have involved only breed comparisons and the effect of thermal conditions with no mention of the level of milk yields of the animals\(^10,11\). If our understanding of the responses of exotic dairy cattle to the humid tropical environment is to be further advanced, however, it is essential that these studies include cows in various physiological states especially cows observed to be producing above average for the ecological zone.

The present study was undertaken to determine the degree of heat stress suffered by dairy cows producing different levels of milk by examining values of rectal temperature, respiration rate and pulse rate in relation to these milk yield levels. In addition the influence of other factors — pregnancy status, month of observation (representing differences in rainfall, humidity, parasite burdens etc.), temperature and animals — with a potential impact on these variables were investigated.

Materials and Methods

Seventeen Holstein-Friesian cows, previously imported from Canada, in third lactation were used for the study at the University of Science and Technology Dairy/Beef cattle Research Station, Boadi. The experimental animals were in different physiological states at the start of the study. That is, cows were in various stages of lactation and some were pregnant while others were still open.

The location of the study area and the management and feeding of experimental animals has been described previously\(^9,12\). Briefly the study area is situated at latitude 06°43’N, longitude 01°36’W at an altitude of 292.8 m in the semi-deciduous forest zone of Ghana. The climate is hot and humid. Temperatures range from 22°C at night to 31°C in mid-afternoon with a daily mean of 26°C. Relative humidity (%) varies from 70 in dry season to 97 in the wet season. Rainfall is bimodally distributed with an annual mean of about 1200 mm. The major rainy season (April-July) reaches its peak during May and June. A short dry season occurs in August followed by a minor rainy season (September-October). The dry season lasts from November to March.

The cows were housed in a stanchion barn except when allowed out to graze in the morning (0800-1200 h) and at night (1800-0600 h). The barn was open at the sides with 1.2 m short walls. During non-grazing hours forage and water were provided ad libitum in the barn. Dairy concentrate was fed in a ratio of one kilogram to two kilograms of milk produced. Non-lactating cows received 2 kg concentrate daily.

The experiment was planned to last a

\(^{1}\) International Livestock Centre for Africa, Kaduna, Nigeria.
year but because of streptothricosis infection of experimental animals the investigation was terminated after 8 months. Recordings were taken from December, 1978 to the end of July, 1979. Measurements of rectal temperature, respiration rate and pulse rate were recorded for each experimental animal in the morning (am:0700-0800 h) and afternoon (pm:1500-1600 h). There were 10 recordings per month, 2-3 days apart. Rectal temperature was measured using a clinical thermometer inserted to its full length in the rectum and left in position for 3 minutes. Respiration rate was monitored by counting flank movements per minute and pulse rate was measured as beats per minute of the caudal artery. Daily ambient temperature data were compiled from records of the Ghana Meteorological Services Substation 8 kilometres from the farm.

Data on am and pm rectal temperatures, respiration rates and pulse rates were analysed by least-squares fixed model procedures. All data with health problems were removed prior to analyses. Fixed effects included lactation status, pregnancy status, month of observation, minimum and maximum ambient temperatures and cow. Lactation status was classified into 4 classes (as 1:0 kg (non-lactating); 2:1-10 kg; 3:11-20 kg; 4:21-26 kg milk/day). Pregnancy classes were 2 (non-pregnant vs pregnant) while month classes were 8 (1:December; 2:January; 3:February . . . . . 8:July). There were 17 cow classes. Maximum and minimum ambient temperatures were considered as continuous variables and were used as covariates. Preliminary analyses revealed that interactions between main effects were not statistical significant (p>0.05) and were therefore not considered in subsequent analysis. The residual mean square was the error term used to test the significance of differences for all effects. The least significant difference (LSD) test was used to compare class means where analysis of variance showed significant difference within classes.

**Results**

The unadjusted means for rectal temperature, respiration rate and pulse rate are provided in Table 1. Also provided are the mean maximum and minimum ambient temperatures and milk yield. Morning values of rectal temperature (coefficient of variation (CV) = 6.3 vs 0.9%), respiration rate (CV = 17.1 vs 12.0%) and pulse rate (CV = 16.2 vs 10.3%) were more variable than afternoon values. The level of milk yield ranged from 2-26 kg/day.

The results of analysis of variance are provided in Table 2. And in Tables 3 and 4 are given the least-squares means. Lactation was surprisingly only a significant (p<0.05) source of variation in pm rectal

| Table 1: Mean values and Standard deviations (SD) of physiological responses, ambient temperature and milk yield |
|-------------------------------------------------|-----------------|-----------------|
| AM^a | PM^a |
| Rectal temperature (°C) | 38.7 | 2.42 | 39.0 | 0.37 |
| Respiration rate (breaths/min.) | 51.0 | 8.7 | 60.0 | 7.2 |
| Pulse rate (beats/min.) | 56.0 | 9.1 | 63.1 | 6.5 |
| Ambient temperature (°C) | 22.0 | 1.7 | 31.6 | 2.3 |
| Milk yield (kg/day) | 13.4 | 5.6 |

^aAM = morning ^bPM = afternoon
Table 2: Mean-Squares and degrees of freedom (df) from analyses of variance for rectal temperature, respiration rate and pulse rate

<table>
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<th>Source of Variation</th>
<th>df</th>
<th>AM (X 10^3)</th>
<th>PM (X 10^3)</th>
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<th>PM*</th>
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<th>PM (X 10^3)</th>
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<td>1658.8***</td>
<td>126.1**</td>
<td>234.3**</td>
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<td>393.4**</td>
<td>186.2**</td>
<td>189.8**</td>
<td>11650.4**</td>
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<td>2123.1***</td>
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<td>273.4**</td>
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<td>55.1</td>
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<td>36.3</td>
<td>2784.4</td>
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</table>

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

Table 3: Least-Squares means (x̄) and Standard errors (S.E.) of rectal temperature, respiration rate and pulse rate by factor sub-classes

<table>
<thead>
<tr>
<th></th>
<th>Rectal temperature (°C)</th>
<th>Respiration rate (breaths/min.)</th>
<th>Pulse rate (beats/min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM*</td>
<td>PM*</td>
<td>AM</td>
</tr>
<tr>
<td>Least squares overall mean</td>
<td>x̄</td>
<td>S.e.</td>
<td>x̄</td>
</tr>
<tr>
<td>520</td>
<td>38.6</td>
<td>0.242</td>
<td>38.9</td>
</tr>
<tr>
<td>Lactation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-lactating</td>
<td>80</td>
<td>38.5</td>
<td>0.612</td>
</tr>
<tr>
<td>1-10 kg milk/day</td>
<td>84</td>
<td>38.7</td>
<td>0.443</td>
</tr>
<tr>
<td>11-20 kg milk/day</td>
<td>242</td>
<td>38.7</td>
<td>0.273</td>
</tr>
<tr>
<td>21-26 kg milk/day</td>
<td>114</td>
<td>38.6</td>
<td>0.516</td>
</tr>
<tr>
<td>Pregnancy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Pregnant</td>
<td>183</td>
<td>38.5</td>
<td>0.303</td>
</tr>
<tr>
<td>Pregnant</td>
<td>332</td>
<td>38.7</td>
<td>0.316</td>
</tr>
<tr>
<td>Regression coefficients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum ambient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>0.101</td>
<td>0.072</td>
<td>0.044</td>
</tr>
<tr>
<td>Maximum ambient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>0.019</td>
<td>0.076</td>
<td>0.019</td>
</tr>
</tbody>
</table>

*AM=Morning  **PM=Afternoon

Means within each sub-class with different superscripts are significantly different (P<0.05).

Temperature but not other attributes of physiological responses. Non-lactating cows showed significantly lower rectal temperatures than lactating cows. There was, however, no significant (p>0.05) differences between the other milk yield groups in any measure of physiological responses (Table 3).

Relationships between milk yield and physiological responses can be influenced by other factors. Methods of evaluations that gave results not con-
founded by other factors were sought. This included the addition of pregnancy status, temperature, month of recording and cow in the statistical models to statistically correct for these effects. As expected these factors were all significant sources of variation in physiological responses.

Pregnancy status significantly influenced pm rectal temperature (p<0.01), pm respiration rate (p<0.01) and am (p<0.01) and pm (p<0.05) pulse rates with non-pregnant cows showing lower values of these attributes than pregnant cows.

Minimum ambient temperature had a significant positive influence on pm rectal temperature (p<0.01), am and pm respiration rates (p<0.01) and am and pm pulse rates (p<0.001) but not am rectal temperature. Maximum ambient temperature was only a significant (p<0.05) source of variation for pm rectal temperature but not other measures of physiological responses.

Month of observation significantly (p<0.05) influenced all measures of physiological responses studied. There was no consistent trend in physiological responses across months. However, am and pm rectal temperatures were higher in December and April (Table 4). Respiration rates and pulse rates on other hand were higher in June and July.

There were significant individual cow variation in most measures of physiological responses (Table 2). These were significant for pm rectal temperature (p<0.01), am (p<0.01) and pm (p<0.001) respiration rates and am and pm pulse rates (p<0.001).

**Discussion**

Normal body temperature in cattle is reported to range from 38.3-39.1°C with a mean of 38.5°C\(^{[15,16]}\). Normal respiration rates and pulse rates on the other hand have been given as 10-30 breaths/min. and 60-80 beats/min. respectively\(^{[15]}\). In this respect it would appear that the animals in this study were able to maintain normal body temperature but probably at the expense of increased respiration rates. These results on rectal temperature, respiration rate and pulse rate are similar to values reported in other humid tropical areas with exotic dairy cows\(^{[10,11]}\).

Differences between morning and afternoon measures of physiological responses found in this trial are consistent with previous studies in the tropics\(^{[10,11]}\). The changes observed between am and pm in these physiological reactions tend to parallel ambient temperatures. The present results therefore support the suggestions that diurnal changes in physiological responses

| Table 4: Least-squares means (X) and standard errors (S.e.) of rectal temperature, respiration rate and pulse rate by month sub-classes |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| Class                                        | Rectal temperature (°C) | Respiration rate (breaths/min) | Pulse rate (beats/min.) |
|                                              | AM\(^{1}\) | PM\(^{2}\) | AM\(^{1}\) | PM | AM | PM |
| December                                    | No. | X | Se. | X | Se. | X | Se. | X | Se. | X | Se. | X | Se. |
| 109                                         | 39.1\(^{a}\) | 0.296 | 39.3\(^{a}\) | 0.037 | 49.8\(^{a}\) | 0.91 | 59.3\(^{a}\) | 0.79 | 48.8\(^{a}\) | 0.74 | 60.6\(^{a}\) | 0.65 |
| January                                      | 97   | 38.8\(^{a}\) | 0.301 | 39.0\(^{a}\) | 0.038 | 50.2\(^{a}\) | 0.93 | 58.3\(^{a}\) | 0.81 | 49.4\(^{a}\) | 0.76 | 58.7\(^{a}\) | 0.66 |
| February                                     | 86   | 38.3\(^{a}\) | 0.368 | 38.8\(^{a}\) | 0.046 | 50.5\(^{a}\) | 1.14 | 55.7\(^{a}\) | 0.99 | 60.0\(^{a}\) | 0.92 | 63.2\(^{a}\) | 0.81 |
| March                                        | 81   | 38.5\(^{a}\) | 0.366 | 38.9\(^{a}\) | 0.046 | 48.8\(^{a}\) | 1.13 | 60.7\(^{a}\) | 0.98 | 60.2\(^{a}\) | 0.92 | 65.7\(^{a}\) | 0.83 |
| April                                        | 30   | 39.1\(^{a}\) | 0.594 | 39.0\(^{a}\) | 0.075 | 46.7\(^{a}\) | 1.84 | 58.7\(^{a}\) | 1.59 | 52.5\(^{a}\) | 1.49 | 61.9\(^{a}\) | 1.31 |
| May                                          | 37   | 38.1\(^{a}\) | 0.561 | 38.8\(^{a}\) | 0.071 | 47.1\(^{a}\) | 1.73 | 58.1\(^{a}\) | 1.50 | 53.1\(^{a}\) | 1.41 | 62.5\(^{a}\) | 1.23 |
| June                                         | 40   | 38.1\(^{a}\) | 0.572 | 39.0\(^{a}\) | 0.072 | 50.4\(^{a}\) | 1.77 | 63.8\(^{a}\) | 1.55 | 61.0\(^{a}\) | 1.44 | 65.4\(^{a}\) | 1.26 |
| July                                         | 40   | 38.0\(^{a}\) | 0.651 | 38.6\(^{a}\) | 0.082 | 52.9\(^{a}\) | 2.01 | 61.3\(^{a}\) | 1.75 | 60.5\(^{a}\) | 1.64 | 64.7\(^{a}\) | 1.43 |

\(^{1}\)AM= Morning  
\(^{2}\)PM= Afternoon  
\(^{a}\)Means within the same column with different superscripts are significantly different (P<0.05).
should be considered when using these parameters for clinical diagnostic purposes\(^{18,11}\). The reasons for the larger variation in these attributes in the morning than afternoon are obscure. The am records were obtained while the animals were eating concentrate or forage. The pm records on the other hand were taken while animals were resting. It is therefore possible that these managemental activities may have influenced the variation in the data. The processes of prehension, mastication, drinking, standing and rising can result in elevated body temperature, respiration rate and pulse rate\(^{3}\). Alternatively, the diurnal variations in physiological responses were probably larger between 0700-0800 h due to increasing ambient temperature as thermal radiation load increased from the rising sun, than between 1500-1600 h when thermal radiation load may have stabilized.

Lactating cows in the present investigation showed significantly higher pm rectal temperatures than non-lactating cows. This higher rectal temperature was apparently the result of additional endogenous heat produced due to lactation rather than any thermoregulatory advantage of the dry cows caused by low morning rectal temperatures\(^{16}\) which were similar between the two groups. Each kilogram of fat corrected milk increases metabolic heat by approximately 80 \(\text{kJ/kg}\)\(^{3}\). This could have put additional strain on the thermoregulatory mechanisms of lactating cows which exceeded their ability to dissipate off the excess heat and body temperature increased.

These results also showed that level of milk yield did not significantly influence physiological responses. This implies that, for cows producing up to 26 kg milk/day and provided with shade and good nutrition, extra metabolic heat production from milk synthesis was not an important factor in the maintenance of homeothermy. This is rather surprising. It cannot be that the high yielding cows had similar endogenous heat production as the low yielding cows (see discussion above). Also, cows producing above 10 kg milk/day are known to be influenced by thermal stress\(^{17}\). A possible explanation is the difference between milk yield groups in the levels of concentrate supplementation. There is evidence that cows on low concentrate diets have higher physiological responses due to a higher heat increment of feeding than cows on higher concentrate diets\(^{18}\). It is therefore possible that in the present study the endogenous heat of lactation of the high yielding cows was matched by the heat increment of feeding of the low yielding cows resulting in similar physiological responses. Alternatively, these cows were able to produce at a higher level probably by adopting more efficient means of heat dissipation in terms of sweating early in the day and at a lower skin temperature or through changes in tissue and coat insulation\(^{19}\). These findings thus suggest that, in environments similar to those of the present study, nutrition rather than heat stress may be the major inhibiting factor in high milk production. This is contrary to the acknowledged behaviour of high yielding cows in the tropics (see introduction).

Cows varied in physiological responses unconnected with physiological state and thermal conditions. This probably enabled some cows to produce milk above the average for the herd. These results are, however, not unique. Studies indicate a higher heritability in rectal temperature\(^{20}\). Differences between animals in body condition (fatness), type of pelage, ability to consume large quantities of forage and postural adjustments evoked by animals to maximise heat dissipation\(^{4}\) may have been some of the factors involved in the between cow variations.

The higher physiological responses of pregnant cows than non-pregnant cows observed in this experiment agrees with previous studies\(^{3}\). The possible cause for the higher response of the pregnant cows is the increased metabolic rate of the foetus and mother resulting in increased heat production\(^{21}\). This additional heat load of metabolism might have exceeded
the thermoregulatory ability of the pregnant cows causing an increase in body temperature.

In this study there was no distinct trend in physiological responses across months. In contrast, Amakiri and Funsho in the humid zone of Nigeria found no changes in rectal temperature across seasons. This was attributed by the authors to acclimatization of the exotic cattle. Despite the results of Amakiri and Funsho, one would have expected that under similar environmental temperatures, physiological responses would be higher in the wet than dry months because of the higher humidities in the wet months which impede heat dissipation through evaporative cooling. Perhaps other sources of heat production, eg. the quality of forage on offer and physical activity such as tail swishing, leg stamping, head movements and rubbing of body parts against inanimate objects caused by parasite molestations, conformed the monthly relationships of the present study.

The effect of environmental temperature on rectal temperature has been observed in most studies to be positive. The present trial tends to follow this general trend. However, the more dominant influence of minimum ambient temperature than maximum temperature on respiration rate and pulse rate, especially for pm values, was unexpected despite the report of Lemerle and Goddard that afternoon ambient temperatures did not explain the variations in physiological responses. The reasons for this are not easily apparent. Previous studies had, however, observed the effect peak air temperature on rectal temperature to occur 7-10 h later. It is, however, doubtful if a similar effect was involved in the present experiment since maximum ambient temperature significantly influenced pm rectal temperature. Also, the fist variable response to heat stress is increased respiratory activity. Presumably these animals dissipated heat by more than one route, eg. sweating in addition to respiratory activity. It is also likely that minimum temperature affords cows the opportunity to dissipate off stored body heat leading to lower physiological responses in the morning. This would be of thermoregulatory advantage in that a lower starting point might delay the onset and lessen the severity of hyperthermia later in the day.

In conclusion, the results indicate that for cows producing up to 26 kg milk/day the environmental conditions were not too stressful. Cows were thus able to maintain homeothermy by using respiratory avenue of heat loss. Thus with good management and nutrition thermal conditions in the humid zone of Ghana are not too stressful to drastically inhibit the milk production of exotic dairy cattle.

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References

programme. Columbus, U.S.A. Ohio State University.

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EFFECT OF SUPPLEMENTARY PHOSPHORUS AND THE SOURCE OF NITROGEN ON FOOD INTAKE AND GROWTH PERFORMANCE OF WETHER SHEEP

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EFFET DU SUPPLEMENT DE PHOSPHORE ET DE L’AZOTE SUR LA CONSOMMATION ALIMENTAIRE ET LA PERFORMANCE DE CROISSANCE DES MOUTONS CASTRES

Résumé

Dans une analyse factorielle 2 x 2, les agneaux à la croissance (poids moyen 38 kg) étaient nourris d’aliments à faible teneur en phosphore contenant de la farine de sang ou de l’urée supplémentées (P) ou non-supplémentées (régime-témoin: T) avec 2 g de phosphore/jour. Même si la consommation alimentaire, le gain de poids quotidien, l’indice de consommation et la digestibilité du régime n’étaient pas beaucoup affectés par le traitement (P>0.05), l’on a constaté une utilisation plus efficace des substances nutritives des aliments servis lorsqu’il y avait consommation suffisante de phosphore. L’urée augmentait très légèrement les gains pondéraux et l’efficience alimentaire. Le taux de l’urée plasmatique était significativement plus élevé (P<0.01) dans le régime contenant de l’urée que dans celui contenant de la farine de sang. On en a déduit que la performance des agneaux nourris de régime à faible teneur en phosphore ne peut être affectée que si P/sang ne baisse en-dessous de 3 mg/100 ml.

Summary

In a 2 x 2 factorial experiment, growing lambs (mean live weight 38kg) were fed low phosphorus diets containing either blood meal or urea supplemented (P) or unsupplemented (control) with 2.0g phosphorus/day. Although feed intakes, daily live-weight gain, feed conversion and diet digestibility were not significantly (P>0.05) affected by treatment, there was evidence of more efficient utilisation of dietary nutrients in the presence of adequate phosphorus intake. Urea supported marginally higher live-weight gains and feed efficiency. Plasma urea was significantly (P<0.01) higher for the urea diet relative to blood meal. It is concluded that the performance of lambs fed low P diets may only be affected if the blood P drops to less than 3 mg/100ml.

INTRODUCTION

Prolonged low phosphorus intakes may not affect the voluntary intake of low quality roughages by cows during pregnancy\(^1\text{,}^2\) but it has been found to reduce appetite in growing heifers\(^3\).

The relative lack of effect of dietary phosphorus inadequacy on voluntary feed intake of the non lactating cow may be due to the large daily turnover of phosphorus in the ruminant’s saliva\(^4\) which probably maintains normal blood phosphorus levels and growth and development of rumen micro-organisms. For the young ruminant, especially in tropical countries where low quality roughages characterised by very low levels of crude protein and phosphorus are the main feeds available, dietary phosphorus and phosphorus nutrition are even more relevant.

Low protein degradability has also been found to reduce intake of low quality roughages due to inadequate concentrations of ammonia — N generated in the rumen liquor\(^6\text{,}^6\text{,}^7\). It is apparent therefore that a response in intake of low quality feeds and consequently growth rate, to either dietary protein degradability or phosphorus supply can be anticipated only up to the point where either of these nutrients limits intake probably through their effects on the rumen microbes.

\(+\text{Present address: Department of Animal Science, Ahmadu Bello University, P.M.B. 1044, Zaria, Nigeria.}\)
The present work describes the effect of supplementary phosphorus and two protein sources of differing rumen degradabilities (blood meal and urea) on the performance of growing wether sheep.

**Materials and Methods**

**Animals and diets**

Sixteen 6-month-old Suffolk x Greyface wether lambs (mean live weight 38 kg) were ranked into four weight groups and randomly allocated, one lamb from each group, to one of four treatments in a 2 x 2 factorial design. The treatments consisted of (fresh basis) either 45.3 g blood meal or 15.0 g urea as nitrogen sources, both calculated to provide equal amounts of nitrogen. Each of these was either unsupplemented (Control) or supplemented (P) with 11.0 g of dicalcium phosphate to supply an additional 2.0 g phosphorus per day. These were fed with unmolassed sugar beet pulp (USBP) and barley husk sittings (BHS) in the ratios of 7:3 (on fresh weight basis). Each diet was further supplemented as shown in Table 1.

**Feeding**

The sheep were individually penned and fed their various treatment diets *ad libitum* for three weeks. Thereafter the total feed offered to each sheep was restricted to 1.5 kg air dry/day, the approximate amount the sheep could consume completely. This restriction was intended to remove appetite differences and thus ensure that possible effects of P addition or the source of nitrogen or both on food intake might be detected from food residues. The sheep were fed for ten weeks.

Small quantities of feeds refused daily were removed and weighed to record intakes. Heparinised blood samples were obtained weekly from each sheep to determine changes in plasma P and Ca and differences in plasma urea. Diets were sampled twice weekly for proximate analysis.

Following the ten weeks of voluntary intake assessment, the digestibility of diets was determined for each animal by total faecal collection over a 7-day period, faecal collection being one day in arrear of feeding. Faeces were collected daily and dried to constant weight at 90°C in a forced draught oven. These were bulked at the end of the experiment, subsampled and milled for proximate analysis.

**Chemical analysis**

Proximate analysis of feedstuffs and faeces were done by normal standard methods. Plasma was analysed for P, Ca and urea by urease-Nesslerization.

**Statistical analysis**

Results were analysed as a 2 x 2 factorial. Main effects and interactions were determined by using the F-test while treatment comparisons were done using Duncan’s Multiple range test.

**Results and Discussion**

The animals remained in good health throughout the ten weeks of the study. There were no interactions between phosphorus addition and the source of dietary protein. Results have therefore been presented as main effects of the two nutrients, in Tables 2 and 3.

**Effect of phosphorus**

For the low P group, phosphorus intakes were approximately 26% less than the recommended level (1.8 g/day for sheep growing at approximately 100 g/day). The comparable voluntary feed intakes in this study (Table 2) are in contrast to observations by other workers. For instance, Fishwick and Hemingway using 3-4 month-old lambs (initial live weight 27.5-33.0 kg) noted that in the absence of phosphorus, the lambs left some feed, recovering full appetite 2-3 days after changing to full supplementation with phosphorus. In a similar trial but with 3-week-old rats, Henery et al. also reported a decrease in food intake caused by severe phosphorus deficiency (one quarter of the normal level). This was accompanied by retarded growth and
Table 1: The amounts (g/kg air dry basis) of the various constituents of each diet

<table>
<thead>
<tr>
<th>Dietary constituents</th>
<th>Blood meal</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control P</td>
<td>Control P</td>
</tr>
<tr>
<td>Blood meal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>USBP</td>
<td>663</td>
<td>663</td>
</tr>
<tr>
<td>BHS</td>
<td>284</td>
<td>284</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>—</td>
<td>15.0</td>
</tr>
<tr>
<td>Salt</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Trace elements and minerals</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Total dry matter (g/kg)</td>
<td>889</td>
<td>900</td>
</tr>
<tr>
<td>Total CP</td>
<td>103</td>
<td>109</td>
</tr>
<tr>
<td>Total P</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Total Ca</td>
<td>6.1</td>
<td>9.3</td>
</tr>
</tbody>
</table>

Table 2: Mean live weights (LW, kg), daily intakes and apparent digestibility of diet dry matter (DM), plasma urea concentration and performance of the sheep

<table>
<thead>
<tr>
<th></th>
<th>Blood meal</th>
<th>Urea</th>
<th>SE+</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake (kg)</td>
<td>1.10</td>
<td>1.18</td>
<td>0.06**</td>
</tr>
<tr>
<td>DM intake (g/kg DMH)</td>
<td>68.0</td>
<td>70.8</td>
<td>3.81**</td>
</tr>
<tr>
<td>DM digestibility coefficient</td>
<td>0.69</td>
<td>0.67</td>
<td>0.002**</td>
</tr>
<tr>
<td>Initial LW</td>
<td>38.3</td>
<td>37.8</td>
<td>0.38**</td>
</tr>
<tr>
<td>Final LW</td>
<td>43.5</td>
<td>43.5</td>
<td>1.09**</td>
</tr>
<tr>
<td>Daily LW gain (g)</td>
<td>110</td>
<td>120</td>
<td>16.0**</td>
</tr>
<tr>
<td>Feed conversion</td>
<td>12.2</td>
<td>10.6</td>
<td>1.66**</td>
</tr>
<tr>
<td>Plasma urea (mg/100ml)</td>
<td>23.9*</td>
<td>41.4*</td>
<td>2.97**</td>
</tr>
</tbody>
</table>

Table 3: The estimated daily intakes (g) of phosphorus (P) and calcium (Ca) and the corresponding changes in blood plasma concentrations (mg/100ml)

<table>
<thead>
<tr>
<th></th>
<th>Blood meal</th>
<th>Urea</th>
<th>SE+</th>
</tr>
</thead>
<tbody>
<tr>
<td>P intake</td>
<td>1.36</td>
<td>1.34</td>
<td>4.14</td>
</tr>
<tr>
<td>Initial plasma P</td>
<td>5.2</td>
<td>5.8</td>
<td>0.47**</td>
</tr>
<tr>
<td>Plasma P at end of experiment</td>
<td>4.0*</td>
<td>3.3*</td>
<td>0.30**</td>
</tr>
<tr>
<td>Decrease (%)</td>
<td>23.1</td>
<td>43.1</td>
<td>2.66***</td>
</tr>
<tr>
<td>Ca intake</td>
<td>8.97</td>
<td>8.97</td>
<td>22.4</td>
</tr>
<tr>
<td>Initial plasma Ca</td>
<td>9.5</td>
<td>9.2</td>
<td>0.76**</td>
</tr>
<tr>
<td>Plasma Ca at end of experiment</td>
<td>22.</td>
<td>11.1</td>
<td>0.38**</td>
</tr>
<tr>
<td>Increase (%)</td>
<td>17.9</td>
<td>20.7</td>
<td>9.8</td>
</tr>
</tbody>
</table>

Reduced food and energy utilisation. However the small non-significant improvement in daily live-weight gain (Table 2) due to P supplementation may suggest a more efficient nutrient utilisation confirming earlier observations by Hegsted. Consequently 27% less food was used for each kg of live weight gain by lambs fed the P supplemented diet.

The lower plasma urea concentrations for the P supplemented group may further confirm the greater efficiency of nitrogen utilization, probably accounting in part for the improvement in live-weight gain. Normal blood phosphorus was maintained in the sheep fed the P supplemented diet. The blood P concentration of the low P group decreased gradually.
from the first week of the experiment. The difference between treatments was significant (P < 0.01) from the third week and remained so till the end of the experiment.

The digestibility of diets was not significantly (P > 0.05) affected by phosphorus supplementation.

**Effect of Protein source**

Voluntary feed intakes were not affected (P > 0.05) by the source of protein supplement. However urea supported marginally higher growth rates with corresponding improvements in feed efficiency. The higher plasma urea recorded for the urea diet (P < 0.01) relative to the blood meal diet is only expected in view of the high solubility of urea. The digestibility of diets containing both types of protein were also comparable. The plasma urea concentrations of lambs fed both the urea and blood meal diets (Table 2) seem to suggest that urea recycling may have maintained rumen ammonia-N concentrations at levels favourable for the rumen microbes. In an earlier experiment involving barley straw diets supplemented with either untreated or formaldehyde-treated soya bean meal, diet digestibility was only slightly affected for lambs whose plasma urea concentration was 17.7 mg/100 ml or less, a level lower than that obtained on the blood meal diet in this present study.

The influence of low dietary phosphorus and the source of dietary protein on feed intake by ruminants have been clearly demonstrated in the experiments cited earlier. The failure to observe reduced appetite on low P diets in the present experiment may be due to the age of the lambs used. At six months and with a mean live weight of 38 kg, the lambs used were relatively mature compared to those used in the experiments cited earlier, having presumably stored more bone phosphorus. It is, however, more important to note that whilst blood P fell, the lowest level recorded at the end of the experiment (3.65 mg/100 ml for the low P diet) was still higher than those recorded by Fishwick and Hemingway (1973) (less than 3 mg/100 ml) which caused a reduction in appetite of growing sheep. For lactating cows fed straw, appetite was also affected only when the blood phosphorus dropped to below 2 mg/100 ml, indicating the greater resilience of more mature animals. It is possible therefore that unless the P status of the lamb is so low that blood phosphorus is reduced to below 3 mg/100 ml the voluntary feed intake of lambs may not be affected. However the increase in blood Ca for lambs fed the low P diet is indicative of resorption which may have assisted in maintaining blood P above the critical level.

In conclusion, lambs aged up to six months appear to maintain normal feed intake when fed low phosphorus diets although growth rates may be slightly reduced. More feed also appear to be required for each kg of live-weight gain.

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**References**

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L’UTILISATION DU FOURRAGE POUR L’ALIMENTATION DES CHEVRES LAITIERES

Résumé
Vingt cinq chèvres Saanen dans leur deuxième ou dernière phase de lactation ont été nourries de 1,5 kg de matière sèche (MS) obtenue d’un mélange de foin et d’ensilage (F/E) dans une proportion de 1:1 (sur la base de la quantité de matière sèche) et à partir de 0,15 jusqu’à 0,45 kg de concentrés distribués chaque jour au cours des 4 semaines précédant la mise bas. Pendant les deux premières semaines après la mise bas, on a augmenté la quantité de concentrés jusqu’à 1 kg/jour et entre 3-12 semaines de lactation, les chèvres ont été nourries ad libitum avec du foin, de l’ensilage ou du mélange foin/ensilage. La consommation de foin pendant la durée de l’expérience était de 1,10; 0,87 et 1,02 kg/jour (±0,085) et la production laitière était de 2,70; 2,99 et 3,18 kg/jour (±0,207) pour les groupes de chèvres ayant reçu respectivement du foin, de l’ensilage et du mélange foin/ensilage. La concentration totale de substances solides pour le groupe nourri avec de l’ensilage et la concentration totale de solides non gras dans le lait pour les groupes affouragés avec de l’ensilage et du foin étaient significativement plus élevées (P<0,05) que celle du groupe servi de foin/ensilage, mais leur production laitière n’a pas beaucoup varié. La variation du poids vif n’était pas très affectée par le traitement même si le groupe alimenté avec l’ensilage a perdu plus de poids (56 g/jour) que le groupe nourri de foin (6 g/jour); le groupe servi de mélange foin/ensilage (38 g/jour) occupe une position intermédiaire. Les résultats indiquent que l’ensilage ou le mélange foin/ensilage peut être utilisé comme alimen tant de base pour les chèvres laitières tout comme le foin, sans que cela affecte la production laitière.

Summary
Twenty five Saanen goats in their second or later lactation were offered 1.5 kg dry matter (DM) of a mixture of hay and silage (H/S) at the ratio of 1:1 (on DM basis) and from 0.15 increasing to 0.45 kg concentrates daily in the 4 weeks before kidding. During the first 2 weeks after kidding concentrates were increased to 1.0 kg/day and by week 3-12 of lactation goats were offered ad libitum hay, silage or H/S mixture. Forage intake for the experimental period was 1.10, 0.87 and 1.02 kg/day, (±0.085) and milk yield was 2.70, 2.99 and 3.18 kg/day (±0.207) for the hay, silage and H/S group respectively. Total solids for the silage group and solid not fat (SNF) concentration in milk for the silage and hay groups was significantly (P<0.05) higher than that for the H/S group, but their yields were not significantly affected. Live weight change was not significantly affected by the treatment though the silage group lost more weight (56g/day) compared to the hay group (6g/day) and H/S group (38g/day) was intermediate. The results indicate that silage or H/S mixture can be used as a basal diet for dairy goats just like hay without affecting milk production.

INTRODUCTION
Hay and silage are commonly used as basal diets for dairy animals. Much research on either one of them or a comparison between the two has been done with dairy cows. On the other hand, there has been very limited research done on either silage alone or a comparison of silage with hay based diets with lactating dairy goats. Nedkvitne and Robstad compared grass silage cut early or late offered to lactating goats. While Chopra and Kurar tested maize silage at different levels to West African bucks. Jones et al. are amongst the few who compared wilted alfalfa-alfalfa and corn silage to alfalfa hay offered to non-pregnant one year old Toggenburg goats. Therefore, there is a marked absence of comparison between hay and silage with lactating dairy goats. Hence the objective of this research was to compare the performance of lactating Saanen goats being offered grass silage, grass hay or a mixture of the two.
Materials and Methods

Twenty five Saanen goats in their second to fourth lactation were used. They were loose housed in pens furnished with wood shavings. From 12 to 4 weeks before kidding they were offered 1.5 kg hay and 0.15 kg concentrate (190 g Crude protein (CP)/kg dry matter (DM)) daily. From 3 weeks before kidding to kidding time hay was gradually replaced by silage until the forage was made up of 1:1 mixture (on DM basis) of hay and silage (H/S), while the concentrate was increased to 0.45 kg/day.

At kidding all the goats used were allocated to one of the three treatments at random according to kidding date, though the groups were balanced as far as possible for live weight on the third day after kidding, which averaged 67 kg (range 52 to 85 kg), litter size and parity.

From the third to the twelfth week each group was either on ad libitum perennial grass (Lolium perenne) hay, silage or a 1:1 mixture of H/S. The ad libitum regime consisted of yoking goats to their respected feeding trough for a total period of 6 hr/day (09.00-11.00 am, 12.30-2.30 pm and 5.00-7.00 pm).

Measurements:

The goats were machine-milked twice at about 08.00 h and 15.30 h and the yield was recorded. Milk samples were taken in two consecutive milkings per week from week 9 to 12 of lactation. Goats were weighed twice weekly at a fixed time.

The DM content of the feeds was measured weekly and that of the refusals was measured on one day for each week for each goat to be used in estimating forage DM intake.

Analysis:

Milk samples were analysed for the concentration of fat (Gerber) and total solids (British Standard Method) and the concentration of solids — not — fat (SNF) was calculated by difference.

Feeding samples were analysed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) and for the concentration of OM in the DM (DOMD g/kg) by the two-stage incubation procedure. The ME concentration of feeds (MJ/kg DM) was calculated as 0.015 DOMD.

Silage sample was squeezed and the pH of the extract was measured, while ammonia, volatile fatty acids and lactic acid were also determined.

Calculations:

DM intake of H/S was calculated using a formula aH + (1-A) (S=R) where a is proportion of refusals which was hay on as fed basis and H,S and R is DM% for hay, silage and refusals respectively.

The results of this experiment were analysed as completely randomized design giving 22 degree of freedom.

Results

The composition of the concentrate, is given in Table 1; while the chemical composition of the concentrate, the hay and the silage is given in Table 2.

The quality of silage appeared to be higher than that of the hay as it had higher CP and lower ADF content. Moreover the in vitro digestibility of DM, OM and the DOMD value of the silage were about 10 percent units higher than those of the hay.

Food Intake.

The mean intake of hay tended to be higher than that of silage or H/S throughout the experimental period but the difference did not reach significance (Table 3, Fig. 1).

The mean silage intake was the lowest and H/S intermediate except for the last two weeks of the experiment when the difference was small and inconsistent. The peak DM intake for H/S was reached during the 3rd week of lactation, with a

Table 1: Composition of concentrates (g/kg)
(Minerals and vitamins were added extra)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>770</td>
<td>Soyabean</td>
<td>140</td>
</tr>
<tr>
<td>Rape seed meal</td>
<td>50</td>
<td>Palm acid oil</td>
<td>10</td>
</tr>
<tr>
<td>Minerals/vitamins</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: The mean values for the chemical composition and *in vitro* digestibility of the feeds used

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conc.</th>
<th>Hay</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (g/kg fresh)</td>
<td>866</td>
<td>847</td>
<td>214</td>
</tr>
<tr>
<td>Organic matter (g/kg DM)</td>
<td>928</td>
<td>929</td>
<td>902</td>
</tr>
<tr>
<td>Crude protein (g/kg DM)</td>
<td>190</td>
<td>82</td>
<td>131</td>
</tr>
<tr>
<td>Acid detergent fibre (g/kg DM)</td>
<td>65</td>
<td>363</td>
<td>324</td>
</tr>
<tr>
<td>Neutral detergent fibre (g/kg DM)</td>
<td>244</td>
<td>666</td>
<td>549</td>
</tr>
<tr>
<td>Gross energy (MJ/kg DM)</td>
<td>17.84</td>
<td>17.75</td>
<td>19.43</td>
</tr>
</tbody>
</table>

* in vitro digestibility

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hay</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>0.577</td>
<td>0.674</td>
</tr>
<tr>
<td>Organic matter</td>
<td>0.550</td>
<td>0.654</td>
</tr>
<tr>
<td>DOMD*</td>
<td>50.6</td>
<td>59.3</td>
</tr>
<tr>
<td>pH</td>
<td>5.72</td>
<td></td>
</tr>
<tr>
<td>NH₃ ug/ml</td>
<td>883</td>
<td>883</td>
</tr>
<tr>
<td>Lactic acid u mol/ml</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Acetic acid u mol/ml</td>
<td></td>
<td>183</td>
</tr>
<tr>
<td>Propionic acid u mol/ml</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>1-Butyric acid u mol/ml</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>N-Butyric acid</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

* g digestible OM/100g DM.

Table 3: Feed intake, milk yield and composition and live-weight change during weeks 3-12 of lactation

<table>
<thead>
<tr>
<th></th>
<th>Hay</th>
<th>Silage</th>
<th>H/S</th>
<th>Se</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake (kg/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage</td>
<td>1.10</td>
<td>0.87</td>
<td>1.02</td>
<td>0.085</td>
<td></td>
</tr>
<tr>
<td>Concentrates</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.99</td>
<td>1.76</td>
<td>1.91</td>
<td>0.085</td>
<td></td>
</tr>
<tr>
<td>Milk composition (g/kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total solids</td>
<td>106ₐ</td>
<td>109ₐ</td>
<td>102ₐ</td>
<td>3.0</td>
<td>*</td>
</tr>
<tr>
<td>Fat</td>
<td>32</td>
<td>34</td>
<td>32</td>
<td>2.0</td>
<td>*</td>
</tr>
<tr>
<td>Solids-not-fat</td>
<td>77ₐ</td>
<td>75ₐ</td>
<td>70ₐ</td>
<td>1.8</td>
<td>*</td>
</tr>
<tr>
<td>Yield (g/d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total solids</td>
<td>265</td>
<td>319</td>
<td>295</td>
<td>30.8</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>88</td>
<td>101</td>
<td>94</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td>Solids-not-fat</td>
<td>185</td>
<td>211</td>
<td>203</td>
<td>19.7</td>
<td></td>
</tr>
<tr>
<td>Milk energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yield (mJ/day)</td>
<td>7.70</td>
<td>8.91</td>
<td>9.24</td>
<td>0.646</td>
<td></td>
</tr>
<tr>
<td>Live-weight change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g/day)</td>
<td>-6</td>
<td>-56</td>
<td>-38</td>
<td>16.7</td>
<td></td>
</tr>
</tbody>
</table>

+ Means with different superscripts differ significantly (P<0.05)

Table 4: The mean values for live-weight changes (g/day) with goats on different forages

<table>
<thead>
<tr>
<th>Live-weight change weeks</th>
<th>Hay</th>
<th>Silage</th>
<th>H/S</th>
<th>Se</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0 + 1) to (11 + 12)</td>
<td>-6</td>
<td>-56</td>
<td>-38</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>0 to 12</td>
<td>-18</td>
<td>-65ₐ</td>
<td>-52ₐ</td>
<td>23.1</td>
<td>*</td>
</tr>
<tr>
<td>2 to 12</td>
<td>-6</td>
<td>-38</td>
<td>-38</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>4 to 12</td>
<td>-2</td>
<td>+24</td>
<td>-12</td>
<td>25.7</td>
<td></td>
</tr>
</tbody>
</table>

+ Means with different superscripts differ significantly (P<0.05).
second lower peak at the 6th week which coincided with the peak of hay, but that of the silage was attained 5 weeks later (Fig. 1). All the concentrate ration was consumed throughout the experiment.

Milk Yield.
Mean milk yield for the H/S group tended to be higher almost throughout the experiment and that of the hay group lowest while that of the silage group intermediate (Fig. 2) but the difference did not reach significance (Table 3). Peak yield for all the three treatments was reached during the 6th week of lactation.

Concentration and Yield of Milk Components.
The concentration for total solids for the silage and SNF for the silage and hay groups were significantly higher (P<0.05) than that for the H/S group, (Table 3). Fat concentration also tended to be higher for the silage group than H/S and hay groups. The yield of total solids, fat and SNF were not significantly affected by the treatments though values for these yields tended to be higher for the silage group than those for hay group with H/S intermediate. Milk energy yield was higher with hay group but no differences were significant.

Live-weight Change.
There was no significant treatment effect on live-weight change, all groups lost weight (Table 3, Fig. 3). The silage group seemed to have lost most weight especially during the first three weeks of lactation, but the weights of all treat-
ments remained fairly constant from about week 5 (Fig. 3).
When the liveweight change is calculated, for the period between the beginning (week 0 to 12, week 0 + 1 to 11 + 12, or week 2 to 12) to the end of the experiment the silage group seemed to loose most weight compared to the hay group but if the period examined is from week 4 to 12 of lactation then the silage group apparently seemed to have gained most weight.

**Discussion**

Although there was no significant difference on hay intake compared to the silage group, the DM intake of hay was 26% higher than that for the silage. Bertilsson et al.\(^{14}\) had similar results with Swedish Red and White cows. They compared their cows which had *ad libitum* forage with fixed amounts of concentrates during week 2 to 10 of lactation. The intake of with fixed amounts of concentrates during week 2 to 10 of lactation. The intake of hay DM was 20% higher than that of the silage though this difference was not significant. Both the forages were cut at ear emergence. Higher DM intake of hay compared to silage is common though the reason is still unknown. May be the major reason for the higher DM intake of hay not being significant in the present experiment was its quality. Even though both hay and silage were made mainly from rye grasses they were from different swards and the quality of the hay appeared inferior to that of the silage. Hay had lower *in vitro* digestibility values for DM and OM by about ten percentage units compared to the silage (Table 2). This low digestibility could have led to lower DM intake, since voluntary intake is
known to have a positive relation with DOMD\textsuperscript{13,14}. Another factor contributing to the lack of significantly higher DM intake of hay could have been its low CP content (82 g/kg DM) compared to that of the silage (131 g/kg DM). The hay diet contained 130 g CP/kg compared to 160 g/kg for the silage diet with the H/S group intermediate (146 g/kg). Since CP concentration of the ration is known to have positive correlation up to a certain level with the voluntary intake,\textsuperscript{15,16} the reduction of the CP level in the hay based diet as compared to the silage based diet (from 160 to 130 gcp/kg DM) may have caused the lack of significant difference even though hay intake remained higher than that of silage intake.

The mean voluntary intake of H/S was intermediate between the two single forages. This was expected since H/S was a mixture of 1:1 hay and silage on a DM basis. However, mixed H/S diets have been reported by some authors\textsuperscript{17,18} to improve feed intake by cattle compared with hay or silage as the sole forage. Bertilson and Burstedt\textsuperscript{19}, reported significantly higher DM intake by lactating cows having a mixture of silage with 4 kg early-cut hay compared to late-cut hay alone. However when the DM intake of this mixture (silage and hay) was compared to that of the early-cut hay, there was no significant difference. The quality of the late-cut hay, was much poorer compared to either the early-cut hay or hay with the silage. This may be the reason for the lower DM intake of the late-cut hay compared to the H/S rather than the associative effect of the combination per se.
Milk Yield

The milk yield of the silage group was 10% higher than that of the hay group. This is in agreement with results of most workers. Bertillon and Burdastedt\textsuperscript{(19)} found out with cows that were fed silage that they produced more fat corrected milk (4-14% and 5-15% respectively) than cows fed hay cut at the same time and originating from the same sward. Bertillon et al.\textsuperscript{(12)} feeding cows hay and silage cut at ear emergence obtained significantly higher milk production on silage even though its DM intake was slightly less than that of the hay group. Also in a review,\textsuperscript{(20)} covering several experiments, the average intake of silage reached 83% of the intake of barn-dried hay yet milk production was the same as for barn-dried hay. All these experiments indicate a better efficiency of utilization of silage for milk production. In the present experiment, the reason for higher milk production for the silage group could partly be due to the higher digestibility of the silage diet compared to the hay due to the difference in harvesting date. Postponement of the harvesting date of hay by 10-20 days resulted in a decrease of 8-10% in fat corrected milk yield of dairy cows\textsuperscript{(19)}.

Milk Composition

The mean concentration of SNF for the silage and hay group as well as the total solids for the silage group was significantly greater (P<0.05) than that of the H/S group. The reason for the lower total solids and SNF concentration for the H/S is difficult to explain. But it may be related to the fact that the H/S group had the highest milk yield resulting in a dilution of some of its milk constituents. However the yields of total solids, SNF and fat were not significantly affected by the treatment, though there was a tendency for higher values for all these constituents for the silage group than that for the hay group with H/S intermediate.

Live-weight change

The results in Table 3 indicated no significant effect of diets on the live-weight change during the experimental period. It was also shown that the silage group lost most weight (56 g/d) followed by H/S group (38 g/d) and the least weight (6 g/d) was lost by the hay group. This live-weight change was calculated using the difference between the mean of kidding week and the last week (11 and 12) as the final live-weight. However this large loss of weight for the silage group could have been caused by either one or two factors. It could have resulted from mobilization of adipose tissue to provide extra energy for more milk production. If this is the case then this extra energy could have contributed partially to the greater milk yield for the silage group as compared to the hay group. Alternatively the extra live-weight could have been caused by silage as compared to the hay. This is because hay and dried grass are known to promote a greater fill than silages made from the same herbage\textsuperscript{(21)}. To try to clarify this point, live-weight change was also calculated for the period between 4 and 12 weeks. This excluded the first 3 weeks of lactation when some of the goats were changing from H/S to either hay or silage and the results showed that for this period the silage group was the only one to gain weight (24 g/d) (Table 4).

On the other hand when the live-weight changes was measured between week 0 to 12, the silage group lost significantly (P<0.05) the highest weight among the treatments. In fact the silage group had lost 50% of the total live-weight loss during the first 2 weeks of lactation presumably when the gut fill was decreasing as it was changing from hay to silage. Therefore it is most likely that the apparent weight loss for the silage group was mainly due to the effect of the initial gut fill changes, since when the first three weeks of lactation were excluded, this group appeared to be gaining weight instead of losing it (Table 4). If this argument is accepted then these results will be in agreement with those of Bertillon et al.\textsuperscript{(22)}. They compared live-weight change of dairy cows offered early cut hay and silage and observed that the hay group lost (0.7 kg) and the silage group
gained (2.8 kg) live-weight from 2 to 10 weeks of lactation.

In conclusion, the results of this experiment indicate that silage can be used as a basal diet for dairy goats, just in the same way it is being used for dairy cows as an alternative to hay, giving satisfactory milk yield and composition depending upon the basal diet and the supplement provided.

References


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SOME FACTORS AFFECTING DIET DIGESTIBILITY IN GOATS

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QUELQUES FACTEURS AFFECTANT LA DIGESTIBILITE DES REGIMES ALIMENTAIRES CHEZ LES CHEVRES

Résumé

Huit chèvres castrées et huit chèvres en lactation ont été nourries de régime alimentaire contenant 1:1 [matière sèche (MS) de base] foin: concentrés présentés selon une formulation factorielle 2 x 2 de deux programmes de régime alimentaire et deux concentrés de différentes concentrations de protéine brute (PB) [153 (taux plus faible de protéine brute et 187 (taux plus élevé de protéine brute)] exprimé en g PB/kg MS. Les chèvres castrées ont été servies de régime contenant un taux plus faible de protéine et les chèvres en lactation nourries de régime avec un taux plus élevé de protéine. Le régime contenant le taux plus élevé de protéine a réduit significativement la digestibilité de MS, de matière organique (MO), d’azote (N) et de fibres détergents en présence de l’acide (FDA). Toutefois, pour MS, MO et FDA, cette baisse de la digestibilité obtenue avec une amélioration du programme de régime alimentaire était significative (P<0,05) uniquement avec le régime contenant un taux plus faible de protéine et non avec celui contenant un taux plus élevé de protéine, ce qui indique que cette réduction pourrait être évitée si la concentration de protéine brute dans le régime est accrue. Dans une autre expérience, les chèvres ont été alimentées avec du foin et des concentrés contenant 112 (taux faible de protéine), 152 (taux moyen de protéine) ou 185 (taux élevé de protéine), exprimé en g PB/kg MS. La digestibilité de matière sèche a été calculée quotidiennement pendant huit jours. La digestibilité des matières organiques, des fibres détergents en présence de l’acide et de l’azote total dans le régime alimentaire était significativement plus élevée avec le régime contenant un taux plus élevé de protéine qu’avec celui au taux plus faible de protéine (P<0,05). Le régime contenant un taux moyen de protéine était en position intermédiaire (réponse linéaire P<0,01). Il y avait une baisse permanente du carré moyen résiduel et du coefficient de variation lorsque la durée de collecte des données a augmenté, mais l’effet principal est apparu au cours des cinq premiers jours.

Summary

Eight castrates and eight lactating females received a diet of 1:1 (dry matter (DM) basis) hay: concentrates in a 2 x 2 factorial arrangements of two planes of feeding and two concentrate CP concentrations (153 lower crude protein (LCP) and 187 higher crude protein (HCP) g CP/kg DM). The castrates received the lower and the lactating higher plane of feeding. The higher plane of feeding reduced significantly digestibilities of DM, organic matter, (OM), nitrogen (N) and acid-detergent fibre (ADF). However, for DM, OM and ADF this reduction in digestibility with increased plane of feeding was significant (P<0.05) with LCP, diet only and not with HCP diet, indicating that this depression could be alleviated when CP concentration of the diet is increased. In another experiment goats were offered hay and concentrates containing 112 (LP), 152 (MP) or 185 (HP) g CP per kg DM. Dry matter digestibility of dietary OM ADF and total N was significantly greater with HP than LP (P<0.05), with MP values being intermediate (linear response P<0.01). There was a continuous fall in the residual mean square and the coefficient of variation as the length of the collection period increased, but the main effect occurred over the first 5 days.

INTRODUCTION

There are a number of factors affecting digestibility of diets ranging from those that are associated with food to those associated with the animal used. Among the most important ones are food and ration composition, preparation of foods
and level of feeding\(^{1(1)}\). As for the last factor a lot of experiments suggest that digestibility decreases with increasing intake\(^{2,3,4}\). There is some evidence that this depression of the digestibility caused by the level of feeding is slightly greater in sheep than it is in cattle\(^{5,6}\). Furthermore Tyrrell et al\(^{1(2)}\) have shown that the depression is alleviated in dairy cows when the CP of the ration is increased. However, little is known of these effects in lactating goats.

The objective of the present experiments was to examine the effect of level of feeding, CP and length of the collection period on digestibility. Level of feeding and its interaction with CP concentration was looked into in experiment 1, and level of crude protein in the diet and the length of the collection period, as a factor affecting the accuracy of digestibility measurement, were investigated in experiment 2.

**Materials and Methods**

**Experiment 1**

Sixteen Saanen goats were used, eight castrates and eight lactating females. The castrates were around one year old with a mean weight of 42 kg (range 39-44 kg) at the beginning of the experiment. The females were at their 17-19th week of their second to fourth lactation and weighed between 55 and 65 kg. All animals received a diet of 1:1 (dry matter (DM) basis) hay: concentrates. The experiment was a 2 x 2 factorial arrangement of two planes of feeding (0.45 MJ metabolizable energy (ME)/kg\(^{0.75}\)/day and 0.9 MJ/kg\(^{0.75}\)/day) and two concentrate CP concentrations (153 low crude protein (LCP) and 187 high crude protein (HCP) g CP/kg DM) (Table 1). The castrates received the lower and the lactating females the higher plane of feeding. Within each group the concentrate type was applied in change over fashion. All the goats were housed in individual pens for the preliminary period of 11 days and in individual metabolism crates for both adjustment of 3 days and collection period of 7 days.

**Measurements.**

Samples of the hay and concentrates were taken daily and bulked for the 7 days of collection. Daily refusals were also weighed and bulked for the whole period for DM determination and chemical analysis. Faeces collected were weighed, mixed and a proportion (50 g/kg) was put into 3 m H\(_2\)SO\(_4\) for nitrogen determination. The remainder was collected in a bucket containing 30 ml H\(_2\)SO\(_4\); a sample (100 ml/l) was bulked and stored at -20°C for subsequent analysis.

**Analysis.**

Food, refusals and faeces were analysed for neutral-detergent fibre (NDF)\(^{1(3)}\) and acid-detergent fibre (ADF)\(^{1(4)}\). Feed were also analysed for the concentration of digestible organic matter (OM) in the DM (DOMD g/kg) by the two-stage incubation procedure of Tilley and Terry\(^{1(5)}\). ME concentration of feeds (MJ/kg DM) was calculated as 0.015 DOMD\(^{1(6)}\).

Estimate have been made of the supplies of ME, CP, RDP and UDP (Table 8). Calculations of ME supplies were made by assuming 1 kg digestible organic matter equals 15.58 MJ ME, and RDP by assuming 0.80 to be the degradability of the dietary protein\(^{1(7)}\).

**Experiment 2**

Twenty one Saanen goats, 7 per treatment at their fifteenth week of their second to fourth lactation were used. They weighed on average 72 kg and were offered 0.90 of the average amount of perennial rye grass (Lolium perenne) hay and concentrates they had consumed during the preliminary period. The goats were allocated to three treatments which had concentrates containing 112 (LP), 152 (MP, or 185 (HP) g CP/kg DM (Table 2). All the goats had 7 days for adjustment in the crates and 8 days for measurement. Digestibility of DM for each of the eight days of collection period was determined. The experiment was analysed as completely randomized designs giving 18 error degrees of freedom.

Milk samples were collected and analysed for the concentration of total nit-
rogen as per Badamana et al.\textsuperscript{(13)} using Rowland\textsuperscript{(14)} method. Other details for digestibility measurements, sample collection and analysis were like the ones used in Experiment 1.

**Results**

The chemical composition of the concentrates and the hay used in experiment 1 and 2 is given in Table 1 and 2 respectively.

**Table 1: Comparison of concentrates (g/kg) (minerals and vitamin were added extra) and chemical composition in vitro digestibility of the feeds used in Experiment 1**

<table>
<thead>
<tr>
<th>Concentrate ingredients</th>
<th>Hay</th>
<th>Concentrates</th>
<th>LCP</th>
<th>HCP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dry matter (g/kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>886</td>
<td>898</td>
<td>898</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic matter (g/kg DM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>919</td>
<td>961</td>
<td>936</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neutral detergent fibre (g/kg DM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>86</td>
<td>154</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid detergent fibre (g/kg DM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>357</td>
<td>60</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crude protein (g/kg DM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>692</td>
<td>227</td>
<td>244</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross energy (MJ/kg DM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.68</td>
<td>17.86</td>
<td>17.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In vitro digestibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry matter</td>
<td>0.650</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic matter</td>
<td>0.638</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Digestible OM (kg/kg DM)</td>
<td>0.581</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Composition of concentrates (g/kg) (minerals and vitamins were added extra) and chemical composition and in vitro digestibility of the feed used in Experiment 2**

<table>
<thead>
<tr>
<th>Concentrate ingredients</th>
<th>Hay</th>
<th>Concentrates</th>
<th>LP</th>
<th>MP</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dry matter (g/kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>885</td>
<td>874</td>
<td>876</td>
<td>874</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic matter (g/kg DM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>924</td>
<td>966</td>
<td>962</td>
<td>959</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neutral detergent fibre (g/kg DM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>619</td>
<td>217</td>
<td>216</td>
<td>209</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid detergent fibre (g/kg DM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>391</td>
<td>76</td>
<td>90</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crude protein (g/kg DM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>86</td>
<td>117</td>
<td>152</td>
<td>185</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross energy (MJ/kg DM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.97</td>
<td>18.32</td>
<td>19.05</td>
<td>18.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In vitro digestibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry matter</td>
<td>0.605</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic matter</td>
<td>0.588</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Digestible OM (kg/kg DM)</td>
<td>0.537</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Feed intakes and treatment means and main effects of plane of feeding and dietary protein content on digestibility of the diets used in Experiment 1

<table>
<thead>
<tr>
<th>Plane of feeding/Animal type</th>
<th>Individual treatments</th>
<th>Main effect of level of feeding</th>
<th>Main effect of level of protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1 x maintenance)/</td>
<td>(2 x maintenance)/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>castrate)</td>
<td>milking)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LCP</td>
<td>LCP</td>
<td>SED</td>
</tr>
<tr>
<td>DM intake (kg/d)</td>
<td>0.352</td>
<td>0.341</td>
<td>0.882</td>
</tr>
<tr>
<td>Hay</td>
<td>0.355</td>
<td>0.905</td>
<td>0.706</td>
</tr>
<tr>
<td>Concentrate</td>
<td>0.702</td>
<td>0.919</td>
<td>0.721</td>
</tr>
<tr>
<td>Total</td>
<td>0.702</td>
<td>1.825</td>
<td>1.825</td>
</tr>
</tbody>
</table>

Mean apparent digestibility of:

| DM                           | 0.727^a               | 0.682^b                       | 0.706^a                       | 0.0089 | **   | 0.0123 | NS   |
| OM                           | 0.745^a               | 0.700^b                       | 0.721^a                       | 0.0085 | **   | 0.01193| NS   |
| ADF                          | 0.607^a               | 0.523^b                       | 0.566^a                       | 0.0079 | **   | 0.0210 | NS   |
| N                            | 0.672^a               | 0.608^b                       | 0.664^a                       | 0.015  | ***  | 0.01315| NS   |

SED = Standard error of difference

^ab = values within the same protein level which do not share the same superscript

^ab = differ significantly (P<0.05)

Table 4: Nitrogen balance of the goats in Experiment 1

<table>
<thead>
<tr>
<th>N Utilization (g/d)</th>
<th>1 x Maintenance LCP</th>
<th>1 x Maintenance HCP</th>
<th>2 x Maintenance LCP</th>
<th>2 x Maintenance HCP</th>
<th>S.E.</th>
<th>Main effect Level</th>
<th>Main effect Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>13.6</td>
<td>15.3</td>
<td>35.1</td>
<td>40.2</td>
<td>0.45</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Faecal</td>
<td>4.5^a</td>
<td>3.9</td>
<td>13.7^a</td>
<td>13.5^b</td>
<td>0.41</td>
<td>**</td>
<td>NS</td>
</tr>
<tr>
<td>Faecal N/intake N</td>
<td>0.33^ab</td>
<td>0.26^a</td>
<td>0.39^c</td>
<td>0.34</td>
<td>0.014</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Urine</td>
<td>6.3^a</td>
<td>7.8^c</td>
<td>10.6^c</td>
<td>16.5^d</td>
<td>0.42</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Urinary N/intake N</td>
<td>0.46^a</td>
<td>0.51^c</td>
<td>0.30^b</td>
<td>0.41</td>
<td>0.017</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Retained</td>
<td>3.1^a</td>
<td>3.8^c</td>
<td>10.8^c</td>
<td>10.1^d</td>
<td>0.50</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Apparenatly digested N (g/d)</td>
<td>9.2^a</td>
<td>11.4^c</td>
<td>21.4^c</td>
<td>26.7^c</td>
<td>0.53</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Retained N/App. dig. N</td>
<td>0.34^a</td>
<td>0.35^a</td>
<td>0.50^b</td>
<td>0.38^b</td>
<td>0.034</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

^ Means with different superscripts differ significantly (P<0.05)

plane on feeding (P<0.001) at both levels of CP in the diets and was increased by the higher level of CP at both levels of intake. No statistically significant interactions between level of intake and CP concentration were established but there were trends for the effect of level of intake to be reduced at the higher level of CP inclusion for DM, OM and ADF.

Nitrogen balance. Within each level of intake apparently digested N was higher for the HCP than the LCP, but most of the extra absorbed N was excreted in the urine, and there was no significant difference for the faecal N loss within the same levels (Table 4). Faecal N loss at twice maintenance was about three times that at maintenance (P<0.01). However the faecal N as a proportion of N intake was significantly (P<0.001) reduced by the higher level of protein and by the lower level of feeding. With urinary N as a proportion of N intake, losses were increased by the level of protein but reduced by the higher level of intake.

Retained N followed the same patterns as faecal N, namely retention was greater at twice maintenance than at maintenance (P<0.01), with no effect of level of N in the diet. However, when retained N was expressed as a proportion of either N intake or digested N the picture was
altogether different. In relation to N intake, there was no main effect of either level of intake or protein, but retention was greater at the higher level of intake for diet LCP (P<0.05) though not for diet HCP. In relation to apparently digested N, retention was significantly increased (P<0.05) by level of intake and reduced (P<0.05) by dietary protein but among individual treatments, the only significant effect of level of intake was with diet LCP, as it was when retained N was related to N intake.

Table 5: Feed intakes and apparent digestibility coefficients of the diets in Experiment 2

<table>
<thead>
<tr>
<th>Diet</th>
<th>LP</th>
<th>MP</th>
<th>HP</th>
<th>S.E.</th>
<th>Significant Treatment</th>
<th>Linear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake (kg DM/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay</td>
<td>0.99</td>
<td>1.03</td>
<td>1.15</td>
<td>0.069</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentrates</td>
<td>0.83</td>
<td>0.88</td>
<td>0.82</td>
<td>0.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digestibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>0.669</td>
<td>0.671</td>
<td>0.687</td>
<td>0.0061</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic matter</td>
<td>0.684\textsuperscript{a}</td>
<td>0.686\textsuperscript{a}</td>
<td>0.705\textsuperscript{b}</td>
<td>0.0061</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Neutral detergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibre</td>
<td>0.545</td>
<td>0.544</td>
<td>0.583</td>
<td>0.0143</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>0.520\textsuperscript{a}</td>
<td>0.548\textsuperscript{a}</td>
<td>0.574\textsuperscript{a}</td>
<td>0.0170</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Total N</td>
<td>0.508\textsuperscript{a}</td>
<td>0.566\textsuperscript{a}</td>
<td>0.595\textsuperscript{a}</td>
<td>0.0164</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

+ Means with different superscripts differ significantly (P<0.05).

Table 6: Nitrogen balance of the goats in Experiment 2

<table>
<thead>
<tr>
<th>Diet</th>
<th>LP</th>
<th>MP</th>
<th>HP</th>
<th>S.E.</th>
<th>Significant Treatment</th>
<th>Linear</th>
</tr>
</thead>
<tbody>
<tr>
<td>N utilization (g/d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed</td>
<td>30.4\textsuperscript{a}</td>
<td>36.2\textsuperscript{a}</td>
<td>41.7\textsuperscript{a}</td>
<td>1.22</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Faecal</td>
<td>14.9</td>
<td>15.9</td>
<td>16.9</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine</td>
<td>6.1\textsuperscript{a}</td>
<td>8.8\textsuperscript{b}</td>
<td>11.7\textsuperscript{c}</td>
<td>0.87</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Milk</td>
<td>6.9\textsuperscript{a}</td>
<td>11.5\textsuperscript{a}</td>
<td>12.0\textsuperscript{a}</td>
<td>0.52</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>Retained</td>
<td>0.5</td>
<td>0.1</td>
<td>1.1</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparently digested N (g/d)</td>
<td>15.6\textsuperscript{a}</td>
<td>20.3\textsuperscript{a}</td>
<td>24.9\textsuperscript{a}</td>
<td>0.93</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Milk N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Milk N + Retained N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>App. dig. N</td>
<td>0.65\textsuperscript{a}</td>
<td>0.57\textsuperscript{b}</td>
<td>0.49\textsuperscript{a}</td>
<td>0.039</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>App. dig. N</td>
<td>0.60</td>
<td>0.57</td>
<td>0.53</td>
<td>0.032</td>
<td>*</td>
<td>**</td>
</tr>
</tbody>
</table>

+ Means with different superscripts differ significantly (P<0.05).

Table 7: The effect of duration of faecal collection on residual mean square and coefficient of variation associated with measured DM digestibility in Experiment 2

<table>
<thead>
<tr>
<th>Duration of measurement (days)</th>
<th>Residual mean squares (RMS)</th>
<th>Coefficient of variation (CV%)</th>
<th>Mean DM digestibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LP</td>
<td>MP</td>
<td>HP</td>
</tr>
<tr>
<td>1</td>
<td>25.85</td>
<td>7.7</td>
<td>0.649</td>
</tr>
<tr>
<td>2</td>
<td>20.05</td>
<td>6.8</td>
<td>0.656</td>
</tr>
<tr>
<td>3</td>
<td>13.56</td>
<td>5.5</td>
<td>0.654</td>
</tr>
<tr>
<td>4</td>
<td>7.34</td>
<td>4.0</td>
<td>0.654</td>
</tr>
<tr>
<td>5</td>
<td>4.60</td>
<td>3.2</td>
<td>0.657</td>
</tr>
<tr>
<td>6</td>
<td>4.12</td>
<td>3.0</td>
<td>0.660</td>
</tr>
<tr>
<td>7</td>
<td>2.79</td>
<td>2.5</td>
<td>0.665</td>
</tr>
<tr>
<td>8</td>
<td>2.37</td>
<td>2.3</td>
<td>0.670</td>
</tr>
</tbody>
</table>
Table 8: Daily nutrient intakes of goats on different levels of CP and feeding in Expt. 2

<table>
<thead>
<tr>
<th>INTAKE:</th>
<th>LCP</th>
<th>1 x Maintenance</th>
<th>LCP</th>
<th>2 x Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestible OM intake (Kg)</td>
<td>0.49</td>
<td>0.48</td>
<td>1.20</td>
<td>1.15</td>
</tr>
<tr>
<td>ME (MJ)</td>
<td>7.7</td>
<td>7.5</td>
<td>18.7</td>
<td>17.9</td>
</tr>
<tr>
<td>Protein in conc. (g)</td>
<td>53</td>
<td>64</td>
<td>142</td>
<td>165</td>
</tr>
<tr>
<td>Protein in hay (g)</td>
<td>31</td>
<td>30</td>
<td>78</td>
<td>72</td>
</tr>
<tr>
<td>Total protein (g)</td>
<td>84</td>
<td>94</td>
<td>220</td>
<td>237</td>
</tr>
<tr>
<td>RDP' (g)</td>
<td>67</td>
<td>75</td>
<td>176</td>
<td>190</td>
</tr>
<tr>
<td>UDP (g)</td>
<td>17</td>
<td>19</td>
<td>44</td>
<td>47</td>
</tr>
<tr>
<td>g CP/kg diet DM</td>
<td>120</td>
<td>136</td>
<td>120</td>
<td>129</td>
</tr>
<tr>
<td>g RDP/MJ ME</td>
<td>8.74</td>
<td>9.99</td>
<td>9.41</td>
<td>10.64</td>
</tr>
</tbody>
</table>

'Degradability of the dietary protein assumed to be 0.8, (12).

Table 9: The effect of duration of measurement on residual mean square and coefficient of variation associated with measured dry matter digestibility

<table>
<thead>
<tr>
<th>Duration of measurement (days)</th>
<th>Residual mean squares (RMS)</th>
<th>Coefficient of variation (CV%)</th>
<th>Mean DM digestibility</th>
<th>H/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>11.76</td>
<td>4.8</td>
<td>66.5</td>
<td>71.6</td>
</tr>
<tr>
<td>4</td>
<td>5.420</td>
<td>3.3</td>
<td>65.6</td>
<td>72.5</td>
</tr>
<tr>
<td>6</td>
<td>5.211</td>
<td>3.2</td>
<td>65.4</td>
<td>72.7</td>
</tr>
<tr>
<td>8</td>
<td>4.610</td>
<td>3.1</td>
<td>64.8</td>
<td>72.1</td>
</tr>
<tr>
<td>10</td>
<td>3.914</td>
<td>2.8</td>
<td>64.8</td>
<td>72.5</td>
</tr>
</tbody>
</table>

Experiment 2

Diet digestibility.

The digestibility of all the fractions measured was slightly greater on HP than on LP, significantly so for OM (P<0.05), ADF (P<0.05) and total N (P<0.01). Digestibility values on MP were very similar to those on LP for DM, OM and NDF and were intermediate between LP and HP for ADF and total N (Table 5).

Significant linear responses were observed for OM (P<0.05), ADF (P<0.05) and total N (P<0.01).

Nitrogen balance.

With increasing N intake, faecal N changed little but urinary N increase markedly (Table 6). Milk N increased significantly but by a relatively small amount. Thus apparently digested N and N digestibility increased markedly as dietary CP intake increased but most of the extra absorbed N was excreted in the urine.

Milk N as a proportion of apparently digested N declined from 0.65 to 0.49 (P<0.01) with increasing dietary CP but the decline in milk N plus retained N as a proportion of apparently digested N did not attain significance because of a non-significant increase in retained N.

The length of the faeces collection period. The cumulative apparent DM digestibility based on increasing collection period from one to eight days is given in Table 7. The results show that there was a continuous fall in the residual mean square and the coefficient of variation as the length of the collection period increased, but the main effect occurred over the first 5 days.

Discussion

The overall effect of the higher plane of feeding was to reduce, significantly, digestibilities of DM, OM, ADF and N. This is in agreement with the results of some
authors\textsuperscript{(15,16)}, with ewe lambs,\textsuperscript{(17,18)} and others with dairy cows.

One of the major reasons given for this decrease of digestibilities of the diets with increasing levels of feeding is the increase of rate of passage of digesta through the gastro-intestinal tract, thus reducing the period food is exposed to digestive enzymes\textsuperscript{(19,20,21)}.

In the present experiment, the interaction of CP concentration with the level of feeding was not significant ($P>0.05$). This may be because the CP content of the two diets was not widely different (120 and 133 g/kg DM) and only just below half as greater as the difference in the CP content of the concentrates (153 and 187 g/kg DM). However, the effect of level of protein on digestibility was demonstrated clearly (Table 3). There was a reduction in digestibility with increase plane of feeding which was significant ($P<0.05$) with the LCP concentrate but not with the HCP concentrate. This implies that the depression of digestibility caused by increasing level of feeding was reduced when the CP concentration of a ratio was increased.

It seems possible that the greater response to increase CP concentration at the higher level of feeding may be related to the change in the rate of passage of digesta from the rumen. Increasing level of feeding is associated with increased rates of outflow of both liquid and particulate matter from rumen\textsuperscript{(22,23,24,25,26,27)}. This reduction of time spent by protein supplements in the rumen due to higher level of feeding would reduce protein degradability in the rumen\textsuperscript{(28,29,30,31)} Thus estimates of the RDP/ME ratio of the present experiment indicate that both diets provided sufficient RDP, a value higher than 8.38, recommended for optimal microbial protein synthesis\textsuperscript{(32)} (Table 8). But even though the HCP group of the twice maintenance had much higher ratio of RDP/ME (10.64) than required there was still a further increase in digestibility of all the nutrients tested. In this case the rumen microbes of such animals may need more rumen degradable protein to meet their requirements. Thus increasing the CP concentration of the diet with increases in the level of feeding may compensate for higher rate of fractional outflow of protein and hence reduce the depression of digestibility caused by higher intake\textsuperscript{(33,34)}.

Furthermore, in Experiment 2, increasing CP in the concentrates, irrespective of the level of feeding, from 112 to 185 g/kg DM (from 99 to 124 g/kg DM for the diets) increased the digestibility of OM, ADF and CP but had less effect on DM and NDF digestibility. Hadjipanayiotou\textsuperscript{(35)} with Damascus kids observed increases in the digestibility of DM, OM and CP in response to increases in CP in the concentrates over a similar range.

In the present experiment it seems CP concentration was still below the level required by lactating animals, so an increase from 99 to 124 CP/kg DM showed an improvement in the digestibility of some nutrients but when there was a further increase in CP concentration (up to 175 g/kg DM) of the diets there was no extra increase in digestibility\textsuperscript{(36)}. The same was the case with Hadjipanayiotou\textsuperscript{(35)} where with Damascus lactating goats he reported no response in digestibility when he increased CP concentration from 135 to 175 g/kg DM.

Another factor affecting digestibility is the length of the collection period. In Experiment 2, when the collection period was extended from one to eight days, there was a continuous fall of both the residual mean square and the efficiency of variation for the cumulative apparent DM digestibility. However, the main benefit occurred during the first 5 days. Therefore it was concluded that 5 to 7 days could be enough to give reliable digestibility measurements with goats. Similar results were obtained by Badamana\textsuperscript{(37)} in another experiment where Saanen goats were offered hay, silage or a mixture of hay and silage, and the collection period was extended from two to ten days. The cumulative apparent DM digestibility showed a continuous fall in the residual mean square and the coefficient of variation as the length of the collection period was increased, but the main benefit occurred over the first 4
days (Table 9). Terada et al. (38) also obtained similar results with Japanese native meat type goats. However, it should be pointed out that the frequency of feeding and the passage of feed affect the rate of production of faeces. Blaxter et al. (39) stated that feeds which pass quickly and are given infrequent intervals give rise to greater variation in the rate of passage than feed which is given at frequent intervals and passes slowly.

Therefore, it is not only the number of collection days per se which matters, but also the precautions taken to reduce all causes of variability in faecal output.

In conclusion the results of these two experiments indicate that goats, like cattle and sheep, show a decrease in digestibility with increasing intake. However this depression of digestibility could be alleviated when CP concentration of the diet is increased. Furthermore, as the principle effect of lengthening the collection period in the digestibility trial is to improve precision of the measurements, the length of the collection period could be reduced to 5 days, though 7 days would be preferred, without the risk of having a high residual mean square or coefficient of variation.

References

12. ARC (1980). The nutrient requirements of ruminant livestock. Technical review by an Agri-

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STUDIES ON THE HEAT TOLERANCE OF SOME GENETIC GROUPS OF CHICKENS IN GHANA

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ETUDES SUR LA TOLERANCE A LA CHALEUR DE QUELQUES GROUPES GENETIQUES DE POULETS AU GHANA

Résumé

Quatre expériences ont été effectuées pour déterminer si la variation de la tolérance à la chaleur existe au sein et entre les poulets commerciaux importés et les poulets indigènes au Ghana. La tolérance à la chaleur a été définie comme étant la différence entre les températures rectales prises le matin (05 H 30) et celles prises pendant la période la plus chaude de la journée (12 H 30). Des différences significatives (P<0.05) existaient au sein des poules d’une race commerciale de pondesuse et aussi entre différentes races. A l’ombre et les matins, la moyenne de la tolérance à la chaleur ne dépassait pas 41.8°C, ce qui est une température normale pour les poulets.

En plein soleil toutefois, en se basant sur l’accroissement du rythme respiratoire, sur la consommation d’aliment, d’eau et le degré de tolérance à la chaleur, il s’est avéré que les poulets locaux étaient plus tolérents à la chaleur, suivis par la race Shaver SX 585, tandis que les parents des poulets de grill étaient les plus sensibles à la chaleur.

Les corrélations entre la tolérance à la chaleur et le nombre d’œufs, la consommation d’eau et d’aliment, et le poids des œufs étaient respectivement de -0.96; -0.95; -0.95; -0.95 pour la race Shaver SX 288, de -0.93; -0.90; -0.23 et de -0.01 pour la race Shaver SX 566.

Summary

Four experiments were conducted to determine whether variation in heat tolerance exists within and between imported commercial chickens and local indigenous chicken in Ghana. Heat tolerance was defined as the difference between rectal temperatures measured in the morning (0530h) and the hottest part of the day (1230h). Significant differences (P<0.05) existed within hens of a commercial layer breed and also between different breeds. Under the shade, and in the mornings mean heat tolerance never exceeded 41.8°C which is normal for chickens.

In the open sun however, based upon increased respiratory rates, feed and water consumption patterns and heat tolerance scores, it was evident that the local birds were the most heat tolerant, followed by the Shaver SX 585, whilst the broiler parents were the least.

Correlations between heat tolerance and egg number, water intake, feed intake and egg weight were respectively, -0.96, -0.94, 0.35, +0.09 for Shaver SX 288 and -0.93, -0.90, -0.23 and -0.01 for Shaver SX 566.

INTRODUCTION

Commercial poultry production in most tropical countries depends upon importations of breeds developed under temperate conditions. The mean ambient temperature of most tropical countries is often above the thermoneutral zone of adult chickens\(^1\) and in many cases results in birds becoming heat stressed\(^2\). Reports indicate that imported breeds frequently fail to achieve the same levels

of performance in the humid tropics as in the temperate zones\(^3,4\). Even though management and nutritional manipulations have been suggested to ameliorate debilitating climatic effects, these were based upon studies in climatic chambers\(^5,6,7\). Such studies are limited by the range of climatic models that can be mirrored and field data are thus needed. As compared with hot-dry climates, our knowledge of climatic physiology in hot-humid environments is relatively
limited).

Heat tolerant birds would obviously fare better under such conditions, as their core body temperatures vary little in response to diurnal ambient temperature variations. White Leghorns and other lighter breeds are reputed to be more heat tolerant than heavier breeds due possibly to differences in metabolic rate.

The present paper reports on experiments undertaken to study the variation in heat tolerance within and between breeds of domestic fowl and its relationship with egg production traits under Ghanaian climatic conditions.

**Materials and Methods**

**Location**

The experiments were conducted in different stations located in the coastal savanna climatic zone (Accra Plains). The mean annual rainfall is between 72.5-86.5 cm. The rains occur in two seasons with peaks in June and October.

The highest mean monthly temperature of about 30°C occurs between March and April and the least of 26°C in August. The average monthly humidity are 75% and 60% during the rainy and dry seasons, respectively.

**Estimation of heat tolerance**

Heat tolerance was defined as the difference between the rectal temperatures of a bird in the morning and during the hottest part of the day. Thus the smaller the difference, the more heat tolerant the bird is. The coolest part of the day was taken for convenience to be 0530 h, whilst the hottest part of the day was determined by taking ambient temperature readings at one-hour intervals from 0530 h to 1830 h daily over three continuous days. The hottest part of the day was found to be 1230 h.

Heat tolerance score for any bird was thus the difference between rectal temperatures taken at 0530 h and 1230 h. When working with large number of birds, these times were adjusted correspondingly to 0500 h - 0600 h and 1200 h - 1300 h respectively.

**Experiment 1**

In order to investigate differences in heat tolerance within genetically-uniform stocks, ten, 72 weeks old Shaver Starcross 585 (SX 585) layers obtained initially at day old from a franchise of Shaver Breeding Farms, Canada, were placed individually in cages. Water and feed were provided for *ad libitum* access over the 10-day experimental period. Both ambient temperature and relative humidity were recorded daily. Rectal temperatures were taken as outlined above, to determine heat tolerance of each bird.

**Experiment 2**

Seven laying hens each of three different breeds were involved in the experiment to determine whether differences exist between genetically diverse groups of chicken in heat tolerance. The genetic groups were: the indigenous local domestic fowl, White Leghorns and White Plymouth Rock broiler parent breed. Both feed and water were provided *ad libitum* over the 10 day trial period. The birds which were weighed before the experiment were individually housed in cages. Heat tolerance of each bird was then measured as defined earlier.

**Experiment 3**

The objective here was to find the ultimate capability of the birds to withstand long exposures to high environmental temperatures. Five layers each of the local indigenous fowl, Shaver Starcross 585 and the White Rock broiler stock were put in open-sided individual cages in the sun to ensure maximum exposure to atmospheric heat. Feed and water were provided *ad libitum* over the 10-day period of the trial.

Response criteria included rectal temperatures in the morning (0500 h - 0600 h) and at noon (1200 h - 1300 h), respiration rates (counts/minute), apparent feed and water intakes (included wastages).

**Experiment 4**

The purpose of this trial was to study the relationship between heat tolerance
and egg production traits of Shaver Star-cross 288 (SX 288), a White Leghorn-based breed and Shaver Starcross 566 (SX 566) a dual-purpose, black-feathered breed.

Ten, 24 week-old hens of each breed of known heat tolerance scores were individually-caged. Over a 5 week period, water and feed were provided ad libitum and the following parameters were measured: initial and final body weights, apparent weekly feed intake, apparent water consumption, daily egg production and mean egg weight of all eggs laid.

In general, analysis of data were in accordance with methods described by Snedecor and Cochran\(^{(11)}\) for one-way classification and separation of means based upon Least Significant Difference, except in experiment 1 where Duncan’s multiple range method was used. In case of experiment 4, product moment correlations were calculated between heat tolerance and egg number, egg weight, feed and water consumption within each breed.

### Results

The rectal temperature for the layers ranged from 39.8°C to 41.9°C in the morning and 41.0°C - 42.3°C in the afternoon (Table 1). The mean morning rectal temperature was significantly (P<0.05) lower than the mean noon rectal temperatures. The variation in heat tolerance between the birds in this trial was statistically significant (P<0.05) (Table 1).

In trial 2, morning rectal temperatures did not vary between breeds (Table 2). Significant differences (P<0.05) however, were observed between the exotic breeds on the one hand, and the local indigenous genotype, in respect of afternoon rectal temperatures. Heat tolerance differences between the breeds followed the trends for the afternoon rectal temperatures and was not related linearly to body weight.

When the breeds were exposed in the open to direct sunlight without shelter in trial 3, the heavy broiler birds started dying and were removed from the experi-

<table>
<thead>
<tr>
<th>Bird No.</th>
<th>Range (°C)</th>
<th>Morning</th>
<th>Noon</th>
<th>Heat tolerance (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean</td>
<td>mean</td>
<td>mean ± s.e.</td>
</tr>
<tr>
<td>1</td>
<td>40.5-41.1</td>
<td>41.0</td>
<td>41.7</td>
<td>0.7±0.1ab¹</td>
</tr>
<tr>
<td>2</td>
<td>40.6-41.9</td>
<td>41.2</td>
<td>41.7</td>
<td>0.5b</td>
</tr>
<tr>
<td>3</td>
<td>40.9-41.2</td>
<td>41.2</td>
<td>41.4</td>
<td>0.2±0.1b</td>
</tr>
<tr>
<td>4</td>
<td>40.7-41.4</td>
<td>41.0</td>
<td>41.6</td>
<td>0.6±0.1ab</td>
</tr>
<tr>
<td>5</td>
<td>40.4-41.4</td>
<td>40.8</td>
<td>41.6</td>
<td>0.8±0.1ab</td>
</tr>
<tr>
<td>6</td>
<td>40.5-41.3</td>
<td>40.9</td>
<td>41.8</td>
<td>0.9±0.1a</td>
</tr>
<tr>
<td>7</td>
<td>40.5-41.0</td>
<td>40.8</td>
<td>41.8</td>
<td>1.0±0.1a</td>
</tr>
<tr>
<td>8</td>
<td>40.5-41.2</td>
<td>40.8</td>
<td>41.5</td>
<td>0.7±0.1ab</td>
</tr>
<tr>
<td>9</td>
<td>39.8-41.1</td>
<td>40.9</td>
<td>41.8</td>
<td>0.9±0.1a</td>
</tr>
<tr>
<td>10</td>
<td>40.3-41.4</td>
<td>40.1</td>
<td>41.1</td>
<td>1.0±0.1a</td>
</tr>
</tbody>
</table>

RH(%) 80-90 84.2 42.58 50.1
\(^\circ\)C 20-24 21.0 25.32 29.6

¹Means the different letters are significantly different (P<0.05)
Table 2: Rectal temperatures (°C), mean body weight (kg) and heat tolerance (°C) of different genetic groups of Experiment 2

<table>
<thead>
<tr>
<th>Genetic group</th>
<th>Body Wt. (kg)</th>
<th>Morning rectal °C</th>
<th>Noon rectal °C</th>
<th>Heat tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Local</td>
<td>0.98</td>
<td>40.8-41.7</td>
<td>41.3</td>
<td>41.2-41.9</td>
</tr>
<tr>
<td>Broiler parent</td>
<td>2.54</td>
<td>40.8-42.2</td>
<td>41.4</td>
<td>41.7-42.3</td>
</tr>
<tr>
<td>White Leghorn</td>
<td>1.24</td>
<td>40.8-42.0</td>
<td>41.4</td>
<td>41.7-42.3</td>
</tr>
<tr>
<td>RH %</td>
<td></td>
<td>68-72</td>
<td>70</td>
<td>55-59</td>
</tr>
<tr>
<td>Room temp. (°C)</td>
<td></td>
<td>25-26</td>
<td>25</td>
<td>25-29</td>
</tr>
</tbody>
</table>

*a,b* on different means indicate significant difference (P<0.05).

Table 3: Summary of results in Experiment 3

<table>
<thead>
<tr>
<th>Breed</th>
<th>Body wt. (kg)</th>
<th>Heat tolerance (°C)</th>
<th>Respiration rate (counts/min)</th>
<th>Feed intake (g/bird)</th>
<th>Water intake ml/bird</th>
<th>Water intake ml/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>morn.</td>
<td>noon</td>
<td>shade</td>
<td>sun</td>
<td>shade</td>
</tr>
<tr>
<td>Local</td>
<td>1.13</td>
<td>0.9±0.07a</td>
<td>36</td>
<td>63a</td>
<td>65.3</td>
<td>66.6</td>
</tr>
<tr>
<td>SX 585</td>
<td>1.93</td>
<td>1.3±0.09b</td>
<td>38</td>
<td>87b</td>
<td>90.4</td>
<td>64.8</td>
</tr>
</tbody>
</table>

RH% were: morning, 50-84; afternoon, 10-30
Ambient temperatures (°C) were: morning, 20-25; noon, 35-42

Table 4: Correlations between heat tolerance and production traits by breed in Experiment 4

<table>
<thead>
<tr>
<th>Breed</th>
<th>Egg number</th>
<th>Daily water intake</th>
<th>Daily feed intake</th>
<th>Egg weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>SX 288</td>
<td>-0.96</td>
<td>-0.94</td>
<td>-0.35</td>
<td>+0.086</td>
</tr>
<tr>
<td>SX 566</td>
<td>-0.93</td>
<td>-0.90</td>
<td>-0.23</td>
<td>-0.001</td>
</tr>
</tbody>
</table>

iment. Of the 2 breeds which remained (Table 3), the local indigenous hens were more heat tolerant (0.9°C vs 1.3°C). The respiratory rate of the exotic SX 585 was higher than that for the local breed, the difference widening tremendously in the sun. SX 585 reduced its feed intake in the sun by nearly 30% whilst the local bird, maintained its feed intake. Both breeds however increased their water consumption in the sun, with the difference (sun-shade) being greater for SX 585 (310 cc) than for the local bird (240 cc) on absolute basis (Table 3). On per unit body weight basis, the reverse was true.

In trial 4, the heat tolerance score for SX 28 was 0.3±0.07 whilst that for SX 566 was 0.6±0.09. According to Table 4, the correlation between heat tolerance and egg production was very high and negative for the breeds. It was however higher in SX 288 (-0.95) which was more heat tolerant, than in SX 566 (-0.93). The trend for the breeds regarding the correlation of heat tolerance with water intake was similar to that for egg number in the sign and ranking between breeds. The magnitude of the correlation coefficient however, was slightly lower for water intake than egg number. Heat tolerance was again negatively correlated with feed intake. The relationship between heat tolerance and egg weight in these young laying flock was negligible.
Discussion

The heritability of heat tolerance in chicken is reported to be medium to high\(^{(12)}\) and familial differences have been documented\(^{(12,13)}\). The results of this study in which the uniformity expected of commercial crossbreeds could not be demonstrated in heat tolerance, suggest that genetic improvement methods for egg production under temperate climates has not achieved uniformity in response to diurnal ambient temperature changes.

Even though ambient temperatures during these trials reached 32\(^\circ\)C which was higher than their thermoneutral zone\(^{(1)}\), breed and individual differences were not apparent in the mornings. In the well-ventilated and shaded conditions of the afternoons, mean rectal temperatures of 41.6 - 41.8\(^\circ\)C were within normal ranges\(^{(1,10,14)}\).

Responses to extremely high temperature conditions (up to 42\(^\circ\)C) appeared to be related to body weight as also reported by Reece et al\(^{(16)}\) and Washburn et al\(^{(10)}\). The high heat tolerance of the local bird could also be genetic adaptation to familiar environment acquired over time\(^{(10)}\). The higher than normal respiration rates\(^{(17)}\), the higher water intake and reduced feed intake observed particularly for SX 585, the less heat tolerant of the 2 breeds placed in the sun, were all of thermoregulatory significance. According to Hardy\(^{(18)}\) evaporation water loss due to increased respiration (panting) is relatively less effective under hot-humid conditions as compared with hot-dry conditions. Ability to consume large amounts of water in relation to the metabolic mass would thus enhance cooling in hot-humid conditions. Fox\(^{(18)}\) associated the better survival time of White Leghorns than Rhode Island Red and New Hampshires under high temperatures, to their high water consumption ability. Whilst reduced feed intake helps reduce additional heat load\(^{(19)}\), it is also accompanied by lowered production, and therefore has negative economic effects.

The negative relationship between ambient temperature and egg mass production is well-documented\(^{(20,21)}\). The present study suggests that this negative relationship may be mediated by water and feed intake mechanisms. Any intervention that enhances water and feed intake under hot-humid conditions would restore egg mass production to a large extent.

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References


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SHORT COMMUNICATION

ECTOPARASITES OF PIGS IN TANZANIA

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INTRODUCTION

The growth of pig industry in Tanzania has, for a long time, been hampered by religious taboos resulting in increased dependency on beef animals as a source of meat. However, over the years there has been an increased backyard activity of keeping pigs and other animals. Apart from socio-religious factors, diseases have also played a major role in limiting growth of the industry. Most important diseases which are known to affect pigs include: African Swine Fever (ASF), trypanosomiasis, bacterial and viral diarrhoea, erysipelas infections and worm infestations etc. For instance ASF outbreaks in Mbeya region has discouraged farmers from keeping large pig herds\(^{1}\).

Ectoparasitism is also important in domestic animals including pigs. Parasites which have been shown to have economic significance in animals are Sarcoptes scabiei, Chorioptes spp, Psoroptic spp, fungi, Demodex spp, fleas and lice\(^{2}\). The purpose of this study was to establish parasites which are common and of economic significance in pigs in Tanzania.

A number of pig herds regardless of size were included in the study. The study covered pigs reared in towns in six regions. All pigs in the herds were clinically examined for presence abnormal behaviour such scratching and rubbing on walls and doors which are clinical manifestations of either mite or flea or lice infestation. In addition, animals were thoroughly examined for evidence of skin lesions. The type of skin lesions and individual animal disease status were noted. During clinical examination animals were also carefully checked for presence of fleas and lice. In order to diagnose type of parasites causing skin lesions, skin scrapings were taken and processed using standard procedures\(^{3}\).

The results of this study show that out of the total 31 herds examined about 88% were infected with Sarcoptes scabiei mites (Figure 1). The majority of the cases (95%) evidenced the hypersensitive form which is characterised by erythematous skin papules and alopecia, whereas a small percentage showed the chronic form with variable amounts of crustations in ears, occasionally on other parts of the body. There was no evidence of clinical features of demodectic mange caused by Demodex phylloides. This was also supported by the observation that these mites were not recovered from skin scrapings taken from animals. In addition, there was no evidence of clinical manifestation of mycotic, infections and as such skin scrapings were not examined for fungal infections. Neither fleas nor lice were encountered in examined animals.

It was thus evident that Sarcoptes scabiei mites were the most prevalent

---

**Figure 1:**

<table>
<thead>
<tr>
<th>Herd number</th>
<th>Sarcoptes scabiei</th>
<th>Demodex phylloides</th>
<th>Ringworm</th>
<th>Flea infestation</th>
<th>Lice infestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>+</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
</tbody>
</table>
ectoparasites found in pigs in Tanzania. No ringworm and demodicetic mange cases were encountered in the examined pigs suggesting that these infestations in pigs are rare conditions\(^5\). Fleas and lice are known to infest pigs and cause rubbing and scratching behaviour\(^2\) which is also evident in mite infestation. Although fleas and lice are common in sheep, goats and cattle in Tanzania (personal observation) and are known to cause infestation in pigs\(^2\), surprisingly the parasites were not detected at all in the herds included in the study. Although this study was carried out in pig herds in only six regions out of 22, it is possible that flea and lice infestations, and fungal infections are rare in pigs in this country.

Sarcoptes scabiei mites are thus the most important ectoparasites of pigs in Tanzania. Due to its high prevalence\(^4\) and the fact that mite infestation may be associated with poor growth rates\(^5,6\) and that mange cases in Tanzania are not treated because of lack of drugs, there is a possibility that sarcoptic mange causes severe loss of production in pigs in Tanzania. These animals are also fed on unbalanced feeds such as maize bran, brewers waste and green fodder and as such further losses of animals productivity due to mange infestation could be immense. Therefore, the economic significance of porcine sarcoptic mange in these poorly fed pigs requires further investigation.

Acknowledgement

The author is grateful to all pig owners for their cooperation.

References


Received for publication on 31st December 1991
SHORT COMMUNICATION

PREVALENCE OF EIMERIA SPECIES IN GOATS FROM PARTS OF CENTRAL KENYA

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INTRODUCTION

Caprine coccidiosis has become a great concern with changing patterns of husbandry. Examination of faeces from goats has shown that goats are infected with a number of Eimeria species from an early age\textsuperscript{10}.

Clinical disease occurs in those under 12 months of age\textsuperscript{20} especially those kept in crowded and unsanitary conditions\textsuperscript{3,4,5,9}. Recent evidence has shown that in goats, E. ninakohlyakimovae is the most pathogenic species while E. arloingi is responsible for most outbreaks\textsuperscript{6,7}.

Various species of Eimeria have been identified in goats worldwide\textsuperscript{3,4,5,6,9}. In Kenya, E. ninakohlyakimovae, E. aliijevi, E. hirci and E. christensenii have been identified in goats at Mariakani\textsuperscript{10}.

This study was undertaken to identify the species of Eimeria in some parts of central Kenya.

A total of 159 faecal samples were analysed from 15 sample areas in central Kenya. These areas represented both large and small scale farms from high and medium potential areas. No breed was preferred and samples were from adults and kids.

Rectal faecal samples were collected into individual plastic cups. The number of oocyst per gram of faeces (OPG) was estimated using the McMaster technique. Saturated Magnesium sulphate was used as the flotation salt. Those samples which were positive for OPG were cultured individually in 2.5% Potassium dichromate solution at room temperature for sporulation\textsuperscript{12}.

The sporulated oocysts were then examined microscopically, measured and differentiated into various species as described previously\textsuperscript{11,4,5,11,13}. 40 sporulated oocysts from each sample were considered.

Nine species of Eimeria were identified in these areas of central Kenya. These were E. arloingi, E. hirci, E. aliijevi, E. ninakohlyakimovae, E. christensenii, E. caprovina, E. jolchjiev, E. apscheronica and E. caprina (Fig. 1). E. arloingi, E. ninakohlyakimovae and E. hirci were the most common while E. apscheronica and E. caprina were the least common species. There was variation in the occurrence of the species depending on location and age of the goats (Fig. 1).

Clinical coccidiosis was encountered in kids 2-3 months old at Naromoru. The kids were weak, emaciated and had diarrhoea. These cases were due to E. arloingi and E. ninakohlyakimovae infections.

Most samples had three or more species. This multiple infection has been reported by some earlier workers\textsuperscript{3,4,5,7}. This complicates the interpretation of oocyst counts since some Eimeria species are known to be severe pathogens while others are less pathogenic.

E. arloingi was the most common species in this study. This has been reported in earlier studies in other countries\textsuperscript{3,4,10,15}. Among other species encountered was E. ninakohlyakimovae which has been reported to be the most pathogenic Eimeria species\textsuperscript{6}. Others were E. hirci, E. aliijevi, E. christensenii, E. caprovina, E. jolchjiev, E. apscheronica and E. caprina. Their prevalence varied with location of the particular farm and age of the goats. This showed that field infections are usually mixed and where disease occurs, all the species present probably contribute to it.

Majority of the goats though harbouring the Eimeria species had no clinical symptoms. This indicated that factors like
Figure 1: Overall percentage occurrence of *Eimeria* species in the selected areas.

- **Adults (≥ 16 months):**
  - *E. apsheronicum* 0.75
  - *E. caprina* 1
  - *E. jolchijevoi* 1.36
  - *E. caprovina* 4.24
  - *E. christenseni* 5.12
  - *E. alijevi* 9.52
  - *E. ninakohlyakimovei* 13.41
  - *E. hirici* 14.12
  - *E. arloingi* 23.03

- **Kids (< 6 months):**
  - *E. caprovina* 1.65
  - *E. christenseni* 24.26
  - *E. hirici* 16.35
  - *E. arloingi* 43.72

**Percentage occurrence**
husbandry method practised, weather conditions and other stress factors may be decisive in whether clinical disease is precipitated or not. It is evident that goats have subclinical coccidiosis. This affects feed intake and utilization with subsequent poor weight gains. This could be a hindrance to livestock development in Kenya especially under intensive management systems.

References

Received for publication on 6th August 1991
SHORT COMMUNICATION

EFFICACIES OF OXFENDAZOLE, FENBENDAZOLE AND IVERMECTIN AGAINST GASTRO-INTESTINAL NEMATODES OF SHEEP AND GOAT IN ZAMBIA

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INTRODUCTION

Investigations on efficacies of anthelmintics are scarce and anthelmintics have been used without efficacy assessments in most farms in Zambia. In the present study, the efficacies of some anthelmintics against gastro-intestinal nematodes were assessed in naturally infected sheep and goats mainly with *Haemonchus contortus*.

Anthelmintic treatments had been frequently conducted in a farm in Lusaka, Zambia every rainy season. In 1986/1987 rainy season, ewes were medicated twice by oral drenching of fenbendazole 5 mg/kg in November and December and five times of drenching of oxfendazole 5 mg/kg every three weeks from January to March. The faecal samples were collected from randomly selected 60 ewes just before and two weeks after the each treatment in November, December, January and March. Only *Haemochus* larvae were found from faeces cultures. Geometric means of EPG did not respond to the treatments and were sustained at the level of 150-560 from November to January while EPG of individual animals greatly varied from 0 to 9,000 after the treatments. The geometric means of EPG were 21 and 65 before and after the treatment respectively in March although EPG of individuals still varied from 0 to 8,000 after the treatment.

To confirm such a variable efficacy of the anthelmintics observed in the farm, 20 ewes from the same farm and 16 goats from another farm were housed in the experimental animal quarter of University of Zambia and fenbendazole, oxfendazole and ivermectin were tested for their efficacies in EPG suppression (Table 1). The geometric mean of EPG declined in all the medicated groups 7 and 14 days after the treatment. However statistically significant reductions of EPG were observed only in the group treated by ivermectin 7 and 14 days after the treatment in comparison to non medicated and the pre-treatment controls (p<0.001) and in the group treated by oxfendazole seven and 14 days after the treatment in comparison with non medicated control (p<0.05). Percent reductions of EPG in individual animals treated by fenbendazole and oxfendazole greatly varied from 100 to 9.3% and 63.6 to 81.3% respectively seven days after the treatment and 100 to -1.4% and 67.4 to -150.8% respectively 14 days after the treatment. The efficacy of ivermectin was consistent and approached 100% reduction in EPG both seven and 14 days after the treatment.

All the 16 goats which were predominantly infected with *Haemonchus* sp. were used to test efficacy ivermectin (Table 1). A total of 11, 12 and 12 goats of the medicated group consisting of 14 animals were positive for eggs of *Trichostrongylus* sp., *Oesophagostomum* sp. and *Strongyloides* sp. respectively prior to the treatment. Both the two non medicated goats were positive for all of these four species. The EPG were significantly reduced after the treatment in all the species (p<0.001). Four out of 14 medicated goats were negative for nematode eggs both 7 and 21 days after the treatment.

Variable or failed efficacy of anthelmintic treatment results from host physiological factors and development of drug resistance. Oxfendazole and fenbendazole are rapidly absorbed from the abomasum, and the rumen acts as a reservoir of the drugs, maintaining the
Table 1: Geometric mean of EPG of ewes and goats, naturally infected with gastro-intestinal nematodes and medicated by anthelmintics

<table>
<thead>
<tr>
<th>Animals</th>
<th>No. of Animals</th>
<th>Treatment</th>
<th>Geometric mean of E.P.G.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Day 0(1)</td>
</tr>
<tr>
<td>Ewe</td>
<td>5</td>
<td>Placebo, p.o.</td>
<td>457</td>
</tr>
<tr>
<td>Ewe</td>
<td>5</td>
<td>Oxfendazole, 5mg/kg, p.o.</td>
<td>692</td>
</tr>
<tr>
<td>Ewe</td>
<td>5</td>
<td>Fenbendazole, 5mg/kg, p.o.</td>
<td>363</td>
</tr>
<tr>
<td>Ewe</td>
<td>5</td>
<td>Ivermectin, 200 μg/kg, s.c.</td>
<td>2089</td>
</tr>
<tr>
<td>Goat</td>
<td>2</td>
<td>Placebo, s.c.</td>
<td>1122</td>
</tr>
<tr>
<td>Goat</td>
<td>14</td>
<td>Ivermectin, 200 μg/kg, s.c.</td>
<td>1820</td>
</tr>
</tbody>
</table>

(1): day of treatment  
(2): 21 days after treatment

The effective concentration of anthelmintics in the host(2). Spontaneous closure of the oesophageal groove due to the passing of the drug results in reduced efficacy of benzimidazoles(3,4). The variable and less efficacy of oxfendazole and fenbendazole observed in the present study may be caused by the development of resistance against fenbendazole and oxfendazole by repeated doses conducted every rainy season in the farm and possibly by the erratic administration of the drugs.

Njanja et al.(6) reported that a subcutaneous injection of 200 μg/kg of ivermectin caused almost 100% reduction in egg count and elimination of *H. contortus* in naturally infected goats in Kenya. The result of our present study also indicated that ivermectin was highly efficacious in the suppression of EPG counts in sheep and goat.

Acknowledgements

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References


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ECTOPIA CORDIS IN A GOAT

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ECTOPIE DU COEUR CHEZ UNE CHEVRE

Résumé

On a évoqué pour la première fois un cas d'ectopie du coeur chez un chevreau nouveau-né.

Summary

A case of ectopia cordis fissternalis in a new born kid is described for the first time.

INTRODUCTION

CASE REPORT

A one-day old male goat kid was brought to the University of Veterinary Hospital for consultation. The animal was weak, laterally recumbent and had extrathoracic heart in the sternal region (Fig. 1). This kid was a twin to a normal female and were both delivered normally. The animal was clinically examined and found to have pale mucous membranes. The heart rate was 120/ min., strong and rythmic. Respiration was 45/min., regular and thoracoabdominal in character. The heart was an elongate tubular structure herniated through a defect in the sternum. The heart lied within the pericardium which was adherent to the sternal ring at the heart base.

Surgery was attempted to replace the heart in the thorax. Blunt dissection was employed to free the pericardial attachment, but this was unsuccessful. Gentle manipulation to accommodate the heart in the existing cavity was also unsuccessful and a large vessel was ruptured leading to the death of the animal.

Postmortem examination showed that the mediastinal cavity was small and incompletely developed. The sternal defect was formed by the unfused sternal ribs lined by the slightly curved-in edges of the posterior pectoral muscles. The pericardium of the base of the heart was

Figure 1: A photograph of the kid showing the herniated heart through a sternal defect.
attached to the lateral pleura and ventral aspect of the diaphragm. No other anomaly was seen in any of the internal organs.

The heart was comparatively long (about 7.5 cm). Externally, it exhibited two constrictions: one near the base demarcating the sinus from the atrium; and the other about the middle indicating the boundary between the atrium and ventricle (Fig. 2). Internally, the heart consisted of an atrium and ventricle. The atroventricular canal was surrounded by a whitish fibrous band. Moreover, two poorly developed flaps representing the cusps of the atroventricular valve were present. The lumenal surface of the sinusesvenosus was smooth, whereas that of the atrium revealed a crescentic fold which indicated an incomplete septum primium. On either sides of this septum there was a small network of fine muscular cords. The lumenal surface of the ventricle showed many muscular cords, passing in different directions in addition to an oblique moderator band. Close to the atroventricular canal a small conus emerged from the ventricle and terminated into a bifurcation forming the aorta and pulmonary artery. These vessels were connected to each other by a patent ductus arteriosus (Fig. 2).

**Discussion**

Ectopia cordis fissisternalis, abdominalis, cervicalis in domestic animals have been reported\(^{1,2}\) in domestic animals. It appears that the case described herein is the first report of ectopia cordis fissisternalis in goat kids.

Studying the anatomy of the heart suggests that the development of this heart was arrested shortly after the completion of the ventricular loop and formation of the primitive ventricle as described by Patten and Carlson\(^{3}\). Subsequent developmental stages that would have led to the formation of four-chambered heart were apparently not reached\(^{4}\).

The finding that the heart consisted of two chambers stimulates speculations as how the animal was compatible with life having such a primitive heart. The morphology of the heart indicates that mixed blood (oxygenated and deoxygenated) reached the heart and was then pumped into the aorta and pulmonary artery. The free admixture of the venous and arterial blood in the common ventricle always leads to oxygen unsaturation in the arterial blood\(^{5}\). The anaemia and marked weakness of the animal were apparent manifestations of arterial oxygen unsaturation. As the animal grows older, more oxygenated blood is demanded. This demand if not fulfilled would lead to circulatory and respiratory failure, and eventual death. Moreover, the presence of the single ventricle pumping blood into the aorta and pulmonary artery would result into tremendous increase in pulmonary blood pressure. Taussing\(^{5}\) noted

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**Figure 2**: Diagram showing the external features of the heart.

- a, atrium; b, ventricle; c, aorta; d, pulmonary artery; e, ductus arteriosus; f, posterior vena cava; g, anterior vena cava.
that perforations in the ventricular septum result in pulmonary hypertension. However, the presence of a patent ductus arteriosus in this case reduced pulmonary hypertension.

Surgical failure to correct the heart was apparently due to the pericardial adhesions, and that the mediastinal cavity was too small to accommodate the herniated heart. This authenticated the findings of Millhouse and Joose\(^6\) who also failed to correct human ectopia cordis fissisternalis due to lack of intrathoracic space and severe angulation of the vessels causing cardiac embarrassment.

References


Received for publication on 9th March 1992
Research has shown that the case described here is the first report of echocardiographic data in domestic animals. The authors describe the anatomy of the heart, suggesting that the development of this heart was arrested early after the formation of the ventricles. The ventricles are connected by the primitive atrium, as described by Peters and Gavosto. Subsequent development of the heart is not described.

The authors note that the heart is involved in the development of the aortic arch and the development of the arch is consistent with the configuration of a functionally normal heart. The pathophysiology of the heart indicates that the aortic arch is normal, but the pulmonary arteries are dilated, leading to hypoxemia in the systemic circulation. The authors discuss the implications of this finding and its potential implications for domestic animals.
SHORT COMMUNICATION

FERMENTED CATTLE BLOOD FOR GROWING PIGS

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LE SANG DE BOVIN FERMENTÉ POUR L’ALIMENTATION DES PORCS A LA CROISSANCE

Résumé

Les sources de protéine pour la préparation des aliments des porcs sont insuffisantes dans les pays en développement. De même, les aliments à base de sang disponibles sur le marché coûtent cher et sont peu appréciés par les porcs. Le sang provenant des petits abattoirs est déversé en plein air et contribue à aggraver la pollution de l’environnement. L’objet de cette étude était d’évaluer la valeur nutritive du sang de bovin fermenté pour l’alimentation des porcs comme supplément de protéine. La fermentation avec de la mélasse de canne à sucre a permis d’obtenir un aliment à base de sang prisé par les porcs. Les résultats obtenus indiquent que le sang fermenté peut constituer jusqu’à 10% des régimes alimentaires des porcs à la croissance sans que cela affecte leur performance. Cette méthode a de bonnes perspectives qui nécessitent donc des études approfondies.

Summary

Protein sources for feed manufacturing of pig rations are in short supply in developing countries. At the same time, commercially available blood meal is expensive and unpalatable to pigs. Blood from small slaughterhouse is wasted and adds to an environmental problem. The objective of this study was to investigate the feeding value of fermented cattle blood for pigs as an alternative protein supplement. Fermentation with cane molasses resulted in blood meal which was readily acceptable to pigs. The results show that fermented blood can constitute up to 10% of diets of growing pigs without detrimental effects on performance. The potential of this method warrants further investigation.

INTRODUCTION

In Kenya and other subsaharan countries protein supplements for use in feed manufacturing are in short supply. In addition, whatever is available is expensive such that the cost of the complete feed is high. Blood meal is a by-product of livestock processing which is not only readily available but also a high quality protein supplement. Unfortunately, the commercially processed blood meal is unpalatable to pigs. It has been indicated that conventionally processed blood meal has a low digestibility for pigs¹. The low digestibility and hence quality is partly brought about by the conventional processing method which involves high temperatures. Methods of blood processing which do not use heat result in a product of superior nutritive value for pigs compared to the conventional method of processing. In Kenya there are numerous slaughterhouses processing between 10 to more than 100 head of cattle per day. In such slaughterhouses, blood is washed into a nearby pit. Over time, these pits emit some very offensive smell and become an environmental problem especially to the community that live nearby. Furthermore, these pits fill up quite rapidly necessitating more pits to be sunk in a limited area. There is therefore a need to look for an alternative way of either disposing or processing the blood in small slaughterhouses. This

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study reports an alternative method of processing blood and its feeding value for growing pigs.

**Materials and Methods**

Cattle blood was freshly collected in a slaughter house and transported to the University 50 kilometres away. Upon arrival the blood was weighed and 20% (weight for weight) cane molasses was added and blended. Thereafter, it was left to stand at room temperature for at least two weeks. During that period blood would ferment and little activity would occur after two weeks. After this time the product would either be fed directly to pigs or sun-dried.

In the pig performance study, 25 Landrace x Large White pigs with an initial weight of 21.1 g were used and were balanced for sex among dietary groups. During a 40 day experimental period, pigs received either of three diets. Dietary treatments were: (1) Maize and Soybean meal, (2) Maize, Soybean meal and 10% blood meal and (3) Maize, Soybean meal and 20% blood meal. All diets were balanced to meet NRC requirements for minerals and vitamins for growing pigs[2]. Synthetic amino acids were not added to the diet. Blood meal was fed in the wet form but included on dry basis to replace soybean meal. Pigs were weighed every two weeks while fresh feed was made and offered daily. Daily feed remains were recovered and weighed while water was available at all times. Analysis of covariance using initial weight as the covariate was applied to the data and adjusted means were compared by the student's t-test[3].

**Results and Discussion**

The 14 day fermentation period resulted in a product with a moisture content of 70%-72%, crude protein (Nx6.25) of 52%-55% on dry matter basis and a pH of 4.0. Sundrying resulted in hard dark blood meal which was easily ground into a powder in an ordinary hammermill. Further storage in the wet form did not cause any considerable physical or chemical change. The results of the animal study are shown in Table 1. These results show that fermented blood is readily acceptable to pigs and that no detrimental side effects were observed. The diet containing 10% fermented blood supported similar performance as the maize-soybean meal diet. While it is recommended that blood meal be included at levels of 3-5% in pigs diets, the observations in this study suggest that fermented blood meal may be of superior quality to conventionally processed blood meal which involve high temperatures for extended periods of time. The modern flash drying technique has been shown to result in blood meal of high lysine availability for pigs[4,5,6]. The availability of lysine could further be enhanced by elimination of high temperature during the drying process. In vitro studies have demonstrated that blood pickled with sulfuric acid had high lysine availability[7]. However, a 20% inclusion rate depressed growth (P<0.05) and feed intake (Table 1). This finding is consistent with that of King and Campbell[8] and is probably due to isoleucine deficiency which results in an amino acid imbalance hence affect feed intake.

It is concluded that fermenting blood in

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**Table 1**: Adjusted total gains (Kg ± SE), daily feed intake (Kg), daily gain (Kg) and feed: gain ratio over the 40 days

<table>
<thead>
<tr>
<th>Level of inclusion of fermented blood</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>9</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Initial weight, Kg</td>
<td>21.0</td>
<td>20.3</td>
<td>20.6</td>
</tr>
<tr>
<td>Total gain</td>
<td>32.64 ± 1.92a</td>
<td>31.78 ± 2.04a</td>
<td>17.46 ± 2.04b</td>
</tr>
<tr>
<td>Daily gain</td>
<td>0.82</td>
<td>0.79</td>
<td>0.44</td>
</tr>
<tr>
<td>Feed intake, dry basis</td>
<td>1.50</td>
<td>1.67</td>
<td>1.09</td>
</tr>
<tr>
<td>Feed, Gain</td>
<td>2.32</td>
<td>2.10</td>
<td>2.50</td>
</tr>
</tbody>
</table>

1 Means bearing different letters are significantly different (P<0.05).
cane molasses enhances the keeping quality of blood. Furthermore, this method has the potential of being applicable and adoptable in a small scale set up. Lack of heat sterilization might cause some health concerns. However, this method of processing warrants further investigation.

Acknowledgements

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References

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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
— informations et annonces

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

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

L'introduction expose le but de la recherche.

Le matériel et les méthodes utilisés.

Les résultats présentés brièvement.

Un débat sur l'importance de l'article.

Remerciements éventuels.

Bibliographie: les références bibliographiques doivent être numérotées dans l'ordre, telles qu'elles apparaissent dans le texte. L'identification des références dans le texte se fera à l'aide de numéros (entre parenthèses) et non par les noms des auteurs. La bibliographie doit respecter la présentation suivante:

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

Si le même auteur est cité plus d'une fois, ses publications seront indiquées dans l'ordre chronologique dans la liste bibliographique et s'il y a plus d'une publication, les lettres "a, b, c," seront ajoutées aussi bien dans la liste bibliographique que dans le texte.

Illustrations
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