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BULLETIN OF ANIMAL HEALTH AND PRODUCTION IN AFRICA
BULLETIN DE LA SANTE ET DE LA PRODUCTION ANIMALES EN AFRIQUE

A Quarterly Journal of Original Articles and Abstracts in English and French

Annual subscription: US$ 50.00

Revue trimestrielle contenant des articles originaux et des résumés d'études en anglais et en français
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FIELD STUDY ON DRUG RESISTANT TRYPANOSOMES OF CATTLE (BOS INDICUS) IN KINDO KOYSHA WOREDA, SOUTHERN ETHIOPIA

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ETUDE DE TERRAIN SUR LES TRYPANOSOMES CHIMIORESISTANTS DES BOVINS (BOS INDICUS) A KINDO KOYSHA WOREDA DANS LE SUD DE L'ETHIOPIE

Résumé

Un test de chimiosensibilité a été effectué avec des bovins infectés par des trypanosomes dans trois villages de Kindo Koysa Woreda au Sud de l'Ethiopie. 58 Zébus infectés naturellement par des trypanosomes ont été sélectionnés et traités au chlorure d'isométabendazol à raison de 1 mg/kg de poids vif (Tryparamidium®, France). Sur les 58 animaux traités, il y avait 22 cas (37,9%) d'infections de rechute/non soignées, parmi lesquelles 19 (86,4%) étaient par T. congolense; 2 (9,1%) par T. vivax et 1 (4,5%) par des infections mixtes dues à T. vivax et T. brucei. Les infections de rechute/non soignées sont apparues pendant les quatre semaines qui ont suivi le traitement. Dans la même étude, on a observé 10 (45,4%) et 3 (30%) infections de rechute/non-soignées avec le traitement à l'acéturate de diminazène (Bérénil®, Allemagne) à raison de 3,5 et 7 mg/kg de poids vif respectivement. On en a conclu que la durée de l'action prophylactique de l'isométabendazol contre les trypanosomes à la dose de 1 mg/kg de poids vif est inférieure à un mois chez les bovins de Kindo Koysa. Les résultats ont montré la présence de populations de trypanosomes résistantes au chlorure d'isométabendazol et à l'acéturate de diminazène.

Abstract

Drug sensitivity test was carried out on trypanosome-infected cattle in three villages of Kindo Koysa Woreda, Southern Ethiopia. Fifty-eight zebu cattle naturally infected with trypanosomes were selected and treated with 1mg/kg body weight of isometamidium chloride (Tryparamidium®, France). Out of the 58 treated animals 22 (37.9 %) cases showed relapse/breakthrough infections of which 19 (86.4 %) were T. congolense, two (9.1 %) T. vivax and one (4.5 %) mixed infection due to T. vivax and T. brucei. The relapse/breakthrough infections occurred within four weeks of treatment. In the same study 10 (45.4 %) and three (30 %) relapse/breakthrough infection for diminazene aceturate (Berenil®, Germany) at a dose of 3.5 and 7 mg/kg body weight were observed respectively. It is concluded that the duration of prophylactic activity of isometamidium against trypanosomes at 1 mg/kg body weight of cattle in Kindo Koysa is less than one month. The results indicated the presence of trypanosome populations that express resistance to both isometamidium chloride and diminazene aceturate.

Introduction

In Ethiopia, trypanosomosis is one of the major diseases, which contribute to the direct and indirect economic losses on livestock production¹. The most important species of trypanosomes affecting livestock in Ethiopia are T. congolense, T. vivax and T. brucei in cattle, T. evansi in camels and T. equiperdum in horses¹²³.

At present there are two approaches to the control of bovine trypanosomosis in Ethiopia. These are: control and eradication of tsetse flies and prevention and treatment of animals using trypanocidal drugs. Nowadays the treatment and prevention of animal trypanosomiasis is dependent on the use of the three drugs namely homidium chloride, isometamidium chloride and diminazene aceturate. Following the prolonged use of these trypanocides, emergence of strains of trypanosomes resistance to the drugs has been reported from different parts of the country⁴⁵⁶.

Experimental studies carried out on T. congolense isolates, from Ghiye Valley, Ethiopia, demonstrated the occurrence of multiple-drug resistance to both diminazene and isometamidium⁵⁶⁷. This indicates a very serious development, which adversely affects the future of trypanosomosis control by chemotherapeutic approach using the available trypanocides.

⁴ Corresponding author.
Therefore, the distribution and degree of drug resistance has to be carefully monitored so as to work out the best possible therapeutic strategies and/or alternative control measures. In view of this, the study was designed to assess the presence of trypanosome populations resistant to isometamidium chloride and diminazene aceturate as a sanative pair in the villages of Kindo Koysha, North Omo Zone of the southern Regional State of Ethiopia.

Materials and Methods

Study Area

Kindo Koysha Woreda is located in North Omo Administrative Region, southern Ethiopia, 420 km southwest of Addis Ababa. The area is within altitude range of 600-1700 meters above the sea level. The distribution of rain is bimodal, with the short rains period from January to April and the long rains from June to mid September. The average annual rainfall is 904 mm, while mean maximum and minimum monthly temperature is 29.2°C and 21°C respectively.

Trypanosomosis has been identified as one of the major livestock diseases in the area. In 1996, for example, a mean prevalence rate of 22.32% was recorded in different villages of the study area. Various tsetse fly surveys carried out in the area indicated the presence of G. moristans, sub-moristans and G. fuscipes8.

Experimental Animals

A total of 58 Zebu (Bos indicus) cattle naturally infected with trypanosomes (T. congolense [33], T. vivax [8], T. brucei [12] and mixed infection [5]) were selected from three villages: Faginamata, Molitch and Mundena. The selection was based on high trypanosomosis prevalence and suspicion of drug resistance based on farmers' complaint.

Treatment and Monitoring

The 58 parasitologically positive animals were treated intramuscularly with isometamidium chloride (Trypamidium®, Lot No. H01971A Rhone Meneux, France) at a dose of 1 mg/kg body weight as 2% (W/V). Blood samples were collected from the ear vein and examined for Packed Cell Volume (PCV) and presence of trypanosomes. Parasitaemia was determined with the phase contrast buffy coat method9 while PCV was measured using the standard microhaematocrit method. Cattle were monitored every 15 days for a period of 60 days post isometamidium block treatment. Subsequently, relapse/breakthrough infections were recorded and parasitaemia animals were treated with 3.5 mg/kg body weight of diminazene aceturate (Berenil®, Lot No. 518W742 Hoechst, Germany). Those that showed parasitaemia for the second time received Berenil at a dose rate of 7 mg/kg body weight.

Results

During the 60 days of monitoring a total of 22 (37.9%) cases of relapse/breakthrough infection were recorded for isometamidium chloride. At day 15 post isometamidium treatment, 13 (22.4%) relapse/breakthrough infection were encountered; out of which 12 (92.3%) animals were due to T. congolense and one (7.69%) due to T. vivax. At day 30 again nine (20%) animals showed relapsed/breakthrough infection, of which seven (77.75%) cases were T. congolense, one (11.1%) case was T. vivax and one (11.1%) case of mixed infection (Table 1). Out of the 22 animals treated with 3.5 mg/kg body weight of diminazene aceturate 10 (45.4%) were found to have parasite in their blood; in which nine (90%) were due to T. congolense and one (10%) was due to T. vivax (Table 2). Subsequently the animals which showed relapse/breakthrough to diminazene aceturate at a dose rate of 3.5 mg/kg body weight were treated with 7 mg/kg body weight of diminazene aceturate, 3 (30%) cattle were found to have T. congolense in their blood (Table 3). Fig. 1 indicates the percentage of relapse/breakthrough trypanosome population after isometamidium and diminazene aceturate treatments as sanative pair.

The proportion of relapse/breakthrough infection after 1 mg/kg body weight of isometamidium and subsequent treatment with 3.5 mg/kg and 7 mg/kg of diminazene aceturate were found to be 38%, 45.4% and 30% respectively (Table 4). Following isometamidium and subsequent diminazene aceturate treatments improvement of PCV was observed during the 60 days study period (Fig. 2).
Table 1: Drug sensitivity of trypanosomes in naturally infected zebu cattle and treated with isometamidium chloride (1mg/kg b.w.) on day 0

<table>
<thead>
<tr>
<th>Trypanosome species</th>
<th>No. of cattle before treatment (No.)</th>
<th>No. of cattle with relapse/breakthrough (Days after treatment)</th>
<th>Total No. of relapse/breakthrough</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 0</td>
<td>Day 15</td>
<td>Day 30</td>
</tr>
<tr>
<td><em>T. congolense</em></td>
<td>33</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td><em>T. vivax</em></td>
<td>8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>T. brucei</em></td>
<td>12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mixed infection</td>
<td>5</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Relapse/ Breakthrough (%)</td>
<td>13/58</td>
<td>9/45</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(22.4%)</td>
<td>(20%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Drug sensitivity of trypanosomes in naturally infected zebu cattle and treated with diminazine aceturate (3.5 mg/kg b.w.) as a sanative pair

<table>
<thead>
<tr>
<th>Trypanosome species</th>
<th>No. of cattle before treatment</th>
<th>No. of cattle with relapse/breakthrough (Day after treatment)</th>
<th>Total No. of relapse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 0</td>
<td>Day 15</td>
<td>Day 30</td>
</tr>
<tr>
<td><em>T. congolense</em></td>
<td>33</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td><em>T. vivax</em></td>
<td>8</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td><em>T. brucei</em></td>
<td>12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mixed infection</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Relapse/ Breakthrough (%)</td>
<td>-</td>
<td>9/22</td>
<td>1/13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(40.9%)</td>
<td>(76.9%)</td>
</tr>
</tbody>
</table>
Discussion
The work described here demonstrated 37.9% relapse/breakthrough infections in the field within four weeks of treatment with the prophylactic dose of isometamidium chloride (Table 1, Fig. 1). Most cases of relapse/breakthrough infections (86.4%) were due to *T. congolense*. The results presented here have also shown that the period covered by isometamidium against trypanosomes, mainly *T. congolense* was less than one month. Similar results from Southwest Ethiopia have been reported by other authors.7

As a sanative pair diminazene aceturate at a dose of 3.5 mg/kg body weight was given to cure relapse/breakthrough infection, but recurrent infection occurred in the field within two weeks

<table>
<thead>
<tr>
<th>Trypanosome species</th>
<th>No. of cattle before treatment</th>
<th>No. of cattle with relapse/breakthrough (Day after treatment)</th>
<th>Total No. of relapse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 0</td>
<td>Day 30</td>
<td>Day 45</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td><em>T. congolense</em></td>
<td>33</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td><em>T. vivax</em></td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>T. brucei</em></td>
<td>12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mixed infection</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Relapse/Breakthrough (%)</td>
<td>3/10 (30%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Drug sensitivity of trypanosomes in naturally infected zebu cattle and treated with diminazene aceturate (7 mg/kg b.w.) to eliminate resistant populations

Table 4: Proportion of trypanosomes that show cross-resistance to isometamidium and diminazene aceturate

<table>
<thead>
<tr>
<th>Drug</th>
<th>No. of cattle relapse/breakthrough per treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Isometamidium chloride</td>
</tr>
<tr>
<td></td>
<td>1 mg/kg b.w.</td>
</tr>
<tr>
<td>Isometamidium</td>
<td>22/58</td>
</tr>
<tr>
<td>Relapse/breakthrough (%)</td>
<td>37.93%</td>
</tr>
</tbody>
</table>
Figure 1: Percentage of relapse/breakthrough trypanosome population after treatment

Key:
1 = Relapse/breakthrough populations after 1 mg/kg b.w. isometamidium treatment
2 = Relapse/breakthrough populations after 3.5 mg/kg b.w. diminazene aceturate treatment
3 = Relapse/breakthrough populations after 7 mg/kg b.w. diminazene aceturate treatment

Figure 2: Average PCV (%) reading pattern with 1mg/kg isometamidium chloride and subsequent treatment of each relapse/breakthrough infections with 3.5mg/kg & 7mg/kg b.w. diminazene aceturate
of treatment. These results agreed with Hassen's work\(^6\) which showed that a \emph{T. congolense} stock from Southwest Ethiopia were resistant to diminazene aceturate at 3.5 mg/kg body weight and to the prophylactic and therapeutic doses of isometamidium chloride (1 mg/kg and 0.5 mg/kg body weight). Similar findings were reported from the Southern Ethiopia where 25% of cattle were identified with recurrent parasitaemia six days post treatment with isometamidium\(^7\).

The drug resistance phenomenon in trypanosome population is dose dependent\(^8\). A trial to compare the therapeutic efficacy of diminazene aceturate at a dose of 3.5 mg/kg and 7 mg/kg body weight in Ghibe, showed that the proportion of animals that relapsed following treatment decreased with higher dosages, but did not cure all the infections\(^7\). The present study also showed relapse/breakthrough infection in the field to the treatment with Berenil at a dose rate of 7 mg/kg body weight.

The results showed drug resistant trypanosome population with a possibility of multiple drug resistance to both isometamidium and diminazene compounds. These results agree with earlier reports in which resistance to phenanthridine (i.e. isometamidium & homidium) and diminazene aceturate has previously been described for populations of \emph{T. congolense} here in Ethiopia\(^4,5\). The simultaneous occurrence of diminazene, isometamidium and homidium resistance in trypanosome populations has been reported in Nigeria\(^13\), Kenya\(^14,15\), Burkina Faso\(^16\), Sudan\(^17\) and Ethiopia\(^4,6\). The present study is consistent with the above results in that 13.6 % of the trypanosome populations were resistant to treatment with 1 mg/kg body weight isometamidium chloride and 7 mg/kg body weight diminazene aceturate. However, it is not known whether the multiple-drug resistance phenotypes of these stocks are expressed by individual trypanosomes or by two distinct populations. If the latter is the case, then the use of sanative pairs would be ineffective to treat such infection.

Observation of a high proportion of recurrent infection with \emph{T. congolense} is consistent with previous reports of Afewerk et al.\(^4\) and Rowlands \emph{et al.}\(^7\). This may be explained by the fact that chemotherapy will undoubtedly have had some effect on the change in the relative frequency of the species. \emph{T. congolense}, especially, appear to be prone to develop persistently drug resistant forms\(^18,19\). Beside this, the proportional infection rate of cattle by \emph{T. congolense} in the greater part of tsetse infested area is by far greater than that by \emph{T. vivax}\(^1\).

Haematological anomalies recover rapidly after treatment with a trypanocidal drug\(^20\). The improvement in the PCV readings after treatment may be due to elimination of the sensitive populations of trypanosomes from the animal's body. However the overall mean PCV is below 30%, the physiological value\(^8\). This may indicate the presence of a drug resistant population and/or a blood sucking/destroying parasites like \emph{Haemonchus, Bunostomum, Oesophagostomum, Babesia, Anaplasma and Coccidia}, and/or reduced response of the bone marrow due to exhaustion when the infection runs a chronic course\(^9\).

In this study cattle naturally infected with trypanosomes were not kept in fly proof stables or in a non-tsetse infested area, rather they were left to graze in their natural environment. Therefore, the risk of reinfection during the study was not eliminated. We do not know whether the relapse in the field was from the trypanosome populations, which was already present in the animals before treatment, or from populations after reinfection with drug resistant trypanosomes. However, the study generated useful information as to the efficacy of isometamidium chloride to trypanosome populations present in the area concerned. Isometamidium chloride at a dose of 1.0 mg/kg body weight is no longer accomplishing its originally described mission of protecting cattle for a period of 12 to 16 weeks in Kindo Koysa, Southern Ethiopia.

In conclusion, this study demonstrated the presence of isometamidium and diminazene resistant population of \emph{T. congolense} in Kindo Koysa. Despite a significant percentage of relapse/breakthrough infections in the field, treatment with 1 mg/kg body weight isometamidium and subsequent treatment with 3.5 mg/kg and 7 mg/kg body weight diminazene aceturate showed an increase in PCV. However,
this treatment regime would certainly not be cost
effective and most probably select for drug
resistant trypanosome populations. More
atentions should be given to the adoption of an
integrated trypanosomiasis control strategy,
involving the vector as well as the parasite.

Acknowledgement
This work was done with the support of the Faculty
of Veterinary Medicine, Addis Ababa University in
collaboration with Sodo Regional Veterinary
Laboratory and Kindo Koysha Woreda Agricultural
Office.

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Received for publication on 25th August, 2000.
COMPOSITION AND QUALITY OF CAMEL DIETS IN CENTRAL BARINGO, KENYA

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COMPOSITION ET QUALITE DES ALIMENTS DES DROMADEAires
DANS LE BARINGO CENTRAL AU KENYA

Résumé
Une étude a été menée entre août et décembre 1991 en vue de déterminer la composition et la qualité des aliments des dromadaires dans le district de Baringo au Kenya. Le choix des fourrages a été arrêté grâce à l’observation directe. La composition chimique et la digestibilité des fourrages choisis ont été déterminées à l’aide de l’analyse immédiate et des techniques in vitro respectivement. L’aliment était composé exclusivement de plantes à brouter, en particulier des arbrisseaux et des ligneux dont la sélection était surtout basée sur leur abondance. On a noté une préférence très marquée pour Euphorbia spp., Salvadora persica, Maerua angolensis et Balanites aegyptiaca. Les espèces ineximes étaient préférées aux espèces épineuses et la diversité des aliments basée sur les espèces de plantes augmentait avec la distance du lieu de pâturage par rapport au village. La saison avait des effets (P<0.05) sur la composition chimique et la digestibilité des fourrages et des aliments. Les fibres solubles (NDF), les fibres non-solubles (ADF) et les ligneux non-solubles (ADL) avaient une teneur plus élevée (P<0.05) pendant la saison sèche que pendant la saison de vert pâturage. Les niveaux de protéine brute (PB), de solubles cellulaires (SC) et de digestibilité de la matière sèche in vitro (DMSIV) étaient, toutefois, plus élevés (P<0.05) pendant la saison de vert pâturage par rapport à la saison sèche. Eu égard aux valeurs de PB et DMSIV, l’aliment était considéré comme ayant une valeur nutritive suffisante durant les deux saisons. Il s’est avéré que les dromadaires en divagation utilisent équitablement les ressources fourragères des parcours et en tirent une alimentation suffisante indépendamment de la saison.

Abstract
A study was conducted between August and December 1991 to determine the composition and quality of camel diets in Baringo District of Kenya. Forage selection was determined using direct observation. Chemical composition and digestibility of selected forages were determined using proximate procedures and in vitro techniques respectively. The diet consisted exclusively of browse species and was dominated by trees and tall shrubs whose selection was based mainly on abundance. Preference was highest for Euphorbia spp., Salvadora persica, Maerua angolensis and Balanites aegyptiaca. Thornless species were preferred over thorny ones and diet diversity based on plant groups increased with the distance of the grazing site from the boma. Season influenced (P<0.05) chemical composition and digestibility of the forages and diets. Neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) were higher (P<0.05) in the non-green season than in the green season. Crude protein (CP), cell solubles (CS) and in vitro dry matter digestibility (IVDMD) levels were, however, higher (P<0.05) in the green season than in the non-green/dry season. Based on the CP and IVDMD values, the diet was assessed as being of adequate nutritive value during both the green and non-green seasons. The ability of free ranging camels to equitably utilize range forage resources and derive adequate nutrition from them irrespective of season is demonstrated.

Introduction
About 80% of Kenya’s land surface is classified as rangeland, more than half of which is semiarid and receives less than 370 mm of rainfall annually1. Although some parts of these Kenyan rangelands have potential for other uses including arable agriculture, most can best be used as grazing lands and animal production remains the main form of land use in these areas. The one humped camel (Camelus dromedarius) is an important component of Kenyan pastoral herds. In recent years, there has been increasing interest in the animal due to its ability to thrive under harsh environmental conditions. Unfortunately, camel husbandry in Kenya is still largely dependent on traditional management systems. With increasing human and animal population pressure in the marginal areas, coupled with diminishing grazing resources, scientific management of this animal is becoming necessary.
Effective management of range animals and their habitats is dependent on adequate knowledge of their feeding habits. This is because such knowledge is required for identification of plants that serve as staples for the animals and which should be favoured in the management of the range forage resources. Some studies have been carried out to determine feeding habits of camels in Kenya. Nearly all, however, have been limited to Marsabit District in the northern part of the country. The objective of this study was to determine the botanical composition and quality of camel diets in Baringo District as a guide towards better management of the animal and the forage resources within its habitat.

**Materials and Methods**

**Study area**

The study was conducted in Salabani area, also known as “Njempis flats” in Baringo District of Kenya. The area receives a mean annual rainfall of 635 mm, has average minimum and maximum temperatures of 20° and 35° C respectively, and has an altitude of about 1,000 metres above sea level. It is characterized by bare ground and loose sandy loam soil with occasional stones on the surface. Its ground is flat and slopes gently towards Lake Baringo. Vegetation in the study area is an acacia woodland dominated by *Acacia tortilis*, *Acacia retigiens* and *Boscia coriacea*. Other major species include *Balanites aegyptiaca*, *Maerua angolensis*, *Cordia sinensis* and *Salvadora persica*. The area is typical of Kenya’s eco-climatic zone V which has shallow sandy loam soils and a moisture index of -42 to -51 and is too dry for agriculture but has considerable carrying capacity for livestock or wildlife; is characterized by thorn-bushland vegetation and as for most parts of Kenya is territory of pastoral tribes. The study area is inhabited by the Njemps people whose major occupation is pastoralism.

**Classification of seasons**

In this study, seasons were classified as green/growing or non-green/dry on the basis of vegetation characteristics and not on the basis of rainfall data (wet or dry). A green/growing season was characterized by presence of scattered annual grasses and a herb layer on the ground together with fresh leafy shoots on the plants whereas the non-green/dry season was characterized by bare ground with most of the forage species having dry mature leaves. On the basis of this classification, periods one and two fell in the first non-green/dry season, period three was the first transition season, periods four and five fell in the green/growing season, period six was the second transition season and periods seven and eight fell in the second non-green/dry season.

**Experimental animals**

The study involved nine male camels of the Somali type, which were randomly selected from a herd of 25 animals. The selected animals were appropriately marked for identification and they were grazed together with the rest of the herd. The whole herd of 25 camels was released on to the pastures at 7.00 a.m. in the morning and locked up in a *boma* (kraal) at 6.00 p.m. in the evening daily during the study duration.

**Experimental design**

The research work was conducted on a randomized complete block desig for 120 days divided into eight 15-day periods. Each period was further divided into three sub-periods. The first sub-period was nine days long while the second and third sub-periods were three days long each. The durations of sub-periods were dependent on the research activity during each one of them. The respective research activities were: determination of activity budgets of the animals in sub-period one, determination of forage selection in sub-period two, and a vegetation survey of the study area in sub-period three.

**Forage selection study**

Dietary selection by camels was determined in sub-period two of each period. Forage selection sampling was determined by direct observation and was quantified by the bite-count technique. In this technique, an animal was closely followed for 30 minutes during feeding and in addition to recording the plant species being foraged upon, the number of bites made on it were recorded with a tally counter when the observers were close enough (3-5 metres) to ensure accurate identification of the plant and parts consumed. A bite was taken as the complete act of breaking off a piece of prehended forage from the parent
plant or picking it up from the ground. This piece consisted of one or several parts of the plant(s). The observations were made on three animals per day, both in the morning and afternoon. Morning observations were made between 9.00-9.30, 10.00-10.30 and 11.00-11.30 hrs. Afternoon observations were made between 14.00-14.30, 15.00-15.30 and 16.00-16.30 hrs.

Immediately following observations on each plant, a representative sample was hand plucked for identification and/or analysis. Care was taken to select the same plants and parts as those selected by the animals. A record of plant number, its species, vegetation class and total number of bites was maintained. As a means of preference rating, the total number of bites made on a species was calculated as a percentage of all the bites recorded during each period.

Chemical analyses of forage samples

Forage samples were first air-dried in the field. They were then dried in a memmert oven at 60°C in a laboratory before being hammer-milled to pass through a two-mm sieve. Samples were analysed for dry matter (DM), ash and crude protein (CP) using proximate procedures. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined using the method of Van Soest. In vitro dry matter digestibility of the forages was determined using the two-stage method of Tilley and Terry. Buffer solution was obtained from sheep maintained on Chloris gayana hay.

Statistical analyses and calculations

The sum of forage chemical values multiplied by their percentages in the diet gave the chemical composition of the camel diets. Kutzyński's similarity index was used to compare diets between consecutive periods as follows:

$$
SI = \frac{\sum_{i=1}^{n} 2Wi}{\sum_{i=1}^{n} (ai + bi)} \times 100
$$

$\beta$ is the diversity index,

$$
\beta = \frac{1}{\sum_{i=1}^{n} (Pi^2)}
$$

Where,

$p$ is the relative contribution of the vegetation classes, and $n$ is the number of vegetation classes.

Selectivity of camels for the overall diet was calculated using the overlap index as described by Horn in the equation:

$$
\text{ai and bi are the percentages of a species in the diets and Wi is the lesser of the two.}
$$

The index revealed the degree of overlap between camel diets for consecutive periods and thus showed to what extent the diet was essentially the same for such periods, especially so for periods within the same season(s).

Spearman’s rank order correlation test was used to compare species rankings in diets between consecutive periods using the formula:

$$
RS = 1 - \frac{\sum_{i=1}^{n} di^2}{n(n^2 - 1)}
$$

Where,

RS is the Spearman’s rank correlation coefficient, $d$ is the ith species in the diet, and $n$ is the sample size.

The index showed if species ranking in the diet was maintained from one period to another, especially so for periods within the same seasons.

Diversity of the diet in terms of vegetation classes for each period was described as the inverse of Simpson’s diversity index. The diversity was calculated from the percentages of the three vegetation classes in the diet (trees and tall shrubs, low growing shrubs, and vines and herbs. The formula is:

$$
\beta = \frac{1}{\sum_{i=1}^{n} (Pi^2)}
$$

Where,
The camel diet consisted exclusively of browse plants and was dominated by trees and tall shrubs (Table 1). The most dominant species was *Euphorbia* spp., which accounted for 20.60 % of the diet. The other major species in the diet were *Salvadora persica* (17.71%), *Maerua angolensis* (12.28 %) and *Balanites aegyptiaca* (11.75 %). The overlap index between species prevalence in the diet and in the vegetation was quite high (0.99). Correlation between dominance ranks of individual species in the diet and in the vegetation was 0.77 (P<0.05).

Similarity in diets between consecutive periods was generally higher than 50.00 % (Table 2). It was highest between period seven and eight (84.88%) and lowest between period five and six (47.47%). Generally, species rankings between consecutive periods were positively correlated.

### Table 1: Percent contribution to the diet by individual species and their abundance in the vegetation.

<table>
<thead>
<tr>
<th>Species</th>
<th>% contribution to the diet</th>
<th>Relative abundance in vegetation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Euphorbia</em> spp.</td>
<td>20.60</td>
<td>4.00</td>
</tr>
<tr>
<td><em>Salvadora persica</em></td>
<td>17.71</td>
<td>7.50</td>
</tr>
<tr>
<td><em>Maerua angolensis</em></td>
<td>12.28</td>
<td>9.50</td>
</tr>
<tr>
<td><em>Balanites aegyptiaca</em></td>
<td>11.75</td>
<td>5.00</td>
</tr>
<tr>
<td><em>Boscia coriacea</em></td>
<td>8.90</td>
<td>15.50</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>6.29</td>
<td>15.00</td>
</tr>
<tr>
<td><em>Barteria acanthoides</em></td>
<td>5.89</td>
<td>2.00</td>
</tr>
<tr>
<td><em>Prosopis chilensis</em></td>
<td>3.83</td>
<td>1.00</td>
</tr>
<tr>
<td><em>Acacia imelifera</em></td>
<td>2.79</td>
<td>5.00</td>
</tr>
<tr>
<td>Acacia nubica</td>
<td>2.66</td>
<td>2.00</td>
</tr>
<tr>
<td><em>Parkisonia aculeata</em></td>
<td>2.36</td>
<td>2.00</td>
</tr>
<tr>
<td><em>Acacia nilotica</em></td>
<td>1.59</td>
<td>3.50</td>
</tr>
<tr>
<td><em>Maerua subcordata</em></td>
<td>0.81</td>
<td>1.50</td>
</tr>
<tr>
<td><em>Cadaba farinosa</em></td>
<td>0.75</td>
<td>2.50</td>
</tr>
<tr>
<td><em>Lantana camara</em></td>
<td>0.75</td>
<td>2.00</td>
</tr>
<tr>
<td><em>Cordia sinensis</em></td>
<td>0.49</td>
<td>6.00</td>
</tr>
<tr>
<td><em>Acacia elator</em></td>
<td>0.48</td>
<td>2.00</td>
</tr>
<tr>
<td><em>Cocconia grandis</em></td>
<td>0.08</td>
<td>1.00</td>
</tr>
<tr>
<td><em>Cordia quercifolia</em></td>
<td>0.05</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Overlap index = 0.99  
Rank order correlation coefficient = 0.77 (P<0.001)
Table 2: Similarity indices (%) and rank correlation coefficients of camel diets for consecutive periods.

<table>
<thead>
<tr>
<th>Periods</th>
<th>Similarity index</th>
<th>Rank order correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 vs 2</td>
<td>54.33</td>
<td>0.482ns</td>
</tr>
<tr>
<td>2 vs 3</td>
<td>63.90</td>
<td>0.500ns</td>
</tr>
<tr>
<td>3 vs 4</td>
<td>81.61</td>
<td>0.612*</td>
</tr>
<tr>
<td>4 vs 5</td>
<td>67.99</td>
<td>0.657 ns</td>
</tr>
<tr>
<td>5 vs 6</td>
<td>47.47</td>
<td>-0.029 ns</td>
</tr>
<tr>
<td>6 vs 7</td>
<td>67.95</td>
<td>0.713ns</td>
</tr>
<tr>
<td>7 vs 8</td>
<td>84.88</td>
<td>0.918**</td>
</tr>
</tbody>
</table>

ns = Not significant
* = Significant at P<0.05
** = Significant at P<0.01

Table 3: Diversity indices of diets within periods and distances of grazing sites from the boma.

<table>
<thead>
<tr>
<th>Period</th>
<th>Diversity index</th>
<th>Distance from boma (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.01</td>
<td>(4.20)</td>
</tr>
<tr>
<td>2</td>
<td>1.30</td>
<td>(5.80)</td>
</tr>
<tr>
<td>3</td>
<td>1.62</td>
<td>(6.15)</td>
</tr>
<tr>
<td>4</td>
<td>1.23</td>
<td>(4.15)</td>
</tr>
<tr>
<td>5</td>
<td>1.00</td>
<td>(2.58)</td>
</tr>
<tr>
<td>6</td>
<td>1.00</td>
<td>(2.46)</td>
</tr>
<tr>
<td>7</td>
<td>1.50</td>
<td>(5.19)</td>
</tr>
<tr>
<td>8</td>
<td>1.40</td>
<td>(5.50)</td>
</tr>
</tbody>
</table>

1. Values in brackets are mean straight distances of the farthest grazing site from the boma.
2. Values with asterisk are mean straight return distances covered by camels during grazing (taken as double the straight site distances).

The correlation was however significant only between period three and four (P<0.05) and between period seven and eight (P<0.01).

Diversity indices revealed a positive relationship between the distance of the grazing site from the boma and diversity of ingested diets (Table 3). Diversity was highest (1.62) during period three when the camels covered most ground during feeding (12.30 km) and was lowest in periods five and six (1.00) when they covered 5.16 and 4.92 km respectively during feeding.

Chemical composition and IVDMD of forages varied with season (Table 4). The levels of CP and IVDMD values increased from the first dry...
Table 4: Mean chemical composition (%DM and IVDMD) (%) of all forages elected during each period of the study (mean ± s.d)

<table>
<thead>
<tr>
<th>Period</th>
<th>CP</th>
<th>NDF</th>
<th>ADF</th>
<th>ADL</th>
<th>ASH</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.84 ± 3.63</td>
<td>40.81 ± 7.07</td>
<td>36.15 ± 7.13</td>
<td>13.78 ± 3.33</td>
<td>12.27 ± 6.64</td>
<td>59.47 ± 3.64</td>
</tr>
<tr>
<td>2</td>
<td>16.41 ± 5.20</td>
<td>42.58 ± 5.49</td>
<td>36.37 ± 5.05</td>
<td>12.45 ± 2.86</td>
<td>12.08 ± 6.08</td>
<td>61.38 ± 3.35</td>
</tr>
<tr>
<td>3</td>
<td>16.83 ± 4.25</td>
<td>40.76 ± 4.84</td>
<td>35.45 ± 4.46</td>
<td>11.42 ± 1.87</td>
<td>11.07 ± 5.98</td>
<td>63.99 ± 4.34</td>
</tr>
<tr>
<td>4</td>
<td>17.03 ± 3.32</td>
<td>39.93 ± 4.58</td>
<td>34.35 ± 2.21</td>
<td>11.39 ± 4.12</td>
<td>11.97 ± 5.90</td>
<td>63.78 ± 5.79</td>
</tr>
<tr>
<td>5</td>
<td>19.15 ± 1.91</td>
<td>38.62 ± 6.87</td>
<td>33.75 ± 2.73</td>
<td>9.50 ± 1.83</td>
<td>12.55 ± 7.80</td>
<td>64.49 ± 6.00</td>
</tr>
<tr>
<td>6</td>
<td>17.18 ± 3.52</td>
<td>41.84 ± 6.47</td>
<td>34.24 ± 4.09</td>
<td>10.72 ± 1.89</td>
<td>12.06 ± 6.57</td>
<td>63.78 ± 5.79</td>
</tr>
<tr>
<td>7</td>
<td>17.18 ± 3.52</td>
<td>43.39 ± 6.93</td>
<td>37.00 ± 4.68</td>
<td>12.50 ± 2.37</td>
<td>11.30 ± 5.65</td>
<td>62.82 ± 3.14</td>
</tr>
<tr>
<td>8</td>
<td>14.26 ± 3.12</td>
<td>43.43 ± 6.25</td>
<td>38.49 ± 4.84</td>
<td>13.34 ± 2.16</td>
<td>11.45 ± 6.05</td>
<td>62.29 ± 2.87</td>
</tr>
</tbody>
</table>

Table 5: Weighted chemical composition (%DM) and IVDMD (%) of diets on period basis.

<table>
<thead>
<tr>
<th>Period</th>
<th>CP</th>
<th>NDF</th>
<th>ADP</th>
<th>ADL</th>
<th>CS</th>
<th>ASH</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.48</td>
<td>43.71</td>
<td>39.34</td>
<td>15.11</td>
<td>56.29</td>
<td>14.16</td>
<td>55.86</td>
</tr>
<tr>
<td>2</td>
<td>15.40</td>
<td>41.56</td>
<td>38.25</td>
<td>12.66</td>
<td>58.44</td>
<td>14.50</td>
<td>62.10</td>
</tr>
<tr>
<td>3</td>
<td>16.10</td>
<td>41.35</td>
<td>36.91</td>
<td>11.27</td>
<td>58.65</td>
<td>14.21</td>
<td>63.69</td>
</tr>
<tr>
<td>4</td>
<td>16.19</td>
<td>39.45</td>
<td>34.50</td>
<td>11.05</td>
<td>60.55</td>
<td>14.10</td>
<td>65.91</td>
</tr>
<tr>
<td>5</td>
<td>19.73</td>
<td>39.66</td>
<td>34.11</td>
<td>9.76</td>
<td>60.34</td>
<td>14.85</td>
<td>66.55</td>
</tr>
<tr>
<td>6</td>
<td>14.76</td>
<td>40.08</td>
<td>35.86</td>
<td>19.34</td>
<td>59.92</td>
<td>14.40</td>
<td>64.06</td>
</tr>
<tr>
<td>7</td>
<td>15.04</td>
<td>40.26</td>
<td>36.06</td>
<td>12.09</td>
<td>59.74</td>
<td>13.03</td>
<td>63.74</td>
</tr>
<tr>
<td>8</td>
<td>14.76</td>
<td>41.10</td>
<td>38.04</td>
<td>13.00</td>
<td>58.90</td>
<td>12.84</td>
<td>61.38</td>
</tr>
</tbody>
</table>

Table 6: Simple correlation coefficients between level of chemical components and the IVDMD of the weighted camel diets.

<table>
<thead>
<tr>
<th></th>
<th>CP</th>
<th>NDF</th>
<th>ADF</th>
<th>ADL</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>1.00</td>
<td>-0.70 ns</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDF</td>
<td>-0.70 ns</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADF</td>
<td>-0.78 *</td>
<td>0.92 **</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADL</td>
<td>-0.80 *</td>
<td>0.88 **</td>
<td>0.89 **</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>IVDMD</td>
<td>0.80 *</td>
<td>-0.94 **</td>
<td>-0.98 **</td>
<td>-0.90 **</td>
<td>1.00</td>
</tr>
</tbody>
</table>

ns = Not significant
* = Significant at P<0.05
** = Significant at P<0.01

season to the growing season when they were highest and fell during the second dry season. On the other hand, NDF, ADF, and ADL levels were highest during the first dry season, dropped to the lowest during the growing season and rose again during the second dry season. The quality of the camel diet based on weighted proportions of each species is given in Table 5. The overall CP content of the weighted diet was 15.56%. It was lowest in period one at 12.48% and was highest in period five at 19.73%, a difference of 7.25% which was 46.59% of the overall mean. The ash content remained virtually unchanged during the study period with an overall mean of 13.89%.
Neutral detergent fibre had an overall mean of 40.90% and varied between 43.71% in period one during the first non-green/dry season and 39.45% in period 4 of the growing season. This was a variation of 4.26%, which was 10.42% of the overall mean. Acid detergent fibre had an overall mean of 36.63% and ranged from 33.11% to 39.34%, a difference of 5.23% or 14.53% of the overall mean. Levels of ADL ranged from 9.76% to 15.11%, which were obtained in period five (green/growing season) and one (first non-green/dry season) respectively. This represented a seasonal difference of 5.35% in levels of lignin in the diet.

The overall estimated mean was 63.02%. The highest and lowest values were 66.55% and 55.86% obtained during period four and one representing the growing and first dry seasons, respectively. The seasonal fluctuation was 10.69% representing 16.96% of the overall mean. The CP level was negatively correlated with lignin and ADF (P<0.05) and had a non-significant negative relation with NDF (Table 6). In vitro dry matter digestibility had a high negative correlation (P<0.01) with NDF, ADF and ADL but was positively correlated (P<0.05) with CP. Acid detergent lignin was positively correlated (P<0.01) with NDF and ADF.

Discussion

The high overlap index in species dominance between diet and vegetation composition implies that on the whole, the animals fed non-selectively and forage species were consumed in proportion to their occurrence in the vegetation. Significance in rank order correlation of species in the diet and the vegetation is further evidence that the animals consumed plants as they encountered them on the range implying that dominant species were eaten more frequently. Thus, forage selection was based on abundance.

Studies on feeding habits of camels in northern Kenya similarly found that camels selected their dietary species in proportion to their frequency in the pasture. Herding is known to deprive animals of the opportunity to freely select forages, thereby turning them into indiscriminant (non-selective) feeders. Reduced selective feeding obtained in this study can be explained as a strategy by the camels to compensate for constant movement due to herding. It is also suspected that low species diversity and relatively uniform maturation dynamics between individual forage species reduced animal selectivity.

Lack of significance in the rank order correlation, coupled with low similarity in diets for most pairs of consecutive periods showed that the animals did not necessarily maintain their order of species preference from one period to another even when such periods fell within the same season.

Additionally, constraints on feeding time imposed by confining the camels at night coupled with close herding during the day may also have influenced them to consume whatever was most available during the available grazing time. The study, therefore, indicates that plant abundance can be a major factor in selection of some species over others. This agrees with earlier findings that a species with higher abundance may be selected more even if the less abundant species is richer in nutrients. Higher preference for thornless species over thorny ones recorded in this study implies that morphological characteristics of plants seemed to influence their selection. Previous studies on feeding habits of camels in Athi-River similarly found that non-thorny species or those with epidermal thorns were selected more than thorny ones.

Food selection in Kenyan camels has been reported by a number of workers. A comparison of the results from this study and those of the above workers shows that camels are mixed feeders capable of adapting their diets to changes in the plant composition on the range.

The results indicate that non-native species, too, are important in camel nutrition in Baringo. Some of these are planted to rehabilitate denuded areas while others are mere ornamentals. Empirical evidence shows that local opinion in Baringo favours multipurpose species such as Prosopis chilensis which, not only serve as forage for livestock, but also provides fuel wood for domestic use. Silvo-pastoralism with emphasis on planting of such trees would thus be a viable practice in central Baringo as it is likely to succeed through local community participation. This will
not only serve to arrest environmental degradation but also serve to improve livestock nutrition as the non-native species will serve as feed supplements during periods of scarce forage.

Study findings intimate a relationship between the diversity of the diets and the distance covered during grazing. The more ground the animals covered during grazing, the wider was the range of food items (plant groups) that were eaten. This implies that camels feeding on natural vegetation under free range conditions are not specialized feeders. This has the advantage of ensuring equitable use of forage resources as the grazing pressure is spread over a wider spectrum of species or plant groups.

The study showed that season influenced forage quality. This was due to its effect on the phenology of the forage species. High CP and IVDMD values of diets in the green/growing season is due to abundance of young fresh shoots while reduced CP and IVDMD values during the non-green/dry season are associated with mature shoots with high fibre and lignin contents. Seasonal fluctuations in diet quality recorded in this study are consistent with previous findings. Although values for CP, NDF, ADF and ADL from this study are similar to those reported for camels diets in Marsabit, the IVDMD values are higher than the ones given for camel diets in Turkana. On the whole, the chemical composition and IVDMD of forage species recorded in this study were comparable to those reported for browse species in other parts of Africa.

Accentuated changes in seasonal levels of CP implied that it was the most sensitive indicator of diet quality during the study. Although the CP content of the overall diet had a strong positive correlation with its IVDMD on period basis, a closer scrutiny of individual species indicated that their IVDMD levels were generally not a reflection of their CP content per se. A plausible explanation for this discrepancy was that some browse species, though rich in crude protein also contained high levels of inhibitory phenolics which depress their IVDMD.

Diet quality remained fairly high even during the non-green/dry season. This implied that range browse is of superior quality as compared to grasses especially during the dry season when grass CP levels drop as low as 5.5%. On the whole, the crude protein levels were higher than the 3.6 % critical minimum required for efficient functioning of rumen microbes. This agrees with findings on quality of camel diets in Turkana. High levels of CP and cell solubles in the camel diets obtained in this study contradict the hypothesis that large sized ungulates are less selective and therefore ingest diets of lower quality than their smaller sized counterparts.

On the basis of their chemical composition and IVDMD, forages selected by camels in this study seem to constitute a compromise between bulk and quality. Digestibility limits voluntary intake of forages by animals. Within certain limits (42% to 64%) however, there is a positive correlation between digestibility and intake. Since the digestibility values for camel diets obtained in this study (55.86% to 66.78%) partially fell within this range, it may be argued that their intake was influenced by forage digestibility.

Conclusion

It is concluded from this study that trees and tall shrubs constitute the major component of camel diets in Baringo District. The animals were found to be mixed feeders and diversity of their diets in terms of plant groups increased with the distance of the grazing site from the boma. Season affected the quality of available browse. The diets were higher in crude protein, less fibrous and more digestible during the green/growing season than during the non-green/dry season. Presence of non-native species in the camel diet indicated that reclamation of denuded areas in Baringo through re-afforestation programmes should pay special attention to animal nutrition. Use of multi-purpose plant species, which not only prevent environmental degradation but also serve as fuel wood and animal feed supplements, is recommended.

Acknowledgements

This work was funded by the Norwegian Agency for International Development (NORAD). Permission to use camels belonging to Kabarak Farm Limited was jointly granted by the farm manager and Dr. Akufana of the veterinary office in Marigat Division, Baringo District.
References


Received for publication on 14th February, 2000.
PERFORMANCE OF SHEEP AND GOATS GRAZED ON NATURAL PASTURE IN CAMEROON

E.N. FAI and R.T. FOMUNYAM
Mankon Research Station, P.O. Box 534, Mankon, North West Province, Cameroon

PERFORMANCE DES MOUTONS ET DES CHEVRES MIS AU PATURAGE NATUREL AU CAMEROUN

Résumé
Les moutons et les chèvres broutaient pendant toute l'année en pâturage naturel dont les principales espèces étaient : Imperata cylindrical, Pennisetum purpureum et Melinis minutiflora. Ils gagnaient du poids à partir du mois de mars au début de la saison des pluies et commençaient à perdre du poids en juillet/aout en pleine période de fortes pluies. Pendant cette période de grosses pluies, le pâturage est abondant, la protéine brute et la matière sèche très faibles. Comme les taux de charge passaient de 40 animaux/hecate à 100 animaux/hecate, les moutons et les chèvres prenaient plus en plus de poids. Les pluies abondantes, la forte teneur en humidité et la maturité rapide des pâturages tropicaux sont à l'origine de la croissance irrégulière et des pertes de production de viande qui en découlent.

Abstract
Sheep and goats grazed all year round on natural pastures whose principal species were Imperata cylindrical, Pennisetum purpureum, Melinis minutiflora, gained weight from March, the beginning of rains and started losing weight in July and August, at the peak of heavy rains. At this period of peak rains pasture was abundant, crude protein and dry matter was very low. The greatest weight losses were in January and February at the end of the dry season. As stocking rates increased from 40 animals per hectare to 100 animals per hectare, sheep and goats increasingly lost weight. Heavy rains, high moisture content and rapid maturity of tropical pastures are implicated in this uneven growth pattern and, subsequently losses in terms of meat production.

Introduction
Tropical pastures are abundant with onset of rains and become standing hay during the dry season. Traditionally, various supplements to; and modification of these lignified materials are fed animals at this period in order to prevent weight losses. However, in most cases meat and milk production are not very encouraging1,2.

Traditionally, sheep and goat management in Cameroon as is in most countries of sub-Saharan Africa is to, extensively herd small ruminants, allow them roam uncontrolled, or tether them and, at night provide some type of shelter. The advantages of this management system are that there is random mating, thus preserving genetic diversity, animals select feed and fend for themselves in terms of health care and other environmental necessities. Thus the fittest survive and adapt to the environment. Some scientists3 have stated that sheep and goats are near the minimum limiting body size for efficient digestion of cellulose and that they have the largest gastrointestinal capacity (as percent body weight) as a compensatory measure for dietary selection and reduced metabolic requirements for maintenance. Economically, the farmers invest very little in terms of labour, feed and health care, but benefit from the random dispersion of manure and urine to the soil.

On the other hand, frequent and indiscriminate mating do occur resulting in premature weaning and subsequently, weaker dams and young which may die or survive. Losses do accrue from such management practices in addition to losses from thefts, disease and slow growth4.

Ravaging and roaming small ruminants are destructive to crops and the environment. Relating agriculture to farm size, an agricultural census5 showed that average farm sizes in Cameroon were two hectares. In Kenya, pasture yields per hectare varied in terms of quantity and quality depending on farm size6. In discussing farm size and number of animals, the best performance was obtained7 grazing West African Dwarf sheep on a grass/legume association, at stocking rates of 16 to 18 ewes per hectare during the wet and dry season.

Other scientist8 suggested 60-200 sheep and goats per hectare during the wet and dry season.
to be ideal. Given a certain stocking rate, a basal production pattern needs to be established in order to judiciously effect improvements in terms of feed and feeding management. The question that needs to be researched is, the nature of the production cycle of small ruminants fed natural pasture and the strategies needed to increase growth rates of the indigenous West African Dwarf breeds in Cameroon.

**Materials and Methods**

**Trial 1:** Seventy West African Dwarf goats (WADG), three years old were randomly allocated to four one - quarter plots so that there were 10, 15, 20 and 25 goats respectively per plot or, 40, 60, 80 and 100 goats per hectare. The plots measured 100 metres long by 25 metres wide. The experimental design was a completely randomized block. Animals grazed from 9.00 am to 5.00 pm each day. They sheltered at night in the stalls of an open sided building with slatted wooden floors. Monthly animal weights and herbage yields were recorded. Herbage was cut in December, two months before animals were placed on pasture. The principal herbage species were *Imperata cylindrical*, *Hyparrhenia* spp., *Melinis minutiflora*, *Andropogon gayanus* and *Pennisetum purpureum*. 12 parcels of pasture one square metre along the sides of the plots were maintained. One plot was cut each month and the grass weighed and analyzed for dry matter and crude protein. Chemical analyses were carried out at the National Nutrition and Biochemistry Laboratory at Mankon according to standard methods.

**Trial 2:** 48 WAD goat and 22 WAD sheep were managed as described in trial 1.

**Table 1:** Quantity and quality of pasture and weather conditions

<table>
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<td>7.5</td>
<td>3.0</td>
<td>4.0</td>
<td>5.8</td>
<td>7.8</td>
<td>7.9</td>
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<td>Dry matter (%)</td>
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<td>69.5</td>
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<td>26.5</td>
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<td>536.6</td>
<td>351.1</td>
<td>145.2</td>
<td>95.5</td>
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</table>
Figure 1: Growth rates of West African Dwarf Goats grazing natural pastures

Figure 2: Mean daily weight gain of West African Dwarf Sheep and Goats (1:3) grazing natural pastures:
Goat Weights

Figure 3: Mean daily weight gain of West African Dwarf Sheep and Goats (1:3) grazing natural pastures:
Sheep Weights
Results

Table 1 shows the estimated herbage yield all year round. Herbage biomass increased from three tons per hectare and leveled off at eight tons dry matter per hectare (Dm/ha). The quality of grass varied all year round with the lowest dry matter observed at the start of the rains in March to the peak of the rains in July - August. The lowest crude protein was observed at the peak of the rains in July - August and lasted all through the dry season, January to February. During the month of March, practically all herbage was dry. Temperatures ranged from 23 - 36°C (a variation of 11 - 13°C). The biggest variability in temperatures occurred in the dry season, which coincided with the greatest number of sunshine hours.

Figure 1 shows that goats gained weight at the start of the rains in March - April and peaked at a weight gain of 30/g/goat/d in July - August. Part of the weight gains were probably compensation for weight losses during the previous dry season. Thereafter, goats started loosing weight. Surprisingly, the initiation of weight losses coincided with the peak of the rains and abundance of grass. As the stocking rate increased, goats gained less weight and lost weight more rapidly.

In the second trial, Figs. 2 & 3 show that sheep grazed along with goats slightly lost more weight than goats at the peak of the dry season and gained more weight than goats at the start of the rains. Weight losses when sheep and goats were grazed together started in July, 4-6 weeks earlier than when goats were grazed alone.

Discussion

The variability of pasture can be attributed to the effect of tropical weather. This is confirmed by observations on the growth pattern of tropical pastures which showed an increase of metabolic activity at high temperatures, including greater enzyme activity associated with lignin biosynthesis and more rapid conversion of photosynthetic products into structural components such as lignin. Subsequently there was a reduction in the quantities of nitrates, protein, soluble carbohydrates and other cell metabolites. A further pool of soluble carbohydrates was reduced during the long dark nights. More so, lack of water encouraged the formation of tannins, terpenoids or alkaloids that affect the quality of herbage. It was also reported that tropical forages contain 15 total digestible nutrient units less than temperate forages as a result of differences in climate and management. These factors apparently explain the growth pattern and quality of grass observed in this study.

Part of the weight gains were probably compensation for weight losses during the previous dry season. Thus as described above, at the start of the rains the protein content of herbage was high and stimulated rumen function that digested herbage in the pre-bloom stage and animals grew rapidly. Three months later, the crude protein dropped, crude fibre increased and most probably rumen function reduced. Confounded by this state was the fact that the herbage became more structural and less digestible. Then the heavy rains also reduced eating time per day as the rains were at times too heavy and splashing very hard. The results showed that animals started loosing weight as nutrients were probably below maintenance requirements. Several observations have been noted of weight losses of ruminants with increased rains, despite an abundance of grass. Other scientists stated that the wetness of heavy rains and the warmth of the tropics constitute a rich environment for disease organisms, which render animals less productive. Although no visible sick animals were observed in this study, the humid warm weather and the not so exacting nutrition of the small ruminant at this period, reduced thriftiness. Small ruminants were at this time then just striving to stay alive and/ or survive.

Apparently, increased animals per unit area meant less choice of grass for goats to nibble upon, given that goats are fastidious feeders. Another researcher also observed weight losses of ewes as stocking rate increased from 16 to 20 ewes per hectare. On the other hand, other workers in the field noted adequate growth rates of goats at stocking rates of 60 to 100 animals per hectare in the tropics. The best results observed in this study were at 40 goats/ha and the worst were at 100 goats/ha. It is worth noting that there was grass visible in the plots, which
the goats trampled upon. Apparently, sheep and goats grazing together consumed more as sheep probably ate what goats left behind and vice versa. The general pattern of increased weight losses with increased stocking rates as observed above, was noted again in this trial. Again the same arguments hold as stated above. However, the two species grazing together, more efficiently utilized the grass for no visible grass was being trampled upon. In conclusion tropical forages are inadequate to sustain sheep and goat growth, with only mineral supplements. Animals started loosing weight at the peak of the rains when herbage yield was highest, crude protein and dry matter lowest. Supplementation is suggested at this period rather than at the peak of the dry season when ruminants would have lost about a quarter of their body weight.

Acknowledgment

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References


Received for publication on 14th February, 2000.
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References


Received for publication on 14th February, 2000.
PERFORMANCE OF SHEEP AND GOATS FED TROPICAL HERBAGE SUPPLEMENTED WITH MAIZE AND CASSAVA BY-PRODUCTS

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P. O. Box 534, Mankon Research Station, Mankon, Bamenda, Cameroon

PERFORMANCE DES MOUTONS ET DES CHEVRES NOURRIS D’HERBAGES TROPICAUX COMPLEMENTES DE SOUS-PRODUITS DE MAIS ET DE MANIOC

Résumé
Les moutons et les chèvres rains de l’Afrique de l’ouest au piquet, broutant des fourrages tropicaux, gagnaient du poids tout juste un peu plus que les niveaux d’entretien, à savoir : 9,8 g/jour pour les moutons et 17,8 g/jour pour les chèvres. Cependant, lorsqu’ils sont nourris en stalle, les moutons et les chèvres gagnaient beaucoup plus de poids (P< 0,05) que leurs congénères broutant des fourrages tropicaux. Par exemple, les moutons nourris en stalle gagnaient 97 g/jour avec des pelures de manioc ; 86,3 g/jour avec un mélange 50:50 pelures de manioc/tiges de mais et 94,5 g/jour avec des tiges de mais comme source principale d’énergie. S’agissant des chèvres, elles gagnaient 72,8 ; 83,3 et 43,6 g/jour respectivement avec les mêmes aliments. Les brebis pleines et les agneaux sevrés servis en stalle avec des pelures de manioc comme source principale d’énergie en pleine saison des pluies gagnaient plus de poids (P.<0,01) 224,7 g/jour et 131,4 g/jour que lorsqu’elles étaient nourries d’un mélange de pelures de manioc/herbe à éléphant : 106,7 g/jour et 97,7 g/jour ou d’herbe à éléphant uniquement: 45,2g/jour et 79,3 g/jour. Ceci montre que l’alimentation stratégique des petits ruminants maintient une croissance élevée.

Abstract
Tethered West African Dwarf sheep and goats, grazing tropical pastures, grew barely above maintenance levels, 9.8g/d for sheep and 17.8g/d for goats. However, when stall-fed, both sheep and goats underwent significantly higher weight gains (p<0.05) than their counterparts grazing tropical pastures. For example, stall-fed sheep gained 97.0g/d on cassava peels, 86.3g/d on a 50:50 mixture of cassava peels/maize stover and 94.5g/d when fed maize stover as the principal energy source. Goats on the other hand gained 72.8, 83.3 and 43.6g/d on the respective diets. Meat production is discussed in terms of management costs. Pregnant ewes and weaned lambs stall-fed cassava peels as principal energy source at the peak of the rains significantly gained more weight (p<0.01) 224.7g/d and 131.4g/d, than when fed a mixture of cassava peels/elephant grass, 106.7g/d and 97.7g/d, or elephant grass alone, 45.2g/d and 79.3g/d. This suggests that strategic feeding of small ruminants sustains efficient growth.

Introduction
Small ruminants at stocking rates of 40, 60, 80 and 100 animals per hectare lost weight at the peak of rains despite abundance of herbage1. Apparently rains drove the animals to shelter and/or prevented animals from feeding. When animals did eat, the dry matter was low and the herbage was of low quality; therefore, the pasture was unable to support adequate growth. This is probably the reason why farmers tether their small ruminants. That is, farmers want their animals to stay fixed on pasture, to be forced to eat as much as possible besides saving on fencing. It has been suggested2 that tethering animals is a good management system provided the tether does not strangle the animals or cause them to be entangled with vegetation. These authors2 also suggested that it is essential to change the place

* Corresponding author.
This management system also minimizes the problems of increased human population, reduction of grazing land and allows for the management of larger animal herd sizes. However, this system reduces the independence of feeding by animals. Fencing and/or housing of small ruminants entail high costs. This study attempted to evaluate the efficiency of tethering and stall-feeding small ruminants beginning at the peak of the rains.

**Materials and Methods**

**Trial 1: Effects of grazing tropical pasture or stall-feeding cassava peels and maize stover on performance of pregnant ewes and does**

Thirty two sheep and 32 goats, all pregnant, of West African Dwarf (WAD) breed, two years old, were randomly assigned to one of four treatments, so that there were eight sheep and eight goats per treatment. The first lot of animals, which served as control, was tethered and each animal had a four-metre rope around its neck and the other end tied to a peg in the ground. These animals grazed for eight hours per day from (9:00 am to 5:00 p.m.) on natural pastures consisting principally of, *Imperata cylindrica*, *Pennisetum purpureum*, *Andropogon gayanus*, *Melinis minutiflora* and *Stylosanthes* spp. The feeding area measured 100 metres long by 25 metres wide. The second lot of animals was stall-fed cassava peels, the third lot had a 50:50 mixture of cassava peels and maize stover and, the fourth lot of animals was fed maize stover as the principal energy source. Tethered animals had free access to a supplement and water, given separately in a concrete trough along the side of a night shelter in the grazing area. Each animal was given 1.5 kilograms of a supplement daily as was also given to stall-fed animals. Stall-fed animals were each given 5 kilograms of feed daily, of which 1.75-3.5 kilograms were cassava peels and/or maize stover, 1 kilogram was cotton seed meal, 400 grams were molasses, 75 grams were bone meal, and 25 grams were salt. The supplement was fed to animals separately as was done for tethered animals. alongside water in concrete troughs in each stall. The cassava peels, mixture of cassava peels and maize stover, or maize stover alone, were fed animals in 15 litre buckets attached to stall walls alongside concrete troughs. Each stall measured 1 metre wide, 1.5 metres long and 2 metres high. The stall walls and floors were made out of wooden slats. The spaces between slats were 1.5 centimetres wide. The animal barn was suspended 1 metre above the ground. The experimental design was a randomized complete block and the trial lasted six months, from the peak of the rains in July - August to the end of the dry season in February.

**Trial 2: Effect of feeding graded levels of cassava peels on the reproductive performance of ewes**

Forty-five pregnant WAD ewes were randomly assigned to one of three treatments so that there were 15 ewes per treatment. Each ewe was confined singly per stall as described in trial one. In the first treatment ewes were fed elephant grass (*Pennisetum purpureum*) as energy source. The ewes on the second treatment had a 50:50 mixture of elephant grass and cassava peels while the third lot of animals on treatment three, had only cassava peels as energy source. Each ewe was given 5 kilograms of feed daily, consisting of 3.55 kilograms of elephant grass in treatment one, 1.775 kilograms of elephant grass and 1.775 kilograms of cassava peels in treatment two and 3.55 kilograms of cassava peels only in treatment three. A 1.45 kilogram supplement consisting of 1.05 kilograms cottonseed meal, 250 grams molasses, 125 grams bone meal and 25 grams salt, was fed with each principal energy source. Each energy source was mixed together with supplement and fed to animals in separate concrete troughs alongside water, *ad libitum* in each stall. The design was a randomized complete block and the trial lasted five months, three-and-a-half months of gestation and, six weeks of lactation.

**Trial 3: Effect of feeding graded levels of cassava peels on the growth of weaned lambs**

Twenty-six-weeks old weaned lambs, from ewes in trial 2, were fed test diets as their dams for 90 days (diets described in trial two). There were five lambs per treatment randomized for sex. Each lamb was confined to a stall as described in trial one. Each lamb was given 2 kilograms of feed daily of which 71% was elephant grass in diet one, 35.5% was elephant grass or cassava peels in diet two and 71% was cassava peels in diet three. Twenty-nine per cent of the 2 kilogram
feed given each day consisted of cotton seed meal (21%), molasses (5%), bone meal (2.5%) and salt (0.5%). The management of feed and animals and, experimental design were as described in trial 2. Maize stover and cassava peels were obtained from crops harvested the previous year, hand chopped into 2 cm pieces, and sun-dried and stored in jute sacks. They were seven months old at the time of usage.

Means from all treatments were subjected to analysis of variance for a randomized complete block and significant means tested by Duncan's multiple range test.

Results

Feed intake values (Table 1) showed that there were no significant differences between treatment means. In terms of weight gains of pregnant females, sheep put on significantly more weight (p<0.05) than goats when fed cassava peels and maize stover, but their weights were similar to those of goats when fed the cassava/maize stover mixture and herbage respectively. Although sheep and goats ate similarly, sheep had a greater feed conversion rate and hence gained significantly greater weights than goats. Small ruminants

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* SEM 2 4 significant at p<0.05

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Table 2: Performance of gestating / lactating ewes fed cassava peels and elephant grass

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<th>Parameters measured</th>
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<td>Lamb weight at 3 weeks (kg)</td>
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</tr>
<tr>
<td>Lamb weight at 6 weeks (kg)</td>
<td>6.9</td>
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</table>

** within rows means with the same superscript are not significant at P<0.01.
** significant at P<0.01
grazing natural pastures grew barely above maintenance levels compared to animals which were stall-fed with agricultural by-products. All pregnant females gave birth except two ewes and d for goats fed the maize stover, 72.8g/d for those fed cassava peels and 83.3g/d for those fed the cassava/maize stover mixture, were similar to weight gains of 84g/d for WAD goats under similar

Table 3. Growth traits of weaned lambs fed graded levels of cassava peels supplemented with cotton seed meal

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<th>Parameters measured</th>
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<tr>
<td></td>
<td>0</td>
<td>35.5</td>
</tr>
<tr>
<td>Feed intake (kg/lamb/d)</td>
<td>0.8a</td>
<td>1.2a</td>
</tr>
<tr>
<td>Weight gain (g/lamb/d)</td>
<td>79.3a</td>
<td>97.9a</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Final lamb weight (kg/lamb)</td>
<td>14.0</td>
<td>16.5</td>
</tr>
</tbody>
</table>

abc within each row means with the same superscript are not significant at P<0.05.
xyz within each row means with the same superscript are not significant at P<0.01.
*: Significant at P<0.05.
**: significant at p<0.01.

one doe fed the maize stover-based diet that aborted. The causes of the abortions could not be determined in this study. No mortality of nursing kids and lambs was observed (Table 1).

Stall -feeding gestating/lactating ewes (Table 2) at the peak of the rains, showed weight increases as cassava peels replaced elephant grass in the diet. All lamb weights were similar for all dietary treatments. No mortality or diseases were observed in the animals during this study.

The same holds true for lambs fed the same diets as their dams (Table 3). Lambs ate significantly more (P<0.05) on the 50:50 mixture of cassava peels/elephant grass based diet, followed by those fed the cassava peels based diet and least by lambs fed on the elephant grass based diet. Lambs grew highly significantly faster (P<0.01) as the level of cassava peel increased in the diet. Lambs fed the cassava peels based diet gained 131.4g/d while those fed the 50:50 mixture of cassava peels/elephant grass diet gained 97.9g/d and those fed the elephant grass based diet gained 79.3g/d. No mortality was observed among these lambs.

Discussion

Feed intake values (Table 1) observed in this trial fall within the range of 1.6 - 4.75% of body weights observed for tropical goats3, but are closer to 3.85% of body weights observed for West African Dwarf sheep and goats10. Weight gains of 43.6g/
turn this energy into meat. The higher growth rate of goats compared to sheep under this management system, confirms goats as better grazers of short grass\textsuperscript{18} and are extremely selective\textsuperscript{13}. Tethered animals must be watered at strategic times, most probably at the time when the tether area is being changed, compared to stallfed animals that had water available at all times and this inadequate watering could have also affected feed utilization by tethered animals.

Although other results obtained in the field\textsuperscript{2} confirmed the findings of this trial (Table 1) that zero grazing is the ideal management system for small ruminants, some scientists\textsuperscript{8} have documented that fencing small ruminants can be quite expensive and labour intensive particularly for small-scale producers. Thus the feeding of small ruminants must be weighted in terms of management and herd size, but most of all in terms of returns of meat and milk production. Cassava peels were very palatable as was shown by the adequate feed intake value of pregnant ewes (Table 2). This apparently explained the increased weight changes as cassava increased in the diets. Cassava peels usually contain cassava ends and pieces and, subsequently cassava starch which supply more energy. Observations in the field\textsuperscript{17} during pregnancy have shown that protein requirements being adequate, the quality of energy that increases glycogenic precursors is critical for the specific oxidation to provide nicotinamide adenine dinucleotide phosphate (NADPH) required for the synthesis of fat from acetate. Thus, these metabolic activities, very critical during pregnancy, resulted in all ewes lambing.

Lamb weights (Table 2) were similar for all treatments and this was not unusual, as the growth of the conceptus can be normal at the expense of ewe weight\textsuperscript{18}. However, in this trial, ewes were fed at the peak of the rains re-enforcing ewe body weight reserves and preventing weight losses usually observed at this period. The slightly increased growth rate of lambs whose dams were fed cassava peels could be justified by the supply of glycogenic compounds that provided glucose and subsequently lactose and fatty acid synthesis, thus more quality milk for lambs.

Table 3 shows the performance of lambs fed the same levels of cassava peels as their dams which could be explained by the same argument described above for their dams. Similar final weights of lambs obtained in this study has been confirmed by work done elsewhere\textsuperscript{19}. This author\textsuperscript{19} stated that the rumen ecosystem is probably the first constraint on the productivity of most African ruminants in general which includes Cameroon. Thus digestion is enhanced by the supply of fermentable sources of nitrogen (such as cotton seed meal in this study), so as to increase rumen ammonia\textsuperscript{20}, and escape protein, as well as glycogenic compounds as was done in this study. No mortality was observed and lambs were quite active and alert apparently because of adequate feeding management. Thus strategic feeding of small ruminants and adequate management can enhance increased meat production for small ruminants.

Acknowledgements

The authors are indebted to the International Development Research Centre (IDRC), Canada and to the Ministry of Scientific and Technical Research (MINREST), Cameroon for the funds used in this study.

References

Received for publication on 18th September, 2000.
MEAT AND MILK PRODUCTION BY SHEEP AND GOATS FED TROPICAL HERBAGE IN CAMEROON

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PRODUCTION DE VIANDE ET DE LAIT PAR LES MOUTONS ET LES CHEVRES NOURRIS D’HERBAGE TROPICAUX AU CAMEROUN

Résumé
La dégradabilité de la matière sèche in vitro et de la protéine des aliments tropicaux consommés par les moutons et les chèvres a montré que la farine d’arachide, la farine de soja, les feuilles de manioc et la farine de graine de coton étaient fortement dégradables : 97,9%, 98% ; 95,9% ; 95,7% ; 88,3% ; 94,6% et 90,6% ; 93,6% respectivement. La farine de poisson était légèrement dégradable : 61,3% (matière sèche) et 72,8% (protéine). La farine de palmiste, la farine de sang et les feuilles de plantain étaient dégradables à moins de 50% après 48 heures d’incubation. Les moutons et les chèvres nains de l’Afrique de l’ouest (WAD), nourris d’herbe à éléphant (Pennisetum purpureum) et d’herbe de Gama (Tripsacum laxum), complémentées de farine de graine de coton, gagnèrent le poids, avec les animaux servis d’herbe à éléphant gagnant plus de poids que ceux nourris d’herbe de Gama. Les chevaux laitiens Saanen, Toggenburg et Anglo-Nubiens ne grandissaient pas autant que les WAD avec les mêmes aliments. Les rendements en lait de 0,26 kg/chèvre/jour pour les chèvres nourries d’herbe à éléphant et 0,49 g/chèvre/jour pour celles servies d’herbe de Gama, étaient plus faibles comparé à ceux des WAD dans les mêmes conditions. Cependant, la matière grasse du lait et les solides totaux avaient une teneur plus élevée : 3,3% et 12 pour les animaux nourris d’herbe à éléphant et 4,7% et 11,77 pour les animaux servis d’herbe de Gama.

Abstract
In vivo dry matter and protein degradability of tropical feedstuffs consumed by sheep and goats, showed that groundnut meal, soybean meal, cassava leaves and cotton seed meal were highly degradable: 97.9% in sheep, 98.0% in goats; 95.9% in sheep, 95.7% in goats; 88.3% in sheep, 94.6% in goats and 90.6% in sheep and 93.6% in goats, respectively. Fishmeal was moderately degradable, 61.3% (dry matter) and 72.8% (protein). Palm kernel meal, blood meal and plantain leaves were less than 50% degraded after 48 hours of incubation. West African Dwarf (WAD) sheep and goats when fed elephant grass, Pennisetum purpureum and guatemala grass, Tripsacum laxum, supplemented with cotton seed meal, gained weight with animals fed elephant grass sustaining heavier body weights than those fed guatemala grass. Dairy kids of the Saanen, Toggenburg and Anglo-Nubian breeds did not grow as well as WAD meat animals on the same diets. Milk yields of 0.26 kg/doe/d for does fed elephant grass and 0.49 kg/doe/d for those fed guatemala grass, were lower compared to values observed for these breeds under similar conditions. However, milk fat and total solids were high, 3.3% and 12 for elephant grass fed animals and, 4.7% and 11.77 for guatemala-fed animals.

Introduction
The growth pattern of tropical pastures is one of rapid growth with the reduction of soluble nutrients and the formation of non-nutrients as lignin1. Some of the strategies used to render these large quantities of lignified material suitable as animal feed is by treatment with chemicals2, and by supplementing with nitrogenous substances3 and minerals4 particularly for dry season feeding. Indigenous West African Dwarf (WAD) small ruminants have adapted to this environment by developing a small, bony, body size.

Increased meat and milk production is also accomplished in Cameroon as in other developing countries by cross breeding high producing temperate animals with local ones. That is, by crossing exotic animals such as Saanens, Toggenburgs, Anglo-Nubians and British Alpine goats with local animals in order to increase milk yields5.6. However, these high-producing animals and their crosses must adapt to tropical feeds and climate and still produce. Strong criticism has been voiced2 against the application of feeding standards developed in industrialised countries to small scale farming systems, because it has been shown that the performance

* Corresponding author.
of animals after feeding a combination of poor quality materials is not always accurately predictable when published laboratory analysis is used. On the other hand, simple internationally recognized laboratory methods must be utilized on small farms to enable results to be interpreted. Several methods have been developed to estimate the utilization of feeds by animals such as solubility in hot water or buffers\(^7\), \textit{in vitro} digestibility\(^8\) and rumen degradability\(^9\).

Such digestible feedstuffs are needed particularly in dry season when all herbage in the field is completely dried up and valueless in terms of supplying nutrients to animals. During these months, elephant grass and guatemala grass are the principal grass species that still stay green, and are available all year round. This study attempted to evaluate milk and meat production by West African Dwarf sheep and goats, at the peak of the dry season in the highlands of Cameroon, when the animals were fed principally on tropical herbage.

**Materials and Methods**

**Trial 1: Rumen degradability of tropical protein feedstuffs**

Four-fistulated wethers/(castrated male sheep) were used to evaluate the rate of degradability of oil seed meals and other protein sources available in Cameroon. Feed samples namely, groundnut meal, soya bean meal, cotton seed meal, cassava leaves, fish meal, palm kernel meal, blood meal and plantain leaves, were ground to pass through a 2.2mm sieve and incubated in a 4x4 Latin square design with samples allocated at random to sheep. Samples were placed in dacron bags 20 cm long by 10 cm wide so that seams were on the outside. Samples were incubated in the rumen for 0, 2, 4, 6, 8,12, 24, and 48 hours. On removal of bags from the rumen, these bags were washed in a washing machine, freeze - dried and weighed. Protein content of the remains was determined by the Kjeldahl method\(^9\).

**Trial 2: Effect of feeding elephant or guatemala grass supplemented with cotton seed meal on the growth of West African Dwarf sheep and goats**

One year old WAD sheep and 16 WAD goats were randomly assigned to two test diets so that there were eight sheep and eight goats per treatment. Animals were confined singly in stalls measuring one metre wide, 1.5 metres long and 2 metres high. Each animal was given 2 kilograms of feed daily of which 80% was elephant or guatemala grass, 18% was cotton seed meal, 1.5% bone meal and 0.5% salt. The grass and the supplements were mixed thoroughly together before feeding to animals in wooden troughs measuring 30 centimetres wide, 60 centimetres long and 30 centimetres deep. Troughs were placed on jute sacks in order to collect spillovers from the troughs. The walls and floors of the stalls were made out of wooden slats. The spaces between slats were 1.25 centimetres. The open sided animal house that contained the stalls was stilted one metre above the ground. The experimental design was a randomized complete block in a factorial arrangement with two animal species and two herbage species as factors.

One-year old re-growths of guatemala and elephant grass were cut each morning at 10.00 am when the dew had dried up, hand chopped into 2 cm pieces and fed individually to animals in wooden troughs. The experiment lasted three months.

**Trial 3: The effect of elephant or guatemala grass supplemented with cotton seed meal on feed intake and weight change of dairy kids and lactating does**

Thirty-six one - year old dairy kids and 24 lactating does of the Saanen, Toggenburg and Anglo-Nubian breeds were randomly assigned to test diets in this trial. In the first part of the trial, 12 kids were allotted to each one of three dietary treatments. A lot of 12 kids which served as the control group, was grazed on natural pastures, in a plot measuring 100 metres long by 25 metres wide consisting principally of elephant grass, \textit{Imperata cylinrdica}, \textit{Melinis minutiflora} and \textit{Hyparthenia} spp. The second and third lots of 12 dairy kids were stall-fed elephant or guatemala grass as described in trial two. In a sub-trial designed to evaluate milk yields and quality from dairy does managed under traditional feeding
systems in Cameroon, 12 does were each fed test diet described in trial two. However, each kid and doe received as supplement, one half kilogram of a concentrate consisting of maize, 44.9%; cotton seed meal, 17.5%; rice bran, 33.1%; bone meal, 4.0% and salt, 0.5%. Water and additional salt was given ad libitum. The experimental design for the trial with dairy kids, and that with lactating does was completely randomized and each of the trials lasted three months.

Statistical analysis
Means of treatments were subjected to analysis of variance for a factorial design (trial 2) and for a completely randomized design (trial 3). Significant means were analyzed by Duncan's multiple range test⁴⁰.

Results
Dry matter and protein degradability results, (Table 1 & 2) show that groundnut meal ranked first in both sheep and goats (97.9% and 98.0% respectively), followed by soya bean meal (95.9% and 95.7%), cotton seed meal (90.6% and 93.6%) and cassava leaves (88.3% and 94.6%). Fish meal and palm kernel meals were not easily degraded. Blood meal (46.9%, 45.2%) and plantain leaves (43.8%, 43.8%) were least degradable. Feeding West African Dwarf sheep and goats elephant and guatemala grasses supplemented with cotton seed meal, (Table 3) during the peak of the dry season, showed that sheep ate significantly more (P<0.05) and grew highly significantly faster (P<0.01) than goats. In terms of herbage usage, elephant grass supported significantly faster growth (p<0.05) than guatemala grass. The interaction term between elephant grass and sheep or goats for dry matter intake and daily feed intake were significantly different (p<0.05). Similarly the interaction term between Guatemala grass and sheep or goats were significantly different (p<0.05). Table 4 shows that there were no significant differences in feed intake and weight gains of dairy kids in the first part of trial three. Dairy kids did not grow as well on the present test diets. Dairy goats grazing natural pastures lost weight while those fed in stalls maintained positive weight changes.

In the last phase of the third trial, (Table 5), there were no significant differences in milk yields and quality among dairy does fed test diets and in their second year of lactation. Does consumed slightly more guatemala grass compared to elephant grass. Milk produced by does fed guatemala grass was 0.49kg/doe/d while that produced by does fed elephant grass was 0.26kg/ doe/d. Milk composition (Table 5) showed that per cent milk protein and fat to be, 2.68 and 3.2 for elephant grass and, 2.96 and 4.2 for guatemala fed does.

Discussions
These degradability results are very valuable in Cameroon and other countries because groundnut

---

**Table 1:** Dry matter degradability of tropical proteins (%) in sheep

<table>
<thead>
<tr>
<th>Feedstuffs</th>
<th>0</th>
<th>2</th>
<th>6</th>
<th>8</th>
<th>24</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut meal</td>
<td>9.4</td>
<td>30.5</td>
<td>53.4</td>
<td>60.6</td>
<td>94.0</td>
<td>9.79</td>
</tr>
<tr>
<td>Soya bean meal</td>
<td>14.8</td>
<td>37.1</td>
<td>45.9</td>
<td>52.0</td>
<td>91.5</td>
<td>95.9</td>
</tr>
<tr>
<td>Cotton seed meal</td>
<td>22.0</td>
<td>25.3</td>
<td>40.2</td>
<td>46.3</td>
<td>75.5</td>
<td>90.6</td>
</tr>
<tr>
<td>Cassava leaves</td>
<td>29.2</td>
<td>31.5</td>
<td>42.1</td>
<td>50.5</td>
<td>85.0</td>
<td>88.3</td>
</tr>
<tr>
<td>Fish meal</td>
<td>34.8</td>
<td>38.4</td>
<td>45.2</td>
<td>47.4</td>
<td>55.2</td>
<td>61.3</td>
</tr>
<tr>
<td>Palm kernel meal</td>
<td>19.2</td>
<td>30.9</td>
<td>36.3</td>
<td>41.2</td>
<td>48.0</td>
<td>54.9</td>
</tr>
<tr>
<td>Blood meal</td>
<td>10.5</td>
<td>21.8</td>
<td>23.9</td>
<td>29.3</td>
<td>42.1</td>
<td>46.9</td>
</tr>
<tr>
<td>Plantain leaves</td>
<td>16.8</td>
<td>29.4</td>
<td>35.3</td>
<td>37.8</td>
<td>40.7</td>
<td>43.8</td>
</tr>
</tbody>
</table>
Table 2: The rate of protein degradability in tropical feedstuffs (%) in Goats

<table>
<thead>
<tr>
<th>Feedstuffs</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Groundnut meal</td>
<td>15.9</td>
</tr>
<tr>
<td>Sova bean meal</td>
<td>9.4</td>
</tr>
<tr>
<td>Cassava leaves</td>
<td>30.2</td>
</tr>
<tr>
<td>Cotton seed meal</td>
<td>20.4</td>
</tr>
<tr>
<td>Fish meal</td>
<td>22.4</td>
</tr>
<tr>
<td>Palm kernel meal</td>
<td>12.1</td>
</tr>
<tr>
<td>Blood meal</td>
<td>9.1</td>
</tr>
<tr>
<td>Plantain leaves</td>
<td>16.8</td>
</tr>
</tbody>
</table>

Table 3: Feed intake and weight gains of West African Dwarf sheep and Goats fed elephant or guatemala grass supplemented with cotton seed meal.

<table>
<thead>
<tr>
<th>Diets</th>
<th>Animal Species</th>
<th>Daily feed intake (kg DM/animal)</th>
<th>Daily weight gain (g/animal)</th>
<th>Daily feed intake per metabolic weight (g/kg W^0.75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elephant grass</td>
<td>Sheep</td>
<td>0.7^a</td>
<td>74.6^a</td>
<td>69.0^c</td>
</tr>
<tr>
<td></td>
<td>Goats</td>
<td>0.6^b</td>
<td>52.4^b</td>
<td>99.0^c</td>
</tr>
<tr>
<td>Guatemala grass</td>
<td>Sheep</td>
<td>0.7^a</td>
<td>70.0^a</td>
<td>69.0^a</td>
</tr>
<tr>
<td></td>
<td>Goats</td>
<td>0.7^a</td>
<td>33.8^b</td>
<td>119.0^a</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td>0.02^*</td>
<td>12.8^*</td>
<td>0.03^*</td>
</tr>
<tr>
<td>Dietary means</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant grass</td>
<td></td>
<td>0.7</td>
<td>63.5^*</td>
<td>84.0^r</td>
</tr>
<tr>
<td>Guatemala grass</td>
<td></td>
<td>0.7</td>
<td>51.9^*</td>
<td>94.0^r</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td>0.01</td>
<td>4.10^*</td>
<td>0.02**</td>
</tr>
<tr>
<td>Animal Species</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>Sheep</td>
<td>0.7^a</td>
<td>72.3^a</td>
<td>60.0^r</td>
</tr>
<tr>
<td></td>
<td>Goats</td>
<td>0.6^b</td>
<td>47.5^r</td>
<td>109.0^r</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td>0.04^*</td>
<td>8.77**</td>
<td>0.53**</td>
</tr>
</tbody>
</table>

^a, ^b, ^c Means within columns bearing the same superscripts is not significantly different at (P<0.01)
^a, ^b, ^c Means within columns bearing the same superscripts is not significantly different at (P<0.05)
* Significant at (P<0.05)
**Significant at (P<0.01)
Table 4: The growth rate of dairy kids fed elephant or guatemala grass supplemented with cotton seed meal.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Elephant grass</th>
<th>Guatemala grass</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (kg/kid)</td>
<td>19.0</td>
<td>18.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Final weight (kg/kid)</td>
<td>19.2</td>
<td>20.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Total weight gain/loss</td>
<td>0.2</td>
<td>2.2</td>
<td>-3.0</td>
</tr>
<tr>
<td>Daily feed intake (g/kg W)</td>
<td>589.0</td>
<td>603.0</td>
<td>ND*</td>
</tr>
<tr>
<td>Daily feed intake</td>
<td>60.0</td>
<td>60.0</td>
<td>ND</td>
</tr>
<tr>
<td>Metabolic weight (g/kg W)</td>
<td>0.0</td>
<td>12.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*ND not determined

Table 5: Yields and quality supplemented with cotton seed of milk from dairy meal does elephant or guatemala grass.

<table>
<thead>
<tr>
<th>Parameters measured</th>
<th>Elephant grass</th>
<th>Guatemala grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily feed intake (g DM/doe)</td>
<td>662.0</td>
<td>695.0</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Milk Production (kg/doe/d)</td>
<td>0.26</td>
<td>0.49</td>
</tr>
<tr>
<td>Milk protein (%)</td>
<td>2.68</td>
<td>2.96</td>
</tr>
<tr>
<td>Milk fat (%)</td>
<td>3.20</td>
<td>4.2</td>
</tr>
<tr>
<td>Milk total solids (%)</td>
<td>12.0</td>
<td>11.8</td>
</tr>
</tbody>
</table>

meal, soya bean meal and cassava leaves are part of the human food chain. This means cotton seed meal can be used for animal feed without any fear of competition. The only constraint might be the presence of free gossypol whose content vary from 400 to 800 mg/kg and falls within the range tolerated by animals. It is apparent that the use of these protein sources will depend upon availability and costs. All the same, the high degradability values suggest that there will be nitrogen available for microbial growth and subsequently fibre fermentation. Although a cautionary note has been sounded that highly degradable proteins are not efficiently utilized for growth of ruminants. Thus the lower dry matter and protein degradability of palm kernel meal, blood meal and plantain leaves suggested that some of the protein will escape rumen fermentation and would be directly digested and utilized for growth. In addition, these feedstuffs are available in large quantities.

Sheep and goats in smallholder systems consumed small amounts of these various feedstuffs, extracting as much nitrogen and other nutrients as possible. Apparently these nutrients add up and encourage growth. This probably explains why it has been stated that feeding standards developed in industrial countries do not accurately predict the performance of livestock production in small farm systems. Other scientists showed that alternative methods of ration formulations can be developed for such small scale production systems and that degradability of proteins of plant origin but not of animal origin, vary with cellulose fermentation in the rumen.
WAD sheep have a bigger adult size, 30-40kg, compared to goats 24-30kg and probably explain the heavier weight gains (Table 3). This was confirmed by relating feed intake to metabolic size. The results obtained for goats were one-and-a-half times higher than values for sheep and is supported by results in the field showing that the metabolism of smaller animals is greater than that of larger animals per unit of body weight.

Apparently the guatemala grass was more succulent than elephant grass and supplied less energy. This then explains the interactions between the two grass species and the two types of animals. The feed intake and weight gain values were comparable to values observed for this breed of animal under similar production conditions. It has been observed for dairy goats that the nutrient status of goats greatly affected live weight and external measurements. Thus, although dairy kids (Tables 4&5) appeared physically normal, they were loosing weight, suggesting that natural pastures supplemented with cotton seed meal were not adequate to stimulate dairy kid growth; even though estimated nutrients were adequate. It was not possible to say what caused the death of the one kid fed guatemala grass as post-mortem examination showed no abnormal signs.

Observations of dairy goats have led to suggestions that Saanen, Toggenburg and Angle-Nubian does produce 1.06, 0.99, and 0.66 kg milk/ doe/d in the tropics compared to 3.3kg/doe/d in the temperate climate. Other scientists suggested that the much lower milk yields observed on imported breeds to the tropics were due to heat stress to which resistance varies, inadequate nutrition and disease control. Still other researchers noted that cattle do attain average milk yields of their respective breeds when their nutrition reaches at least two-and-a-half times their maintenance requirements. Feed intake values were three percent of total animal body weights in this trial but diets were apparently not nutritious enough to stimulate greater milk yields. In terms of milk fat, some findings have shown higher protein values of 3.4 - 4.1% but lower fat values of 2.65 - 4.06% for similar breeds in the tropics. This author also observed total solids of 10.67 - 12.17, which were similar to values of 12.0 and 11.77 for elephant grass and guatemala grass observed in this study. It would appear that these differences are due to breed, nutrition, stage of lactation and management.

In conclusion, oil seed cakes were highly degradable suggesting a ready supply of nitrogen to stimulate rumen action. Elephant grass and guatemala grass supported growth of indigenous WAD sheep and goats, but were inadequate to stimulate adequate dairy kid growth and milk production at the peak of the dry season.

Acknowledgements
The authors are grateful to the International Development Research Centre (IDRC), Canada and to the Ministry of Scientific and Technical Research (MFNST), Cameroon, for the funds used to carry out this study. Special thanks go to Dr. J. Topps for assistance with degradability studies.

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Received for publication on 18th September, 2000.
ESTIMATES OF PHENOTYPIC AND GENETIC TRENDS OF GROWTH TRAITS IN N’DAMA HERD IN NIGERIA

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EVALUATION DES TENDANCES PHENOTYPIQUES ET GENETIQUES DESTRAITS DE CROISSANCE CHEZ LETROUPEAU N’DAMA AU NIGERIA

Résumé

Les données sur le poids à la naissance (PN), le poids au sevrage ajusté à 205 jours (PSA) et le gain pondéral quotidien avant le sevrage (GQS) des N’Dama élevés à la ferme de Fashola entre 1947 et 1984 ont été recueillies et utilisées pour déterminer les tendances phénotypiques et génétiques des traits de croissance. Les tendances phénotypiques évaluées étaient de : $0.07 \pm 0.2$ kg/an ; $0.18 \pm 0.66$ kg/an et $0.005 \pm 0.008$ kg/an pour PN, PSA et GQS respectivement. En revanche, toutes les tendances génétiques estimées étaient relativement faibles et très proches de zéro, à savoir : $0.02 \pm 0.05$ kg/an ; $0.02 \pm 0.05$ kg/an et $0.01$ g/an respectivement. L’établissement polynomial séquentiel de l’ensemble des données a indiqué que la fonction quadratique décrit bien les données. Les équations de régression obtenues pour les courbes de tendance phénotypique étaient comme suit :

\begin{align*}
Y &= 9.91 + 0.001b^1 + 0.02b^2 \\
Y &= 46.44 - 0.15b^1 + 0.01b^2 \\
Y &= 0.21 - 0.0002b^1 + 1.18b^2
\end{align*}

pour PN, PSA et GQS respectivement.

Les équations pour les courbes de tendance génétique étaient :

\begin{align*}
Y &= 0.10 - 0.01b^1 - 0.34b^2 \text{ pour PN et PSA} \\
Y &= 0.002 - 0.0002b^1 - 70.85b^2 \text{ pour GQS.}
\end{align*}

Abstract

Data on birthweight (BTHWT), 205-day adjusted weaning weight (ADWNWT), and pre-weaning daily gain (ADG) of N’Dama cattle reared at Fashola Stock Farm between 1947 and 1984 were obtained and used to estimate phenotypic and genetic trends of growth traits. Estimated phenotypic trends were $0.07 \pm 0.2$ kg/yr, $-0.18 \pm 0.66$ kg/yr and $0.005 \pm 0.008$ kg/yr for BTHWT, ADWNWT and ADG respectively. In contrast, all estimated genetic trends were relatively small and not significantly different from zero. They were $0.02 \pm 0.05$ kg/yr, $0.02 \pm 0.05$ kg/yr and $0.01$ gm/yr respectively. The sequential polynomial fitting of the data set indicated that quadratic function described the data adequately. The obtained regression equations for phenotypic trend curves were

\begin{align*}
Y &= 9.91 + 0.001b^1 + 0.02b^2 \\
Y &= 46.44 - 0.15b^1 + 0.01b^2 \text{ and} \\
Y &= 0.21 - 0.0002b^1 + 1.18b^2
\end{align*}

for BTHWT, ADWNWT and ADG respectively.

The equations for genetic trend curves were:

\begin{align*}
Y &= 0.10 - 0.01b^1 - 0.34b^2 \text{ for BTHWT and ADWNWT and} \\
Y &= 0.002 - 0.0002b^1 - 70.85b^2 \text{ for ADG.}
\end{align*}

Introduction

Most African countries have pursued breed evaluation studies in their search for increased livestock production because it forms an essential part of successful planning of future breeding schemes, and allows documentation of progress from past selection. Such an evaluation should
require separation of the genetic and environmental portions of the total phenotypic trend. But what is of interest to the animal breeder is the trends in genetic merit.

Genetic trend studies have interested many groups in dairy cattle populations \(^1\). Past efforts to estimate genetic trends in beef cattle have been confined mostly to small, single herd populations. However, in recent years more emphasis has been given to performance and progeny testing in beef herds in America\(^2\). It is however a concern that little or no information is available on genetic trend of African indigenous beef breeds in the tropics. It is, therefore, the objective of this study to obtain phenotypic and genetic trends of growth traits in the N'Dama Cattle reared in the humid tropical zone of Nigeria.

Materials and Methods
The N'Dama herd from which the data used in this study were obtained were those kept at Fashola Stock Farm, Nigeria between 1947 and 1984. Management details and climatic conditions of the farm have been described\(^3\). The data consisted of 4,153 birth weight and 1,463 actual weaning weight records.

Actual weaning weight was adjusted to 205-day weight, for sex of calf and age of dam using standard procedures\(^4\). Pre-weaning daily gain was computed as the difference between actual weaning weight and birth weight divided by weaning age.

Statistical analysis
Annual phenotypic mean for all traits was computed using the ML procedure\(^5\) and using the model of Wilson and Willham\(^6\) represented as

\[
Y_i = \left( \sum_k y_{ik} \right) / n_i
\]

where
- \(Y_i\) is the phenotypic average for trait X of the calf crop born in the \(i^{th}\) year.
- \(y_{ij}\) is the record of trait X of the \(j^{th}\) calf in the \(i^{th}\) year.
- \(n_i\) is the total number of calves belonging to the \(i^{th}\) year.

Annual Genetic merit was computed as the average Expected Progeny Difference (EPD's) of the sires weighted by the number of progeny for each sire added to that of the dams and expressed as

\[
G_i = \left( \sum_k n_{ik} s_k \right) / n_i + \left( \sum d_i \right) / n_i
\]

where
- \(G_i\) is the genetic merit of the Calf crop for the trait X in the \(i^{th}\) year.
- \(n_{ik}\) is the number of progeny of the \(k^{th}\) sire in the \(i^{th}\) year in the herd.
- \(s_k\) is the Expected Progeny Difference (EPD) for trait X of the \(k^{th}\) sire.
- \(d_i\) is the EPD for trait X of the \(j^{th}\) dam in the herd with a progeny record in the \(i^{th}\) year.
- \(n_i\) is the total number of progeny with records for trait X in the \(i^{th}\) year.

EPD’s which is one-half the breeding value is a prediction of how future progeny of a sire or dam are expected to perform for a particular trait as compared to a fixed breed average. It was estimated by multiplying the least square constant for each sire and dam by the weight factor as described by Legates and Warwick\(^7\) and can be expressed as

\[
EPD = b(X_n - X_h)
\]

Where \(b\) is the regression coefficient (weighting factor) which is dependent on the number of progeny and the heritability of the trait

- \(X_h\) is the average of the bull's progeny.
- \(X_n\) is the average of the other progeny in the same herd.

And \(b = \frac{n}{n + (6^{2}/6w)}\)

\[
= \frac{n}{n + [(4 - h^2)/h^2]}
\]

where
Table 1: Within herd estimates of phenotypic genetic and environmental trends of birthweight, 205-day adjusted weaning weight and pre-weaning daily gain in N'Dama cattle at Fashola Stock Farm

<table>
<thead>
<tr>
<th>Trends</th>
<th>BTHWT (kg)</th>
<th>ADWNWT (kg)</th>
<th>PDG (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenotypic</td>
<td>.07±.02</td>
<td>.18±.66</td>
<td>.005±.003</td>
</tr>
<tr>
<td>Genetic</td>
<td>.02±.05</td>
<td>.02±.05</td>
<td>.00001</td>
</tr>
<tr>
<td>Environmental</td>
<td>.05±.03</td>
<td>-.02±.35</td>
<td>.005±.003</td>
</tr>
</tbody>
</table>

BTHWT = Birth-weight;  
ADWNWT = 205-day adjusted weaning weight;  
ADG = Pre-weaning daily gain

Table 2: Results of sequential polynomial fitting of the trend curves for growth traits in N'Dama Cattle.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression</th>
<th>Parameter</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polynomial</td>
<td>a</td>
<td>b¹</td>
<td>b²</td>
</tr>
<tr>
<td>Birthweight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>17.88</td>
<td>.07±.02</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-.54</td>
<td>.02±.05</td>
<td>-</td>
</tr>
<tr>
<td>Quadratic</td>
<td>9.91</td>
<td>.001±.002</td>
<td>.02±.002**</td>
</tr>
<tr>
<td></td>
<td>.10</td>
<td>-.01±.03</td>
<td>-.34±.6</td>
</tr>
<tr>
<td>Cubic</td>
<td>6.57</td>
<td>.0001±.0001</td>
<td>.05±.0003**</td>
</tr>
<tr>
<td></td>
<td>.18</td>
<td>-.01±.03</td>
<td>-.54±.35</td>
</tr>
</tbody>
</table>

205-day adjusted weaning weight

| Linear                            | 100.98     | -.18±.66  | -        | -        | .45      |
|                                  | -.54       | .02±.05   | -        | -        | 1.18     |
| Quadratic                         | 46.44      | -.15±.06  | .01±.0001**| -        | 99.00    |
|                                  | .10        | -.01±.03  | -.34±.06**| -        | 70.21    |
| Cubic                             | 28.81      | .003±.01  | .01±.0002**| -.00**   | 99.99    |
|                                  | .18        | -.01±.03  | -.54±.35 | -.06±.11 | 70.99    |

Preweaning daily gain

| Linear                            | .34        | .005±.003 | -        | -        | 20.28    |
|                                  | -.002      | .00       | -        | -        | 0.00     |
| Quadratic                         | .21        | -.0002±.0004 | 1.18±.04**| -        | 98.59    |
|                                  | .002       | -.0002±.0001 | -.70.85±.11.99**| -        | 71.37    |
| Cubic                             | .13        | -.000     | 2.42±.04 | -1.90±.06**| 99.98    |
|                                  | .002       | -.0002    | -68.41±64.70 | 154.83±40.32 | 71.37    |

a = intercept, b's are partial regression coefficients. Values on top are for phenotypic trend while those below are for genetic trend.
Fig. 1: Phenotypic and genetic trendline of birthweight of N'Dama Calves at Fashola Stock Farm between 1947 and 1984

Fig. 2: Phenotypic and genetic trendlines of pre-weaning daily gain of N'Dama Calves at Fashola Stock Farm between 1960 and 1983
Estimates Of Phenotypic And Genetic Trends Of Growth Traits In N’Dama Herd In Nigeria

Fig. 3: Phenotypic and genetic trendlines of 205-day adjusted weaning weight of N’Dama Calves at Fashola Stock Farm between 1960 and 1983

\[ n = \text{the number of progeny} \]

\[ 6^2_s = \text{the variance due to sire} \]

\[ 6^2_w = \text{the residual variance or an intra herd basis for the specific trait} \]

Phenotypic and genetic trends were then obtained by regressing annual phenotypic and genetic merit on years. Phenotypic and genetic trend lines for the traits were obtained by plotting annual phenotypic and genetic merits for each trait for each year that such records were collected and connecting all such points. Heritability estimates were made using variance components adopting the Henderson methods in mixed-model\(^8\).

Results

Table 1 shows the annual phenotypic, genetic and environmental trends obtained for birthweight, 205-day adjusted weaning weight and pre-weaning daily gain of the N’Dama cattle. The trend charts for the traits are depicted in Figs. 1, 2 and 3, respectively.

Heritability estimates of \(0.45 \pm 0.08, 0.06 \pm 0.04\) and \(0.07 \pm 0.04\) were obtained for BTHWT, ADWNWT and ADG, respectively. The estimated phenotypic trend of birthweight was relatively large (\(0.07 \pm 0.02\)kg/yr), non-significant (\(P > 0.05\)) and in the desirable direction. The estimate for the 205-day adjusted weaning weight had a phenotypic trend of \(-0.18 \pm 0.66\)kg/yr which was not significant (\(P > 0.05\)).
and in the undesirable direction. Pre-weaning daily gain had a value which apart from being not significant (P>0.05) was absolute value not different from zero (.005kg/yr). All traits had a genetic trend that was not significantly different (P<0.05) from zero (Table 1).

There were total phenotypic changes of 7.43Kg; 14.72Kg and .077Kg and total genetic changes of .094Kg; -.058Kg and -.3g in BTHWT, ADWNWT and ADG, respectively. Trend curves were far from linear.

The results of sequential polynomial fitting of the data are presented in Table 2. In all traits, the linear function alone was not significant yielding R² of .04 to 25 percent. It was increased to 100 percent by sequentially adding the quadratic and cubic components. Sequential R² values for genetic merit were not as high as those obtained for phenotypic trend. Quadratic function was significant for both phenotypic and genetic trend curves.

**Discussion**

Birthweight trend charts showed a steady increase in the genetic merit of N'Dama calves between 1950 and 1960. The gain was fairly constant between 1961 and 1970 and in 1971 a reduction was observed. Although there were years when pronounced genetic improvement was observed (1952, 1960, 1965, 1970, 1975 and 1980), it could not be sustained as a result of the differential contributions of sires in each year since sires varied in their expected progeny difference (EPD's). The period 1960–70 seems to have had sires and dams with higher EPD's, therefore, influencing the genetic trend chart. The non-systematic fluctuations in the annual phenotypic mean could be explained by the seasonal and yearly variations in climatic conditions thus affecting pasture availability and quality. Annual phenotypic means varied from 16.22 to 23.65Kg, thus confirming the differential contribution of sires and the fluctuations in feed availability. Years where sires with higher EPD's contributed more offspring and such animals were exposed to favourable climatic conditions and abundant feed availability, the resultant effect would be a larger phenotypic value.

Although the observed phenotypic trend of .07+.02kg/yr was higher than .03kg/yr reported by Tunwason et al.11 for birthweight of Angus, the 0.48kg/yr genetic trend reported for birthweight of Angus was higher than .02kg/yr obtained in the present study for N'Dama.

The phenotypic and genetic trend charts of weaning weight and average daily gain were similar (Figs.2 and 3). In the first few years, there was favourable genetic merit, which dropped with time. The phenotypic trend was more sporadic as a result of the environmental influence on weaning weight and pre-weaning daily gain performance of the animals. With the obtained positive genetic trend one would have expected corresponding positive phenotypic trend, but because of the masking effect of the environment, this was not possible. This may have been responsible for the wide variation observed with both traits (60.36 to 119.53kg in ADWNWT and 178 – 569g in ADG). The environmental influence was constant between 1960 and 1964 while in the years 1978 to 1983 environmental influence allowed ADWNWT and ADG to continue increasing. However, the obtained genetic trend was lower than .30kg/yr reported in the literature13 for weaning weight in Angus. The difference can be attributed to the intense selection that has taken place in the temperate breeds. The generally low heritability estimate of .06+.04 for waning weight and .07+.04 for average daily gain may also have accounted for the poor genetic trend.

Genetic trends estimated from these data sets suggest that selection practices had not been very successful. If there was any selection it varied since the traits exhibited trends that were far from linear as quadratic and cubic functions were better fits. Similar observations were also reported in Angus weaning weight data8.

The sequential polynomial fitting of the trend curves showed the quadratic function was a better fit of the phenotypic curves as it yielded an R² of above 98% in all traits. It was significant for the genetic curve but it yielded R² of about 70%. In order to fully account for changes in the genetic merit of a calf crop over time, a higher polynomial fitting would be a better fit to the data set. This finding, therefore, suggests that the relationship
between phenotypic and genetic progress in growth traits of N'Dama and time is very complicated. Consequently, progress in time will not necessarily result in increases in these traits since the total variance of such traits cannot be accounted for by time.

References


Received for publication on 25th August 1997.
INFLUENCE DE LA TEMPÉRATURE DE PASTEURISATION SUR LA FLORE TOTALE DU LAIT

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Abstract

The total count of bacteria is a parameter which characterizes the hygienic and sanitation quality of milk. This work was carried out to determine the influence of pasteurisation temperature under local conditions on the total milk flora.

The milk was treated at different processing temperatures applicable in the dairy industry. The total bacterial count of the milk was determined by the classic method of plate count using agar and by colometric tests with resazurine.

According to the results of the resazurine test, milk pasteurised at 64°C and 85°C are of good quality, whereas raw milk and milk pasteurised at 74°C are of fair quality.

Other results obtained show that milk pasteurised at 85°C and milk heated to boiling had counts of less than 30,000 cfu/ml and 10,000 cfu/ml respectively. It was only in boiled milk that the level of survival of micro-organisms was less than 0.1%.

Résumé

Le dénombrement total de bactéries est l’un des paramètres qui caractérisent la qualité hygiénique et sanitaire du lait. Ce travail a été mené pour étudier l’influence de la température de pasteurisation sur la flore totale du lait dans les conditions locales.

Le lait a subi différents traitements thermiques utilisés en industrie laitière. Le dénombrement total de bactéries du lait a été effectué par la méthode classique en milieu gélosé et par le test colorimétrique avec le résazurine. Selon le test de résazurine, le lait pasteurisé à 64°C et 85°C est de bonne qualité tandis que le lait cru et le lait pasteurisé à 74°C est de qualité normale.

Les résultats de cette étude montrent que dans le lait pasteurisé à 85°C et le lait porté à la température d’ébullition, le nombre total de bactéries est inférieur à 30000 UFC/ml et 10000 UFC/ml respectivement. Cependant, c’est seulement dans le lait bouilli que le taux de survie des micro-organismes est inférieur à 0,1%.

Introduction

Le lait est un produit alimentaire de haute valeur nutritive et un milieu idéal pour les microorganismes. Les conditions souvent précaires de production de lait et l’hygiène insuffisante rendent le lait souillé. La contamination bactérienne du lait dépend de la santé des animaux, de la propreté des bêtes (leur peau et leurs mamelles, etc), des trayeurs, des ustensiles de laiterie, etc. Certains auteurs¹ ont rapporté que dans 1 ml de lait produit par la vache à la peau sale, on trouve jusqu’à 2 millions de bactéries en comparant à 20000 seulement à la peau nettoyée. D’autres sources de contamination sont les aliments, l’accumulation de fumier, la litière ainsi que les mouches². Le développement des microbes dans le lait diminue sa valeur alimentaire, contribue à l’accumulation des microorganismes pathogènes et leurs toxines, donc rend le lait dangereux sur le plan bactériologique³. C’est pour cela qu’il faut prêter beaucoup d’attention à la qualité sanitaire et hygiénique du lait. Pour caractériser cet indice, on utilise différents paramètres, parmi lesquels il y a le dénombrement total de bactéries du lait⁴.

Les températures de stockage et de pasteurisation influencent beaucoup la flore microbienne du lait. Senyk et al.⁵ ont montré que le dénombrement total le plus élevé de microorganismes (sur le milieu SPC) est observé dans le lait cru réfrigéré à la température de 10°C. En effet, la température de 10°C de stockage du lait est considérée comme la température critique. Pour prévenir le développement de microorganismes, le lait doit être conservé à la
La température de 2 à 3°C. Il est connu que le froid ne détruit pas les microbes, mais ralentit leur développement, tandis que la chaleur provoque la destruction des microorganismes. Les traitements recommandés pour la pasteurisation du lait sont de 62,8°C à 65°C x 30 minutes, de 71,7°C à 78,3°C x 15 secondes, de 85°C et plus, moins de 100°C. Cependant, les procédés de pasteurisation du lait utilisés en industrie laitière ne sont pas toujours efficaces dans les conditions locales. Pour obtenir du lait pasteurisé microbiologiquement propre, le taux de survie des microorganismes ne doit pas dépasser 0,1%. Le but de ce travail est d'étudier l'influence de la température de pasteurisation sur la flore totale du lait dans les conditions locales.

Tableau 1: Evaluation de la qualité du lait par le test de résazurine

<table>
<thead>
<tr>
<th>Catégorie</th>
<th>Qualité du lait</th>
<th>Temps de changement de couleur</th>
<th>Couleur du lait</th>
<th>Nombres de bactéries par ml de lait</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Bonne</td>
<td>1 heure</td>
<td>Bleu-d'acier</td>
<td>Moins de 500.000</td>
</tr>
<tr>
<td>II</td>
<td>Normale</td>
<td>1 heure</td>
<td>Bleu-violet</td>
<td>500.000 – 4.000.000</td>
</tr>
<tr>
<td>III</td>
<td>Mauvaise</td>
<td>1 heure</td>
<td>Rose</td>
<td>Plus de 20.000.000</td>
</tr>
<tr>
<td>IV</td>
<td>Très mauvaise</td>
<td>20 minutes</td>
<td>Blanche</td>
<td></td>
</tr>
</tbody>
</table>


Matériel et Méthodes

Echantillonnage

Dix échantillons de lait frais sont prélevés après la traite du matin dans le mélange de lait. Le lait est recueilli dans des récipients stérilisés et acheminé au laboratoire de technologie laitière. Les prélèvements sont effectués selon les méthodes normalisées, durant la période allant du mois de mars au mois de juillet à raison de deux échantillons par mois en quantité de 1000 ml chacun.

Traitement thermique

Le lait cru a subi les différents régimes de pasteurisation souvent utilisés en industrie laitière: - à la température de 64°C avec une durée de 30 minutes; - à la température de 74°C avec une durée de 15 secondes; - à la température de 85°C avec une durée de 2 secondes.

Le 4ème traitement thermique, appelé contrôle, a été effectué à la température d'ébullition (100,2°C). Le contrôle consiste à faire des comparaisons avec les traitements mentionnés ci-dessous. Le refroidissement du lait après la pasteurisation à la température de 10°C.

Analyses bactériologiques

A. Test de résazurine

Le test colorimétrique avec le résazurine est effectué selon le procédé décrit par Patriiti et Aristova. Un mélange de lait (10ml) et une solution de résazurine (1 ml) agités et incubés à la température de 38°C pendant une heure dans un bain-marie. Le changement de coloration est observé (Tableau 1).

B. Numération des microorganismes

Les ensemencements sont réalisés en plaçant 1 ml de la dilution (1/10) du lait dans une boîte de Pétri vide et en ajoutant le milieu gélosé (PCA) que l'on mélange ensuite soigneusement. Trois boîtes de Pétri sont ensemencées par dilution. Les préparations d'une solution de Ringer et des dilutions du lait (jus 10°) ont été réalisées selon la norme internationale. Les boîtes préparées à partir d'échantillons de lait cru et de lait pasteurisé sont incubées pendant 3 jours à 30-32°C.

Le taux de survie des microorganismes (TSM) est évalué comme suggèrent Bogdanova et al.

\[
TSM (\%) = \frac{UFC/ml dans le lait pasteurisé}{UFC/ml dans le lait cru} \times 100
\]

UFC – Unité Formant une Colonie.

Milieu PCA (SPC) – OXOID CM 463.
La composition (g/l) est la suivante (pH 10 (approx.))
Extrait autolytique de levure 2,5
Trypton 5
Glucose 1
Agar 15

Résultats et Discussion
Les résultats du test colorimétrique avec la résazurine (Tableau 2) montrent que le lait cru est de qualité normale. Ces résultats concordent avec ceux rapportés par Imlé et Kameni pour le lait produit au centre les années précédentes. Selon le test de résazurine, les laits pasteurisés à 64°C et 85°C sont de bonne qualité. Le lait pasteurisé à 74°C en général est d'une qualité normale, néanmoins, sur dix échantillons trois seulement sont de bonne qualité. Cependant, il ne faut pas oublier que le résultat du test de résazurine caractérise plus l'activité biologique des microorganismes que leur nombre; par conséquent, il ne faut pas s'attendre à une concordance exacte avec les données obtenues par la méthode de numération en boîtes de Pétri.

Le dénombrement total de microorganismes dans le lait cru est en moyenne de $1707 \times 10^3$ UFC/ml (Tableau 3). Ces valeurs sont inférieures aux valeurs rapportées par Eka et Ohaba pour le lait des vaches Fulani au Nigeria ($6,7 \times 10^6$ UFC/ml). Toutefois, nous constatons une augmentation de la flore totale du lait cru par rapport aux résultats trouvés auparavant au laboratoire, qui varient entre $1100 \times 10^3$ à $2100 \times 10^3$ UFC/ml. Ceci peut s'expliquer par les conditions sanitaires insuffisantes pendant la traite.

La température de pasteurisation de 64°C diminue le nombre total de bactéries jusqu'à $259 \times 10^3$ UFC/ml. En revanche, le taux de survie des microorganismes pour ce traitement qui est de 15,17% est supérieur à 0,1%, limite acceptable pour le lait pasteurisé. Le nombre de bactéries contenues dans le lait pasteurisé est plus élevé pour la température de 74°C : $835 \times 10^3$ UFC/ml. Le TSM pour ce régime de pasteurisation qui est de 48,92% est plus faible que la valeur (56,7%) rapportée par les chercheurs du laboratoire pour le même traitement du lait. L'augmentation de la température de pasteurisation jusqu'à 85°C permet de détruire considérablement la flore microbienne.

Tableau 2: Classification du lait par le test de résazurine

<table>
<thead>
<tr>
<th>Essai</th>
<th>Lait cru</th>
<th>Lait Pasteurisé</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>64°C</td>
<td>74°C</td>
</tr>
<tr>
<td>1</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>2</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>3</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>4</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>5</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>6</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>7</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>8</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>9</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>10</td>
<td>II</td>
<td>II</td>
</tr>
</tbody>
</table>
Tableau 3: Dénombrement total des microorganismes dans le lait

<table>
<thead>
<tr>
<th>Traitement thermique</th>
<th>Lait pasteurisé</th>
<th>TSM % Moyenne</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>0°C*</td>
<td>1100 x 10³</td>
<td>2530 x 10³</td>
</tr>
<tr>
<td>64°C</td>
<td>220 x 10³</td>
<td>328 x 10³</td>
</tr>
<tr>
<td>74°C</td>
<td>730 x 10³</td>
<td>960 x 10³</td>
</tr>
<tr>
<td>85°C</td>
<td>14 x 10³</td>
<td>22 x 10³</td>
</tr>
<tr>
<td>Contrôle</td>
<td>40</td>
<td>80</td>
</tr>
</tbody>
</table>

*0°C – Lait Cru

du lait (18,5 x 10³ UFC/ml). Le TSM pour ce traitement thermique qui est de 1,08% dans nos conditions est toujours supérieur à 0,1%. Eka et Ohaba15 ont trouvé 45 x 10³ bactéries/ml dans le lait pasteurisé au Nigeria; malheureusement, les auteurs n’indiquent pas la température de pasteurisation du lait.

La courbe de survie des microorganismes (Figure 1) montre que l’augmentation de la température de pasteurisation diminue le nombre de microorganismes du lait. Cependant, pour la température de 74°C le log UFC est le plus élevé. En effet, Kameni et Imélé9 ont montré que pour le même traitement thermique du lait, le log UFC est le plus élevé (5,2). Aleev16 indique qu’un nombre très élevé de microorganismes (des centaines de milliers dans 1 ml) du lait pasteurisé est observé à la température de 72°C et qu’une baisse considérable jusqu’à des dizaines de milliers de cellules/ml est constatée dans le lait pasteurisé à 76°C (durée 19 s). Selon Koroleva et al.17, le taux maximal de microorganismes dans 1 ml de lait à la sortie du pasteurisateur ne doit pas dépasser 10.000. D’autres auteurs18,19 indiquent que le nombre total de germes vivants dans le lait pasteurisé se trouve dans une limite de 3 x 10⁴ cellules/ml. La température d’ébullition (le contrôle) permet d’obtenir un produit de très bonne qualité (TSM = 0,004%).

Figure 1: La courbe de survie des microorganismes
Conclusion
Les résultats obtenus ont montré que le nombre de bactéries le plus élevé (835 x 10³ UFC/ml) est constaté pour la température de 74°C de pasteurisation du lait. Dans le lait pasteurisé à 85°C, le nombre total de bactéries ne dépasse pas la limite de 3 x 10⁴ UFC/ml. Toutefois, le TSM (1,08%) était supérieur à 0,1 %, la limite acceptable. Et c’est seulement dans le lait porté à la température d’ébullition que le TSM est inférieur à 0,1%. Donc, dans les conditions locales, les procédés de pasteurisation utilisés en industrie laitière ne sont pas toujours efficaces. Une autre étude doit être effectuée pour déterminer le temps (la durée) nécessaire pour chaque température de pasteurisation du lait pour obtenir un régime efficace. En effet, un travail était déjà mené pour la température de 74°C.⁹

Bibliographie

Reçu pour publication le 14 novembre 2000
SHORT COMMUNICATION

PREVALENCE OF GASTROINTESTINAL PARASITES OF PIGS IN THE WESTERN HIGHLANDS OF CAMEROON

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University of Dschang, Cameroon

Data on faecal samples collected from pigs in the Dschang area between June 1995 and June 1999 were studied for the prevalence of infestation and parasite types in the gastrointestinal tract. Six hundred and twelve (97.6%) out of six hundred and twenty seven samples had one or more gastrointestinal parasites. Eight different parasite types were identified. Coccidia *Hyostrongylus*, *Ascaris* and *Oesophagostomum* had high prevalence rates. A total of 77.3% of infested pigs had mixed infestations. Different age groups were susceptible to the gastrointestinal parasites although adult pigs had higher prevalence rates than younger pigs. However, coccidia counts were higher in younger pigs than in adults. Gastrointestinal parasitism is present in pigs in this area and the infestation is of a mixed type with several types of parasites present.

Pigs have been described as one of the most prolific and fast-growing livestock that can convert food wastes to valuable product\(^1\). The most important diseases of pigs in the tropics, Cameroon included, are due to parasitic infestations\(^2\). There is an increased pig farming in Cameroon. The danger from parasites is greatest when large numbers of pigs are kept under poor management conditions as reflected by poor sanitary conditions, poor nutrition and inadequate veterinary attention. Also, there is a dearth of information regarding the epizootiological factors that contribute to outbreaks of parasitic diseases in pigs in Cameroon.

This study was therefore carried out in order to establish the prevalence of gastrointestinal parasite infestations of pigs in the Western Highlands of Cameroon. Dschang is located between latitude 5\(^\circ\)25' and 5\(^\circ\)30'N and longitude 100 and 10\(^\circ\)51'E with an altitude ranging from 1400 to 2000m. It has two main seasons, a rainy season of nine months from mid-March to mid-November and a dry season of three months extending from mid-October to mid-March.

Data on faecal samples collected from pigs in

<p>| Table 1: Prevalence of gastrointestinal parasite infestation and mean egg counts of parasites of pigs according to age in Dschang area |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Parasite        | No. of infested pigs | Prevalence of infestation (%) | Mean oocyst or egg count/g faeces |</p>
<table>
<thead>
<tr>
<th></th>
<th>Young</th>
<th>Adult</th>
<th>Young</th>
<th>Adult</th>
<th>Young</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coccidia</td>
<td>73</td>
<td>389</td>
<td>11.6</td>
<td>62.0</td>
<td>73.7</td>
<td>5986.3±11032.8*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5112.8±7644.8*</td>
</tr>
<tr>
<td><em>Hyostrongylus</em></td>
<td>53</td>
<td>300</td>
<td>8.5</td>
<td>47.8</td>
<td>56.8</td>
<td>676.5 ± 716.3</td>
</tr>
<tr>
<td><em>Ascaris</em></td>
<td>61</td>
<td>270</td>
<td>9.7</td>
<td>43.1</td>
<td>52.8</td>
<td>1398.2 ± 1372.1</td>
</tr>
<tr>
<td><em>Oesophagostomum</em></td>
<td>48</td>
<td>271</td>
<td>7.7</td>
<td>43.2</td>
<td>50.9</td>
<td>759.1 ± 1153.2</td>
</tr>
<tr>
<td><em>Strongyloides</em></td>
<td>30</td>
<td>137</td>
<td>4.8</td>
<td>21.8</td>
<td>26.6</td>
<td>520.8 ± 559.5</td>
</tr>
<tr>
<td><em>Trichuris</em></td>
<td>23</td>
<td>150</td>
<td>3.7</td>
<td>23.9</td>
<td>27.6</td>
<td>363.6 ± 393.5</td>
</tr>
<tr>
<td><em>Globocephalus</em></td>
<td>3</td>
<td>76</td>
<td>0.5</td>
<td>12.1</td>
<td>12.6</td>
<td>233.3 ± 230.9</td>
</tr>
<tr>
<td><em>Physocophalus</em></td>
<td>1</td>
<td>8</td>
<td>0.2</td>
<td>1.2</td>
<td>1.4</td>
<td>100.0 ± 0.0</td>
</tr>
</tbody>
</table>

* mean ± S.D

* Corresponding author.
Figure 1: Prevalence of gastrointestinal nematode infestation of pigs in Dschang according to predilection sites.

Figure 2: Yearly distribution of pigs infested with gastrointestinal parasites in Dschang.
the Dschnag area between June, 1995 and June, 1999 were extracted from the parasitology diagnostic record book in the Department of Animal Production, University of Dschang. According to the records, 627 faecal samples collected from pigs of different ages were examined within 48 hours of collection. Pigs were classified into two groups, young (less than six months) and adults (above six months). The different helminth egg types and oocysts were identified as described by Soulsby\(^3\) while egg counts were carried out using the modified McMaster method described in MAFF\(^4\). The data were used to determine the prevalence of infestation of pigs with each of the gastrointestinal parasites in the different age groups, and the predilection sites of the parasites.

Out of the 627 faecal samples examined, 612 (97.6\%) has one or more gastrointestinal parasites. Infestation occurred throughout the year. Eight different parasites were identified; two were stomach parasites (\emph{Hydrostrongylus} and \emph{Physocephalus} spp.), four were small intestinal parasites (\emph{Ascaris}, \emph{Strongyloides}, \emph{Globocephalus} spp. and coccidia), and three were large intestinal parasites (\emph{Oesophagostomum}, \emph{Trichuris} spp. and coccidia). The prevalence of each type of parasite in each age group is presented in Table 1. The prevalence was higher in adult pigs than in young ones for each type of parasite with coccidia, \emph{Hydrostrongylus}, \emph{Ascaris} and \emph{Oesophagostomum} spp. Having high prevalence rates in each age group. There was a higher mean oocyst count in young pigs than in the adult pigs while the mean worm egg count was higher in the adults than in the young ones.

The prevalence of infestation according to predilection sites of the different nematode species is shown in Figure 1. The Prevalence was highest (37.2\%) in pigs that harbourred nematodes in all the three major parts of the gastrointestinal tract; stomach (Sto), small intestine (S.I.) and large intestine (L.I).

The yearly percentage distribution of infested pigs showed that more pigs were infested between October and January compared to the other months (Figure 2).

The 97.6\% prevalence of gastrointestinal parasites observed in this study is an indication that gastrointestinal parasite infestation is high in pigs in the Dschang area. A high prevalence, though lower than 97.6\%, for parasitic diseases in pigs in Nigeria has been reported earlier\(^5\). The identification of seven different types of gastrointestinal nematodes in pigs in Dschang is similar to the findings of Salifu \emph{et al.}\(^6\) in Jos and Port Harcourt, Nigeria. The high prevalence of infestation of pigs with \emph{Hydrostrongylus}, \emph{Ascaris} and \emph{Oesophagostomum} spp. seen in this study has also been reported\(^6,7,8\).

The higher mean egg counts observed in adult pigs suggest that adults were the main source of infestation for the young ones. However, the higher prevalence rates seen in adult pigs could be because most farmers in this area either sell or consume majority of the young pigs after weaning, leaving only the adults for breeding. The higher mean oocyst count seen in young pigs than in adults conforms to Soulsby’s\(^9\) report that coccidiosis in pigs is primarily a disease of the young animals with older animals being carriers.

The high infestation rate of pigs between October and January could be due to stress from climatic change and inadequate nutrition. This period also corresponds to the post-harvest season when pigs are no longer confined and fed but are left to scavenge for food. This finding is in conformity with that of Blood \emph{et al.}\(^10\) who reported an increase in the effect of parasitism in poorly nourished animals.

In order to obtain a better understanding of the impact on production of gastrointestinal infestations in pigs, more studies are recommended so as to determine the effects of the factors involved in this area. Prevention and control should be tackled by combining efficient sanitary and good deworming programmes and a balanced nutrition bearing in mind that the infestation is mixed.

\textbf{References}


Received for publication on 19th September 2000.
SHORT COMMUNICATION

GROSS PATHOLOGIC LESIONS ASSOCIATED WITH RABBIT MANGE IN ZARIA AREA

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The infection of animals by mites often result in pathological lesions referred to as mange. It is a pruritic and contagious skin condition often resulting in dermatitis, alopecia, and scab formation. As irritation increases, animals rub and scratch the affected areas while keratinization and proliferation of connective tissue lead to thickening and formation of fold. Thus, it is a chronic debilitating skin disease. The lesions expose the affected animals to secondary bacterial infection, resulting in stress, loss of condition and death of untreated animals.

Notodres cati var cuticuli and Psoroptes communis var cuticuli cause ear canker in rabbits although Chorioptes cuticuli had earlier been thought to be the main cause.

The present investigation was carried out to provide further information on the extent of gross pathologic lesions caused by mites on rabbits in the Zaria area and to ascertain the species involved in order to assess the need for embarking on responsive control measures, especially now that protein intake from rabbit meat is becoming more popular.

From 15 different flocks made up of 325 rabbits of the New Zealand white and Flemish giant breeds, 102 of the rabbits, which were sampled and found to have skin lesions on different parts of the body were used in this research. The rabbits were kept in cages mostly with a few under the semi-intensive management. They were fed with maize bran, grasses and legumes.

The rabbits were restrained by using the left hand on the anterior dorsal part and the right hand on the posterio-dorsal part, with the rabbit in a squatting position. This minimized struggles during the scraping of the lesions. Deep skin scrapings were taken from skin of affected rabbits with the help of sharp scalpels with the skin moistened with mineral oil, which allowed the scrapings to adhere to the scalpels. The scalpel was held at an acute angle and the shaving continued until the cutis ver was reached and the blood oozed freely. In cases of scabby lesions in the ear canals, a pledget of cotton wool held in forceps was used to detach the scabby materials. Scrapings taken from each rabbit were put in a polythene bag and sent to the laboratory for treatment.

Each scraping was put in a test tube, about 5mls of 10% KOH aqueous solution was added with the aid of a test tube holder, it was gently heated for about two minutes for the digestion of the hairs. It was allowed to cool, and then centrifuged at 200 rpm for two minutes. The supernatant was decanted while the sediment was pipetted onto a slide for examination under the microscope. The causative agents (mites) were then identified using morphological characters as described by Marharet and Russell. The assessment of the type and the level of damage to the skin was based on physical examination of the lesions on the rabbits.

Sixteen rabbits (15.69%) from four locations were observed to have ear canker which was presented as encrusted lesions inside the ear canal. Psoroptes cuticuli was identified in all the cases. Notodres cati var cuticuli was isolated from 66 (64.71%) out of 85 (83.33%) rabbits with crusty and scabby lesions around the ear, face, nose and leg (Table 1). In such similar lesions, Sarcocptes scabiei, Demodex cuticuli and cheyletiella spp. were seen in three (2.94%), four (3.92%) and one (0.98%) cases, respectively. Eleven (10.78%) rabbits with crusty and scabby lesions around the ear, face and leg had apparently no mites isolated from them. On a particular rabbit with scabby lesions around the ear, face, nose and eye lids, Notodres cati var cuticuli was
Table 1: Species of mites isolated from different gross lesions

<table>
<thead>
<tr>
<th>Mites Isolated</th>
<th>No. of rabbits</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&amp; Percentage infestation</td>
<td>Ear canker (encrusted lesions inside the ear canal)</td>
</tr>
<tr>
<td>Psoroptes cuniculi</td>
<td>16 (15.69%)</td>
<td>Crusty and scabby lesion around the ear, face, nose and leg</td>
</tr>
<tr>
<td>Notodectes cati var cuniculi</td>
<td>56 (64.71%)</td>
<td>Scabaei lesions on the face and eye lid</td>
</tr>
<tr>
<td>Demodex cuniculi</td>
<td>4 (3.92%)</td>
<td></td>
</tr>
<tr>
<td>Sarcoptes scabei</td>
<td>3 (2.94%)</td>
<td></td>
</tr>
<tr>
<td>Cheyletiella spp.</td>
<td>1 (0.98%)</td>
<td></td>
</tr>
<tr>
<td>No parasite</td>
<td>11 (10.78%)</td>
<td></td>
</tr>
<tr>
<td>Demodex faticularum</td>
<td>1 (0.98%)</td>
<td></td>
</tr>
<tr>
<td>Notodectes cati var cuniculi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The absence of mites in gross lesions typical of mange on eleven of the rabbits calls for caution on making hasty conclusions of diagnosis and the need to check for other possible related skin diseases of rabbits which may be differently diagnosed.

Acknowledgements

We would like to express our sincere gratitude to the technical staff of the Entomology Laboratory, Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria.

References


Received for publication on 18th January, 2000.
SHORT COMMUNICATION

THE ECONOMIC IMPACT OF PROGRESSIVE ATROPHIC RHINITIS IN GROWER-FINISHER PIGS IN A MEDIUM-SCALE PIGGERY IN KENYA

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Atrophic rhinitis is a disease that affects mainly young pigs1 and occurs in two forms; non-progressive atrophic rhinitis and progressive atrophic rhinitis2. Progressive atrophic rhinitis is caused by toxigenic type D strains of Pasteurella multocida3,4. However, Bordetella bronchiseptica and certain management factors affect both the course and the severity of the disease1,4,5,6. The affected pigs have an initial rhinitis, which is later followed by chronic atrophy of the turbinate bones, facial distortion and growth retardation7,8,9. Reports on the economic importance of atrophic rhinitis are variable. Some workers have reported an association between the disease and body weight gains10,11 while others report no association between the presence of the disease and body weight gains12,13. The lack of a standard system for evaluating the conchal lesions has been suggested as a factor that may contribute to the different results that have been reported by various workers14.

Occurrence of atrophic rhinitis in Kenya was only recently reported15. However, there are no documented reports on the economic importance of any form of atrophic rhinitis disease in Kenya. Therefore, this study describes the economic impact of progressive atrophic rhinitis in grower-finisher pigs in medium-scale piggery in Kenya.

A manager of a medium-scale open and continuous system piggery reported persistent sneezing in the weaner and grower-finisher pigs to the veterinary clinic of the University of Nairobi. At the time of reporting, the piggery had one hundred and seventeen (117) pigs consisting of fifteen (15) sows, one (1) boar, seventy four (74) grower-finishers, sixteen (16) weaners and eleven (11) piglets.

At the farm, a clinical history of the condition was taken followed by a thorough clinical examination. Physical inspection of the premises revealed that the pigs were housed in dusty pens with low partitions of stone walls. The main clinical signs observed in the affected pigs were a combination of sneezing, conjunctivitis, lacrimation, tear staining of the hair on the medial canthi of the eyes, coughing, emaciation, lateral deviation of the snout brachynathia superior, serous to mucopurulent nasal discharge and nasal bleeding in one grower-finisher pig. In pigs with deviation of the snout there was wrinkling of the facial skin while pigs with excessive nasal discharge were heavily matted with dirt around their snouts.

A few affected weaners and grower-finishers were randomly selected and sampled by first cleaning the external nares with alcohol and then inserting a cotton tipped flexible wire into the nasal cavity midway between the nostrils and the level of the medial canthus of the eye. The samples were transported to the laboratory using Stuart transport medium. Using the laboratory procedures described by Holt and others16 attempts to isolate Bordetella bronchiseptica and pasteurella multocida were unsuccessful and only nasal commensals were obtained. After sampling, the acutely affected pigs were treated with intramuscular injection of long acting oxytetracycline (Tetroxy®, Bimed, U.K) at a dose rate of 20mg/kg-body weight, with the same treatment was repeated after seven days. The treatment reduced the number of sneezing pigs and the severity of sneezing but did not eliminate the sneezing completely in all the pigs until the pigs were slaughtered.

Two months later 15 pigs consisting of eight apparently normal pigs and seven chronically sick pigs of the same age and from the same pen were slaughtered. The weights of the two groups were recorded and analysed using Statistix® (analytical software, Tallahassee, FL., USA). The
chronically sick pigs had a mean carcass weight of 63.6 ± 4.86 kilograms while the apparently normal pigs had a mean carcass weight of 75.0 ± 4.11 kilograms. There was a significant (P<0.05) difference between the carcass weight of the chronically affected pigs and that of the apparently normal pigs. There was no significant difference in carcass weights within the groups. The total carcass body weight of the affected pigs was lower than that of the apparently normal pigs by 155 Kg (25.8%). The gross benefit of treatment using Tetroxy\textsuperscript{a} was $199 (Kshs.14,725) (1US$=74Kshs) or $28.4 (Kshs 2,104) per pig. The cost of Tetroxy\textsuperscript{b} was $6 (Kshs 480) and the cost of labour was equivalent to the professional fees of $4 (Kshs 320). Therefore, the benefit of treatment to the farmers (Equivalent to the gross benefit minus the cost of drugs and labour) was $189 (Kshs. 13,986).

An initial tentative diagnosis of progressive atrophic rhinitis was made based on the clinical signs of sneezing, lacrimation and deviation of the snout\textsuperscript{14,15}. The diagnosis of the disease was later confirmed by pathological findings of cross-sections of the snout at the level of first and second upper premolar tooth that demonstrated varying degrees of turbinates atrophy. This method has been used to confirm this condition\textsuperscript{2,17}. Bacterial isolation was attempted but was unsuccessful and cultural failures have also been reported previously\textsuperscript{a}.

The pigs that were chronically affected by progressive atrophic rhinitis had significantly lower mean carcass weight at slaughter than the apparently normal pigs. Since these pigs were of the same age and managed in the same way the difference in the carcass weight was attributed to the disease as observed by other workers\textsuperscript{1,11}. Giles et al.\textsuperscript{11} found that growth rate was severely decreased in pigs that had clinical atrophic rhinitis and/or severely atrophied turbinates. While Backstrom et al.\textsuperscript{10} found that in farrow-finisher herds, the herds with clinical atrophic rhinitis had low mean daily weight gains of between 15-18% than those herds with no clinical atrophic rhinitis. The treatment of acutely affected pigs with long acting oxytetracycline did not clear the sneezing in all pigs until the pigs were slaughtered. This drug has previously been shown to be effective in the treatment of swine-herds with enzootic atrophic rhinitis\textsuperscript{18}. The poor response in this case could have been due to the poor management factors such as the excessive dust that prevailed at that time and which could not be adequately addressed. Excessive dust has been shown to facilitate colonization of the pig’s upper respiratory tract by Pasteurella Multocida\textsuperscript{19}. The failure of the treatment to eliminate completely the sneezing in affected pigs could have interfered with the feeding in the affected pigs thus the low weight gain.

The results of this study show that clinical progressive atrophic rhinitis has a negative effect on growth weight gains and so could be of economic importance in the open and continuous systems of pig farming in Kenya. The results of the treatment indicate that treatment of acutely sick pigs may be beneficial to the farmers.

Acknowledgement
The authors wish to acknowledge the co-operation and commitment of the farm manager and his stockman during the investigation.

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Received for publication on 18th July, 2000.
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Introduction stating the purpose of the work.

Materials and Methods used.

Results presented concisely.

Discussion of significance.

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Surname and initials of author(s), year of publication (in parentheses), World List abbreviation of title of periodical (underlined), volume number (arabic numerals), first page number. The title of the articles should not be included.

2. Books
Surname and initials of author(s), year of publication (in parentheses), the exact title (underlined), town of publication, publisher, first page number.

3. Annual Reports
Name of country, year of reference, followed by the name of the department or organisation, first page number.

If the same author is cited more than once, his publications should be arranged in chronological order in the list of references, and if more than one publication is included, the letters “a, b, c” should be added in both the list of references and in the text.

Illustrations
Tables should be limited and number of headings restricted. A massive table is difficult to read even if it can be reproduced. Tables and figures should be numbered consecutively. Table 1 etc., or Fig. 1 etc., respectively, and attached at the end of the text. References to tables and figures in the text should be by number and not to “table below” or “figure below”. Coloured illustrations are reproduced only at the author(s) expense.

Short Communications
A Short Communication implies the article does not justify publication as a conventional paper. Such communication should be restricted to two printed pages or 1,000 words including a maximum of two illustrations. It should therefore contain similar features as a regular but summary and separate sub-headings are not necessary.

Proofs
One set of proofs will be sent to the author to be checked for printer’s errors and should be returned within three days.

Offprints
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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 interafriacain 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 pas par les noms des auteurs.

La bibliographie doit respecter la présentation suivante:

1. Journal
Le nom de l'auteur (ou des auteurs) suivi des initiales du ou des prénoms, l'année de parution (entre parenthèses), l'abréviation du titre du périodique suivant la World List of Scientific Periodicals (soulignée), le numéro de la première page. Le titre de l'article ne doit pas être inclus.

2. Revue
Le nom de l'auteur (ou des auteurs) suivi des initiales du ou des prénoms, l'année de parution (entre parenthèses), le titre exact (souligné), la ville où elle a été publiée, les éditeurs, le numéro de la première page.

3. Rapport annuel
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
Les tableaux et les titres doivent être en nombre aussi réduit que possible. Un tableau d'une trop grande dimension est difficile à lire même s'il peut être reproduit. Les tableaux et les figures doivent être numérotés dans l'ordre, respectivement Tableau 1, etc., ou Fig. 1 etc. et joints à la fin du texte. Les références aux tableaux et aux figures dans le texte doivent être numérotées et non pas indiquées "tableau ci-dessous" ou "figure ci-dessous". Les illustrations en couleurs ne sont reproduites qu'aux frais de l'auteur (ou des auteurs).

Brève communication
Une brève communication signifie que l'article ne peut pas être publié comme une communication normale. Elle ne doit pas dépasser deux pages imprimées ou 1 000 mots en incluant deux illustrations au maximum. Elle doit donc respecter les mêmes normes qu'un article habituel, sauf que le résumé et les sous-titres ne sont pas nécessaires.

Epreuves typographiques
Les épreuves typographiques sont envoyées à l'auteur qui en effectue la correction des coquilles et en assure le retourn rapide (dans les 3 jours).

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Le coût de l'abonnement annuel y compris le tarif d'affranchissement (par voie terrestre) et le frais de manutention, est de 50 $EU. L'envoi par avion est possible sur simple demande.

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Il est également possible de se procurer, sur simple demande, les anciens numéros aux mêmes prix.