# Animal nutrition

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## Introduction

Wilson and Semenye's paper outlined the procedures followed by ILCA's field teams in surveying the productivity of livestock in arid and semi-arid areas. They emphasised that quite large differences may exist between herds and flocks within the same production system in contrast to quite strong similarities in mean productivity among the pastoral systems themselves.

Productivity is largely determined within a particular environment by genotype, health and nutrition. For most of the extensive pastoral areas we are concerned with there exist no potentially better breeds than the present well adapted zebu-based cattle and the local strains of sheep and goats; but ILCA's systems studies have shown, even in these adapted animals, the occurrence of serious losses associated with disease. The nature of arid and semi-arid grazing lands, with short and unreliable periods of rainfall, necessarily means that animals and their keepers undergo long periods of nutritional hardship.

## Genotype

Current low reproductive rates and heavy calf mortality prevent any deliberate selection for productivity in cattle apart from the rigorous natural selection that this situation implies. In smallstock the common pattern is to sell or slaughter for meat a large proportion of the males at early ages - from six months to one year. In the absence of any deliberate attempts to keep the fastest growing males for future breeding, it is probable that they are the first to be eaten, and that the smaller or slower growing are the more likely to be left for breeding. There may thus be an unintentional, but beneficial, selection for multiple births, of which the offspring are always lighter at birth and slower growing. It is possible that individual herders do exert selection for particular types of animals; among the Maasai of Kenya for example it is basic policy to promote both large and small framed cattle chosen from every recognizable breeding "line" in the herd. This ensures a wide range of variation in the herd and is held to maximize production in the wet season and minimize losses in the dry season over the herd as a whole. In ILCA's Kenya studies Sahiwal crosses are found to grow faster than local Maasai zebu calves, and the pastoralists appear to be retaining Sahiwal cross cattle for breeding rather than offering them for sale, despite the higher prices that they fetch. Free-range grazing on common land and use of common watering points mean opportunities for animals to mate with males from another herd or flock and are therefore inconsistent with a deliberate policy of genetic improvement. Aprons are used by some pastoralists in range areas to prevent breeding of sheep and goats until the best mating season, and castration of inferior males is a recognized practice. The basic attitudes and mechanisms for genetic improvement are there to be used if clear-cut methods for identifying the most productive animals for the environment could be developed and ways of exploiting their merit could be promoted.

## Health

The interaction of nutrition and health in deciding overall productivity has been recognized in all ILCA programmes. Efforts have been made from an early stage to diagnose the main diseases, study their epidemiology and impact on production, and test available control measures.

In 1982 an agreement was reached with the research branch of the Kenya Ministry of Livestock Development to conduct collaborative research on the incidence and impact of animal diseases on Maasai herds and flocks. Through this arrangement the research branch has made available one senior and one junior veterinarian. The former is responsible for designing the research project (contents, sampling, phasing, analysis and interpretation of data) in consultation with ILCA scientists and for supervising the junior veterinarian, who is responsible for carrying out the field investigation in collaboration with the ILCA team. This component of the research was launched in June 1982.

In Mali and northern Nigeria veterinarians have been appointed to ILCA teams to carry out surveys of epidemiology of common diseases in livestock being recorded in the main programme and the causes of mortality in animals dying or slaughtered. The widespread practice of killing animals *in extremis* for meat, makes it difficult to arrive at reliable statistics for the number of deaths due to disease. In Mali it was found that most deaths occurred in the overgrazed zone outside the live delta and major causes included tick-borne diseases and pneumonia-like infectious diseases (*Pasteurella, Diaplococcus)*. No evidence was found of protozoal parasites but sarcoptic mange was common and many samples examined showed the presence of the internal parasites *Monieza, Eimeria, Paramphistomum, Oestrus ovis, Echinococcus,* or *Fasciola hepatica.*

The Mali team has now set up a section of Animal Health and Nutrition reflecting the close relationship of these two aspects of animal productivity, and research in the present phase will give more attention to disease and parasites as causes of the high mortality in young animals, which averages 21 % in calves up to 12 months, and 6.2 % for the herd as a whole. Preweaning mortality was as high as 35 % in goats and 30 % in sheep, varying between pastoral systems (rice, millet) and with type of birth. Of the total deaths recorded 16 % were abortions, 22 % were still births or occurred on the first day, and a further 14 % in the first 7 days. Seventy percent of all deaths occurred before 15 months.

Fewer figures are available from the newer Ethiopian rangelands project concerning disease incidence, but similarly heavy losses of young animals have been recorded and there can be no doubt that many are disease related.

In all systems studied, internal and external parasites are prevalent and tick-borne diseases are major problems. In some Fulani areas ticks are regularly removed by hand, usually by children; internal parasites are "treated" by use of traditional herbal preparations or by the annual "cure salée" or access to salt outcroppings, which is believed to have curative properties. Most pastoralists are aware of the symptoms of common diseases, indeed they also recognize and classify diseases, by signs and by postmortem indications, into groupings which can readily be translated into standard Western terms.

ILCA's systems studies have made it possible to assess major diseases and to estimate their impact on productivity. Work now in progress will make it possible to evaluate various approaches to disease control, in economic and in practical terms, and their relationship to nutrition and management of the flock or herd. Wilson (1982, and this workshop) has outlined a programme for improvement of smallstock productivity involving the upgrading of management, diagnosis and control of epidemic diseases, selection of males for growth rate and twin-born females for retention as breeders, control of breeding times, treatment of parasites, careful culling of least productive females and supplementary feeding for special purposes.

## Nutrition

### General

The most useful record for nutritional purposes is liveweight since this is an integrated measure of the nutritional response of the animal, and liveweight gains or losses give a sensitive indication of nutritional adequacy or inadequacy. Weighing is possible, given a weighing scale or tripod and clock face balance and necessary assistance, during both initial and continued surveys, as described by Wilson and Semenye in this workshop, and yields very useful information. Where weighing facilities are not available, a very useful approximation may be made by measuring heart (or chest) girth of cattle and estimating the liveweight from these by means of one of the published formulae. The relationship between heart girth and weight depends on breed, and to some extent on condition and sex.

A more robust, easily applied but more subjective method is to visually assess body condition. This is readily done on large numbers of animals and, if clear criteria are set for distinguishing grades of condition, it can be reproducible. Up to five grades are easily distinguished; it is often claimed that nine or ten grades can be used by experienced observers but reproducibility within, and particularly between, observers may be rather poor. The fewer the grades the more repeatable the grading, but the greater the differences in body weight corresponding to each change of grade. Infrequent watering of cattle is likely to superimpose a two or three day cycle on liveweights, as also on visual estimates of condition. Since individual cattle may take in up to 30 litres of water (30 kg of liveweight) in five minutes one may question the interpretation of measurements made either before or after watering. In these conditions heart girth may be a more reliable measure.

More detailed information about nutrition can be obtained from samples of blood, faeces, or body tissues. In ILCA studies in northern Nigeria we have analysed samples of blood to correlate with the mineral content of range grass and browse species, and samples of liver to estimate tissue stores of copper and vitamin A in cases where forage analysis has suggested these might be low. Blood plasma inorganic phosphate analysis has often been used to assess the adequacy of supplies of phosphorus, an element closely linked with animal performance, but recent work in the semi-arid tropics of Australia has shown that more reliable information is obtained by analysis of small samples of rib-bone obtained by simple surgery. The skeleton acts as reserve of minerals, and bone is readily mobilised to maintain plasma concentrations when the P content of the diet falls too low. We have analysed many samples of milk from the Ethiopian pastoral programme, but milk composition seems to be determined very much by genetic and physiological factors such as age and stage of lactation. The "let-down" problem in zebu cows means that it is difficult to obtain a truly representative sample of milk in field studies. The wide variation we have found (2.5 to 70% fat) may reflect this problem, but average figures of about 13.5% to 14.0% total solids, and fat percentage increasing from 4% to 6 or 7% during lactation, suggest that our samples are reasonably representative and consistent and that the Borana cow produces excellent quality milk under pastoral conditions. Milk quality is of great importance not only because of the need for good calf growth rate, but also because pastoral families live on a predominantly milk diet for much of the year. ILCA's nutritional studies include records of weight and height for age of representative groups of pastoralists and their families, together with observations of their food consumption and daily work routine. The very hard work of lifting water from wells for stock comes during the late dry season, when milk production is at its lowest in a seasonally-calving herd, and when last season's grain reserves are getting low. The supply of labour and work capacity per person may limit the possibility of introducing any management changes needing extra work.

Because of the self-evident importance of nutrition in all the pastoral zones, it was decided early in ILCA's work to do more intensive research into this component of the system.

## Methods used

### Amounts and composition of forage available

Liveweight or body condition measures the response of animals to their nutritional environment integrated over weeks or months. For many purposes it is necessary to know to which component of that environment they are responding or how the factors of feed quantity and quality, grazing, watering and walking are interacting.

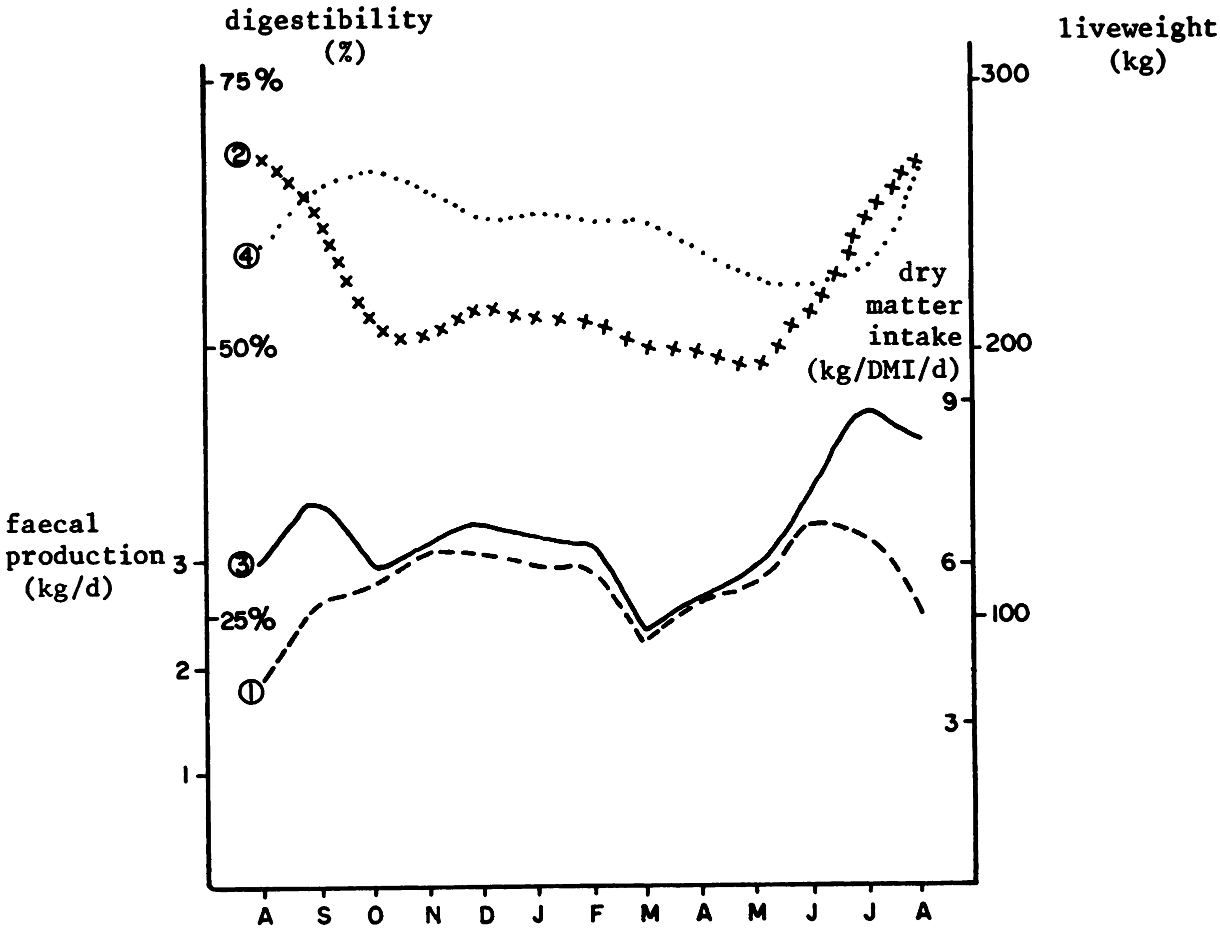


Fig 1. *Relationship between faecal production (1), digestibility (2), dry matter intake (3) and liveweight (4) of cattle.*

Figure 1 shows the annual weight changes of cattle in the agropastoral system of central Mali, and it is easy to distinguish several main periods of the year :

- the wet season, when rapid gains are made on abundant high-quality feed;

- the main dry season, when slow but steady weight losses occur on an initially adequate but diminishing supply of poor quality feed; and

- the late dry/very early wet season, when weight loss is often more rapid. This last period may be so serious in its effects that it is referred to as the 'crise de Juillet'. Several possible causes for ill-thrift at this time have been suggested, including leaching of the remaining forage, mycotoxins produced by fungal growth following the first rains, excessive energy expenditure in seeking the fresh grass or diarrhoea causing reduced digestibility and apparent loss of weight.

Table 1 shows results of quadrat sampling on pastures in the Fulani agropastoral system of northern Nigeria's subhumid zone, in which the main rainfall occurs between June and October. Because of the good growth of tall grasses in this cattle area, the protein and digestibility figures are generally low, particularly in the dry period between October and May. Table 2 shows corresponding data from a grass and browse system grazed by goats and sheep in northern Kenya. The bimodal rainfall occurs in the period January to March and in October, and a marked decline in availability and quality of feed occurs during the intervening dry months of July, August and September. Because of the high content of browse, the protein content was notably higher throughout most of the year than shown in Table 1.

Table 1. *Composition of forage available to traditionally managed cattle in northern Nigeria.*

| Month : | M | J | J | A | S | O | N | D | J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| available DM[1] (t/ha) | 0.7 | 1.1 | 2.0 | 2.0 | 2.3 | 2.5 | 2.2 | 1.2 | 1.2 | 1.1 | 1.0 | 1.0 |
| CP[2] (% of DM) | 9.4 | 9.8 | 8.5 | 6.8 | 6.0 | 4.8 | 3.0 | 4.2 | 4.5 | 5.4 | 5.4 | 5.1 |
| digestibility (% DM) | 61 | 60 | 54 | 50 | 48 | 46 | 42 | 52 | 47 | 53 | 53 | 53 |
| grazing time (h/d) | 9.5 | 7.6 | 7.1 | 7.1 | 7.0 | 6.9 | 7.0 | 7.9 | 8.2 | 8.2 | 9.3 | 9.4 |

[1]DM = dry matter

[2]CP = crude protein

Source : Bello Sule, unpublished results, ILCA, Kaduna.

Table 2. *Composition of forage and browse available to sheep and goats in northern Kenya.*

| Month | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| available DM[1] (kg/head) | 1.5 | 1.20 | 1.50 | 1.20 | 0.90 | 0.80 | 0.70 | 0.55 | 0.70 | 1.20 | 1.25 | 1.50 |
| CP[2] (% of DM) | 17 | 21 | 18 | 14 | 22 | 22 | 17 | 14 | 14 | 21 | 26 | 21 |
| digestibility (% DM) | 64 | 68 | 64 | 60 | 62 | 55 | 35 | 30 | 40 | 68 | 71 | 67 |

[1]DM = dry matter

[2]CP = crude protein

Source : Smith et al (1982).

Preliminary analysis of the availability and nutritive value of agro-industrial byproducts indicated that, though the oilseed cakes and meals were excellent supplements for the low-protein pastures, the quantities and reliability of supply were altogether inadequate for any widespread use in pastoral areas (Dicko, 1980b). Emphasis was thus placed on better management of pastures and crop residues about which not enough was known, and a detailed study was therefore carried out during 1979-80 of the grazing behaviour and feed intake of cattle in the agropastoral system illustrated in Figure 1. Traditional herders graze animals during the rainy season (July-October) on the natural vegetation of the Sahel, largely composed of annuals like *Schoenfeldia gracilis*, *Loudetia togoensis*, and *Zornia glochidiata*, with *Pterocarpus lucens* as the principal browse species (Hiernaux, 1978). From November until December, they graze the standing stalks and residues of the millet fields, combined with some grazing of the regrowth of surrounding fields in fallow. In December in the particular production system under study, they are moved to the residue of the rice fields, with also a substantial regrowth of weeds. If the rice straw and residues are completely grazed the herd is moved about April back to the millet fields, to await the rain in July. Observations presented here were made over one complete year in a locally-owned herd of 90 cattle. During a five day period each month the grazing behaviour of four steers was recorded at 15-minute intervals day and night while simultaneously the total faecal production of other four steers was measured with a bagging technique specially developed for free-ranging animals (Dicko, 1980a).

Composition and amount of feed eaten

Forage intake was estimated by the 'indirect' method, in which the output of faeces was first measured (the indigestible part of the feed eaten) by means of a harness and collection bag and this then multiplied by a factor, ratio of total feed eaten to indigestible part, or feed: faeces ratio. This is numerically equal to the ratio 100/100 % digestibility and the digestibility was estimated in several ways.

1. By cutting or plucking by hand samples of forage eaten by the animals. The digestibility of these samples was estimated by chemical analysis. It is difficult to obtain a sample close to that eaten by free-grazing animals. By close observation of the grazing behaviour of each animal, samples could be taken in proportion to the number of bites seen to be taken from each grass or shrub forage type in the hope that the total sample thus obtained would be representative of the day's diet.

2. By allowing the animal itself to select its diet, then taking samples of the material grazed through a large cannula fitted surgically into the rumen. This means physically emptying the contents of the rumen by hand before the animal goes to graze, and then taking samples from the freshly ingested material in the rumen after 1-2 hours of grazing.

3. A technique used in later work in Kenya involves collecting samples of herbage grazed by means of a surgical fistula into oesophagus, which allows feed being swallowed to pass out into a suitable collection bag attached to the neck. This is less time-consuming than the rumen method, and yields a sample which has not been subjected to the fermenting effect of the rumen's active bacterial population.

Two options exist for analysis - either *in vitro* digestion with rumen liquor or purified enzymes, or else analysis for fibrous fractions closely related to digestibility and the use of a predictive equation such as that of van Soest (1976).

4. In other pastoral countries it has been observed that a close relationship exists between forage digestibility and the composition of the faeces derived from that forage. Data from digestion trials have been analysed so as to predict forage digestibility from either faecal fibre components (which are related negatively to digestibility) or faecal nitrogen concentration (positively related to digestibility). For the Mali study two equations were used, based upon a wide range of native and introduced grasses and legumes grown in northern N.S.W., Australia.

## Results obtained

### Grazing behaviour

Fig. 1 showed not only the weight changes but also the faecal output, digestibility and estimated feed intake of the cattle studied. The mean observed values are given in Table 3, while Fig. 2 gives grazing times and other details as monthly means.

Table 3. *Intake and performance measurements.*

| Month | Mean Lwt (kg) | Lwt Gain (kg/d) | DDMI[1] kg/d | DCPI[2] kg/d | MEI[3] MJ/d | Distance (km/d) | |
|---|---|---|---|---|---|---|---|
| | | | | | | grazing | walking |
| A | 237 | 0.75 | 3.91 | .747 | 57.09 | 6.01 | 4.83 |
| S | 258 | 0.28 | 4.29 | .631 | 60.37 | 7.84 | 5.09 |
| O | 266 | -.14 | 2.62 | .213 | 35.81 | 7.28 | 13.07 |
| N | 261 | -.52 | 3.22 | .240 | 42.98 | 9.44 | 5.10 |
| D | 248 | 0.13 | 3.83 | .176 | 49.17 | 7.39 | 3.90 |
| J | 251 | -.13 | 3.54 | .299 | 43.39 | 7.77 | 2.32 |
| F | 248 | 0.08 | 3.28 | .390 | 44.92 | 7.64 | 3.28 |
| M | 242 | -.34 | 2.44 | .176 | 29.95 | 6.93 | 3.94 |
| A | 236 | -.32 | 2.87 | .127 | 35.46 | 7.85 | 4.84 |
| M | 228 | -.12 | 2.66 | .253 | 34.04 | 8.03 | 3.38 |
| J | 224 | -.15 | 3.74 | .348 | 48.30 | 8.62 | 4.64 |
| J | 230 | 1.15 | 5.51 | 1.434 | 70.72 | 7.19 | 6.91 |

[1] Digestible dry matter intake.

[2] Digestible crude protein intake.

[3] Metabolisable energy intake.

Grazing time was lowest during and after the rainy season (August to October) when pasture is relatively abundant and of good quality. On millet residues and rice straw from November to December grazing time increased steadily until April to June when biomass was much reduced. Both in the rainy season and in the dry season significant negative correlations (r = -0.85 and -0.92 respectively) were found between standing biomass and grazing time. Covariance analysis showed that grazing time was significantly lower for a given biomass in the period July to October, when forage quality was high. This is shown in Fig. 3.

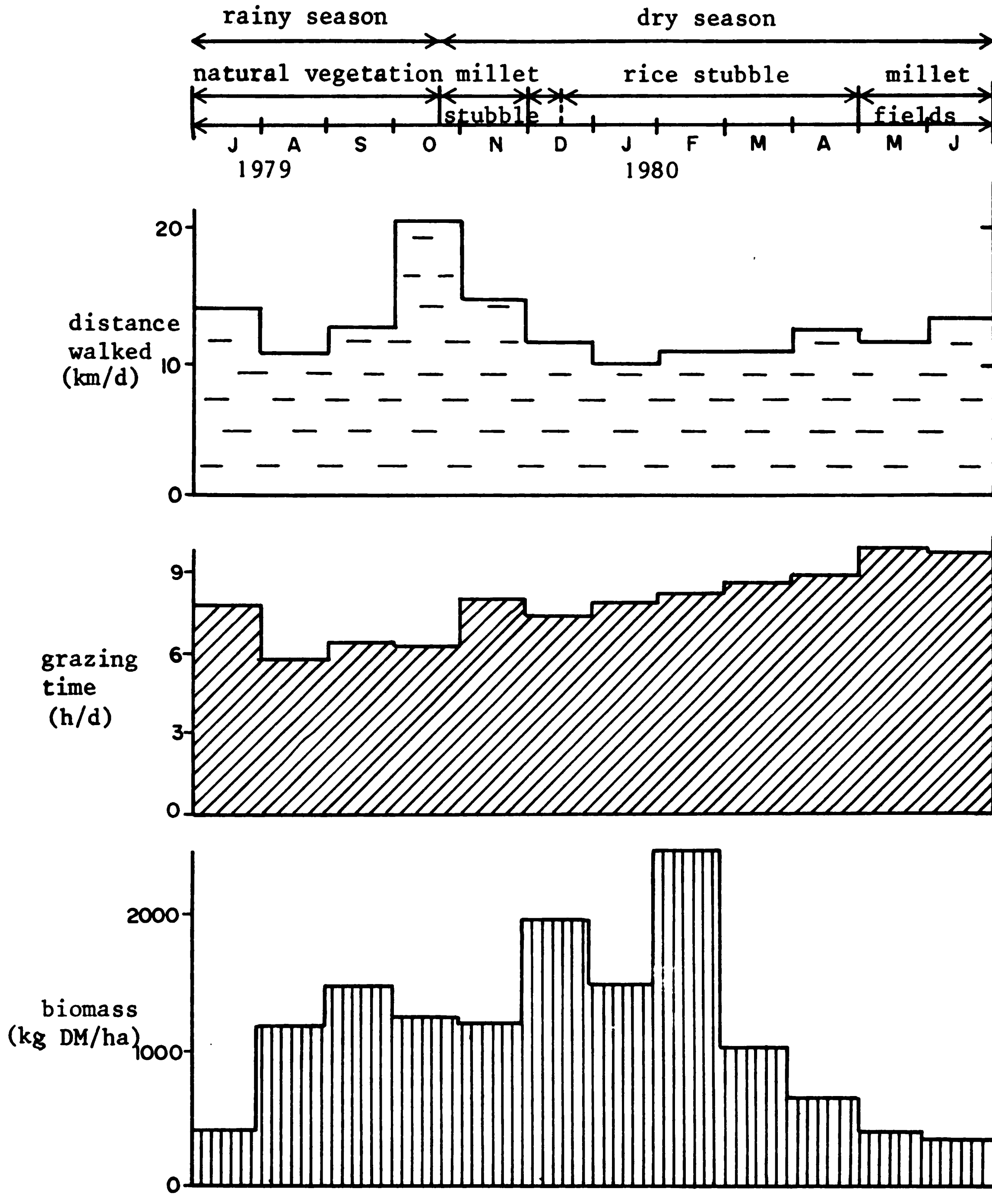


Fig 2. *Relation between biomass availability and grazing behaviour.*

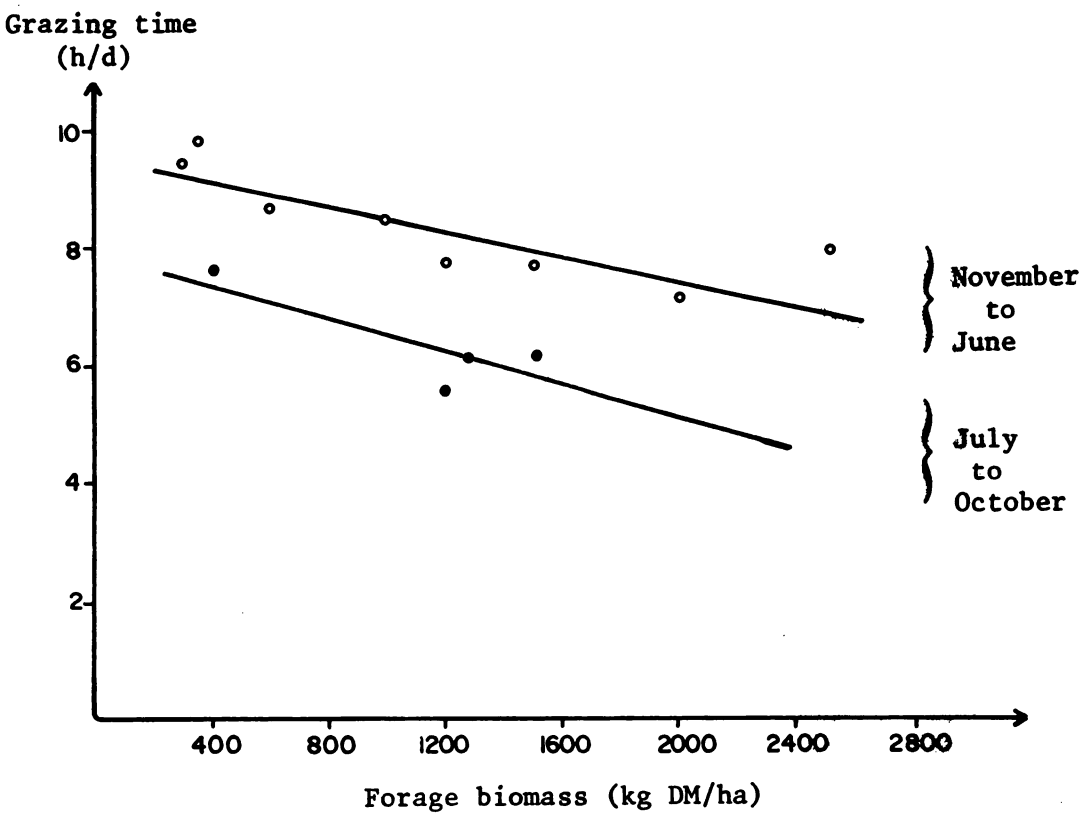


Fig 3. *Relationship between forage biomass and grazing time.*

Differences in grazing preference are shown in Table 4. The low amount of time spent on millet residues, compared to that on rice straw and fallow regrowth, points to the relative importance of these latter agricultural residue resources particularly for cattle. Sheep and goats spent far more time on fallow regrowth and on browse grazing respectively. The distance walked was about 6 to 9 km during grazing plus 3 to 12 km per day between camp, pasture and water.

Table 4. *Estimation of annual grazing time of ruminants on different types of forage.*

| | Cattle | | Sheep | | Goats | |
|---|---|---|---|---|---|---|
| | Hours | % | Hours | % | Hours | % |
| Total time | 2 883 | 100 | 1 948 | 100 | 2 051 | 100 |
| Time on browse plants | 115 | 4 | 669 | 34 | 1 791 | 87 |
| on pasture or fallows | 1 519 | 53 | 1 142 | 59 | 215 | 11 |
| on millet stems | 179 | 6 | 135 | 7 | 45 | 2 |
| on rice straw and regrowth | 1 070 | 37 | 2 | - | - | - |

Intake

The monthly mean dry matter (DM) intake figures for cattle are related to the time spent grazing (Fig. 4) in the rainy season, intake was approximately 1 kg D.M. per hour, in the early dry season approximately 0.8 kg DM per hour, whilst in the late dry season this was reduced to 0.5 - 0.6 kg DM per hour. The slightly higher values in December and June appear to be associated with the grazing of rice fallows.

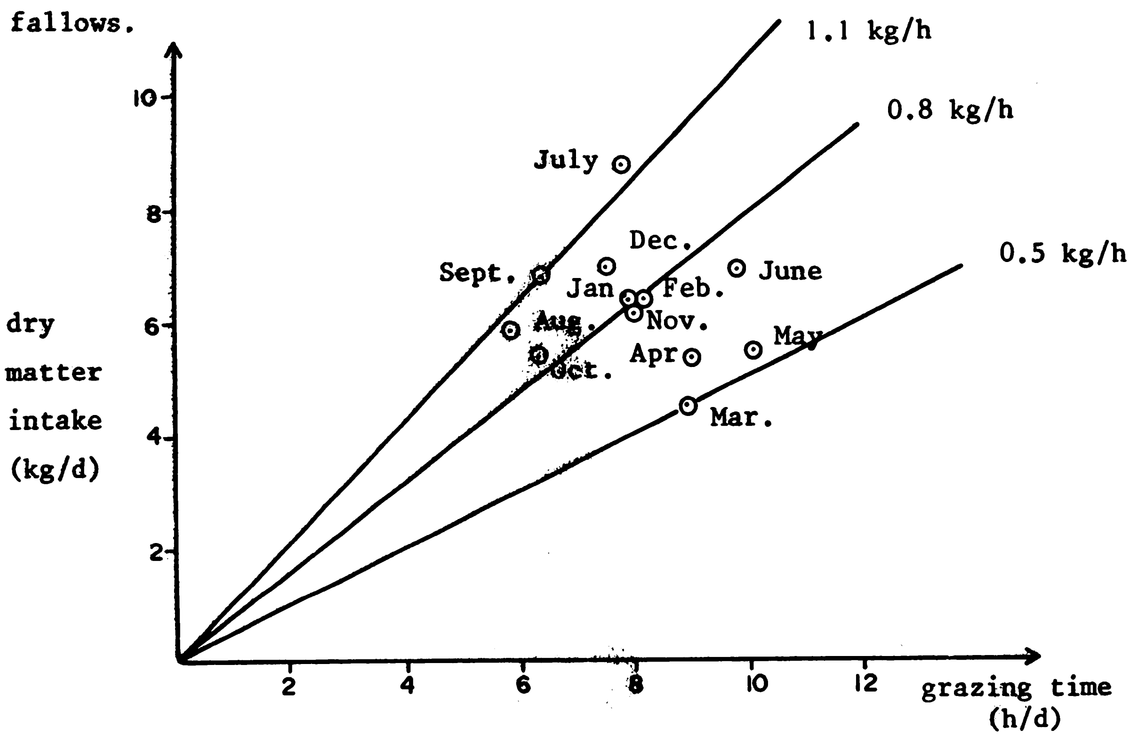


Fig 4. *Relation between voluntary intake and grazing time in different months.*

The N content of rumen samples was consistently higher than the plucked forage samples (Table 5), perhaps indicating feed selectivity even in the dry season. In the month of July, in the main growth period, both were equally high. Both sets of values showed a similar trend during the year but the difficulties of copying the grazing selection of animals gives greater credibility of the analyses of rumen samples, though these may have been influenced by saliva contamination (Table 8). Seasonal trends in protein content and digestibility (Table 5) were similar to corresponding data from Botswana (APRU, 1978) obtained by use of cattle with oesophageal fistualae.

Table 5. *Composition of forage eaten by grazing cattle;* (a) *Botswana (April, 1978),* (b) *Mali.*

| Month | F | M | A | M | J | J | A | S | O | N | D | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (a) CP[1] | | | | | | | | | | | | |
| (% of DM) | 11.2 | 9.4 | 7.1 | 6.4 | 6.2 | 5.8 | 5.3 | 6.2 | 8.3 | - | 11.6 | 10.5 |
| DM[2] | 56 | 54 | 51 | 48 | 45 | 39 | 46 | 44 | 53 | - | 63 | 55 |
| (b) CP % | | | | | | | | | | | | |
| (i)[3] | 5.8 | 3.5 | 3.7 | 4.6 | 7.2 | 23.1 | 9.7 | 8.1 | 7.7 | 7.3 | 6.2 | 5.2 |
| (ii) | 10.6 | 7.8 | 6.3 | 8.6 | 8.3 | 23.6 | 16.6 | 14.6 | 8.8 | 8.7 | 7.6 | 7.6 |
| DM % | 51 | 53 | 53 | 48 | 53 | 62 | 66 | 62 | 48 | 52 | 55 | 55 |

[1]CP = crude protein

[2]DM = dry matter percentage

[3](i)= samples plucked by hand

(ii)= samples obtained from rumen

## Factors affecting intake

Intake of DM averaged 6.32 kg DM, or 2.6% of the mean cow liveweight of 244 kg. Linear and multiple regression analyses showed that forage protein (N x 6.25) content had much more influence on DM intake (r = 0.68) than had forage digestibility alone (r = 0.48), though the two were closely related.

Weight changes of cattle and their relation to intake

Regression analysis of liveweight changes showed a correlation of 0.68 with digestible dry matter intake (DDMI), 0.89 with crude protein intake (CPI) and 0.89 also as multiple correlation with DDMI and CPI, indicating the major contribution of CP intake to the relationship. Metabolisable energy (ME) intakes were estimated from a formula proposed for tropical grasses (INRA, 1978). The linear

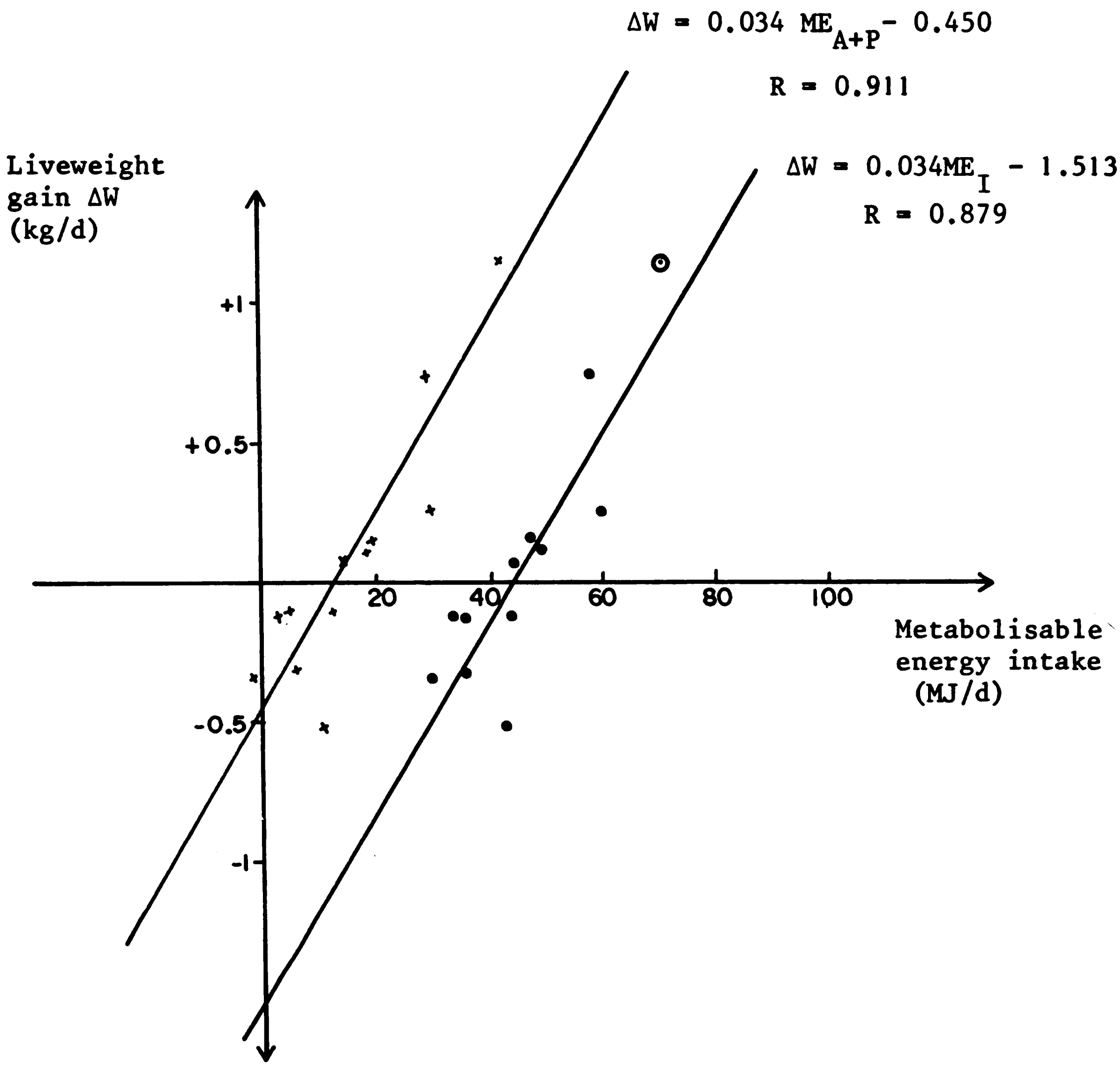


Fig 5. *Liveweight change as a function of total metabolisable energy intake ($ME_I$) and of metabolisable energy intake available for activity and production ($ME_{A+P}$).*

regression of liveweight change on ME intake (Fig. 5) gave:

$$\text{Liveweight change (kg/d)} = 0.034\ \text{MEI (MJ/d)} - 1.513\ (r = 0.88)$$
$$= 0.034\ (\text{MEI} - 44.5)$$

indicating a total maintenance energy expenditure of 44.5 MJ/d. If the ME intakes are reduced by the estimated minimum maintenance requirements of about 112 kcal/kg$^{0.75}$ or about 31 MJ per day the regression becomes:

$$\text{Liveweight change (kg/d)} = 0.034\ (\text{available ME} - 13.2)\ (r = 0.91)$$

indicating that in this environment the additional energy expenditure for grazing activities and walking amounted to 13.2 MJ/d, or an additional 42% of the minimum maintenance requirement.

## Evaluation of methods

Some discrepancies were noted among the various methods of estimating digestibility, upon which this 'indirect' approach depends. Initial comparison of the estimates suggested that the rumen samples gave consistently lower values than the rest, and a mean value was used which excluded the rumen samples, in calculating the values shown in Table 3 earlier (Dicko et al, 1981). A later analysis showed that liveweight changes were most closely correlated with intake estimated via *in vitro* digestibility of rumen samples (r = 0.80), via *in vitro* digestibility of hand-plucked samples (r = 0.78) and via the digestibilities calculated from faecal nitrogen content (r = 0.75 for equation 1; r = 0.68 for equation 2). Estimates are shown in Table 6. All estimates from the rumen samples were markedly lower perhaps because of some initial digestion, and faecal nitrogen regressions gave higher estimates than the rest.

Table 6. *Estimates of digestibility by different methods.*

| Month | Faecal nitrogen Eq. 1 (a) | Eq. 2 (b) | Van Soest equation hand (c) | rumen (d) | *In vitro* digestion hand (e) | rumen (f) |
|---|---|---|---|---|---|---|
| A | 63 | 61 | 61 | 46 | 66 | 64 |
| S | 66 | 64 | - | - | 54 | 51 |
| O | 56 | 56 | 47 | 42 | 40 | 39 |
| N | 53 | 58 | 53 | 43 | 52 | 38 |
| D | 54 | 57 | 60 | 44 | 53 | 56 |
| J | 54 | 57 | 62 | 47 | 54 | 52 |
| F | 54 | 57 | 58 | 53 | 54 | 49 |
| M | 54 | 57 | 60 | 57 | 51 | 44 |
| A | 57 | 57 | 60 | 58 | 54 | 56 |
| M | 54 | 57 | 47 | 51 | 50 | 50 |
| J | 55 | 57 | 55 | 50 | 56 | 46 |
| J | 77 | 77 | 63 | 61 | 71 | 68 |
| Mean | 58.2 | 59.6 | 56.7 | 50.3 | 54.7 | 51.2 |

In later work in Ethiopia and Kenya the oesophageal fistula method has been used. Although this method undoubtedly samples the feed actually selected by the animal, not all food eaten is collected. The proportion which comes out of the fistula depends somewhat on the exact position and size of the opening and therefore differs between cows. Table 7 shows fairly consistent and significant differences among four animals given test feeds in known amounts, but no differences between feeds of different physical types averaged over the four animals. This indicates the need to 'calibrate' animals from time to time, and to use a small group rather than rely on single animals. The total weight of forage collected per hour of grazing time cannot be simply multiplied by the number of hours of grazing per day to calculate total daily intake, unless the percentage feed recovery is known and is used to correct the weights collected.

Table 7. *Percentage recovery of different feeds from oesophageal fistulae in four cattle (no. observations in brackets).*

| Feed given | Percentage recovery (%) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | All |
| hay | 59 | 39 | 17 | 53 | 41 (19) |
| grass | 54 | 49 | 16 | 58 | 43 (20) |
| concentrates | 30 | 31 | 29 | 84 | 41 (20) |
| mean | 48 (18) | 40 (11) | 20 (18) | 65 (12) | 4. (59) |

Table 8. *Composition of material collected from oesophageal fistula compared with composition of feed eaten.*

| Material | DM[1] (%) | Nitrogen (%) | Phosphorus (%) |
|---|---|---|---|
| hay feed | 50 | 0.87 | 0.21 |
| OF[2] - total | 55 | 1.00 | 0.52 |
| - squeezed | 51 | 0.97 | 0.34 |
| grass feed | 56 | 1.20 | 0.24 |
| OF - total | 58 | 1.32 | 0.43 |
| - squeezed | 52 | 1.28 | 0.33 |
| concentrates feed | 61 | 3.45 | 1.01 |
| OF - total | 68 | 2.92 | 1.04 |
| - squeezed | 62 | 2.97 | 1.01 |

[1]DM = dry matter

[2]OF = oesophageal fistula

Table 8 shows the effect of mastication and addition of saliva on chemical composition of samples. More saliva is added to hay than to grass or concentrate samples before swallowing, and the effect of this on nitrogen and particularly on phosphorus content, is quite clear. The phosphorus content of hay and grass was more than doubled by the phosphorus contained in the saliva, which demonstrates the effectiveness of the recycling process by which ruminants are able to thrive on poor quality feeds for many months.

In current work in Kenya Semenye is using Maasai cattle with fistulae, and this is the method of choice where precise knowledge of botanical, and with less confidence chemical, composition is needed, and where the large amount of work can be justified. For many purposes it is now felt that close observation of grazing behaviour may be sufficient, matched with analyses of forage samples carefully plucked to mimic grazing selectivity. Additional information may be obtained by analysis of faecal samples, which is closely related to the characteristics of the feed eaten, at least in terms of nitrogen, phosphorus and fibre contents.

The collection of faeces by harness and bag, as used here, is much easier with animals which are accustomed to close herding and regular handling than with free-ranging cattle. The standard chromium oxide method would also be relatively easy with herded cattle, and would make it possible to work with larger numbers and with young growing cattle as well as with females. This is now being explored.

An interesting development of this work is the finding that the average amount of forage taken in per 'bite' or per monthful, is fairly constant. This has been calculated from careful recording of the number of mouthfuls taken in a given time; the number of mouthfuls per unit time or the intensity of grazing, is closely related to the rate of walking while grazing. This is illustrated for several conditions in Fig. 6 (Dicko, pers. comm.). At maximum grazing intensity an animal takes a number of monthfuls per minute characteristic of the pasture and when its rate of walking is slowest. As grazing becomes less intense, the number of mouthfuls per minute declines linearly with increase in walking speed. It is hoped that the availability of fistulated cattle may make it possible to test this idea under a wider range of conditions. Number of monthfuls is also being recorded by a simple automatic device (Semenye, pers. comm.).

## Conclusions

This component research study amply verified the nutritional limitation to cattle performance during the dry season, and showed that this had several aspects. The main initial constraint appeared to be the low quality of the dry forage which caused the cattle to graze selectively for long periods and expend extra energy in doing so. Samples of forage obtained in various ways confirmed earlier findings that the protein content of the forage was more closely related to animal performance than was its digestibility. The close relationship of forage N content to other quality attributes makes it difficult to assert which one is of primary importance. In tropical pastures it is well known that animal performance depends on maintaining forage protein content above about 8% (Milford and Haydock, 1965). In the present work protein content of forage was below 7.5% for most of the period November to June during which liveweight losses occurred.

These findings emphasize the particular value of protein or non-protein nitrogen supplements for grazing ruminants, and help to explain the better sustained production of animals which browse on high-protein leguminous plants during the dry season. If it is true that protein content is the most valuable single attribute, and is correlated with most other measures of quality, then improvement in protein content should be sought even at the cost of some reduction in gross DM production. Biomass protein content can be increased even within the constraints of climate and soil fertility by management deliberately aimed at increasing the contribution of legumes, herbs and browse plants rather than of lower-quality grasses, however high their DM yield. Where pastoral systems rely on crop residues or stubble grazing in the dry season, as is common, the inclusion of a forage legume with the cereal crop combined with minimum fertilizer input, would both provide supplementary protein to livestock and enhance soil fertility so as to produce better crop yields and better fallow grazing in later years.

Because of the great importance of nitrogen content and digestibility in determining intake and performance of ruminants, ILCA is collating these and other data on a wide range of forage and browse samples. The widespread practice in Africa of supplying salt in various forms to livestock, suggests that soils and plants may be deficient in particular mineral elements. ILCA has carried out a wide sampling of forage plants on various soils and throughout the year in northern Nigeria, and proposes to extend this survey into the Malian and Niger Sahel and into the Ethiopian and Kenyan rangelands. Analyses are, of course, most informative when they relate to the species and the plant parts actually eaten by grazing animals; this is why ILCA is interested in methods of sampling which mimic the animals' selectivity or, as in O.F. methods use the animal itself to obtain samples for analysis.

Knowledge of the nutritional features for which animals select their forage intake has particular value for ILCA's simulation modelling work. Mathematical descriptions and predictive models have been developed for water use and plant growth (van Keulen et al, 1981) and for animal performance (Konandreas and Anderson, 1982) but a weak point in the sequence is the lack of knowledge about feed intake and selectivity of African livestock under African pastoral conditions.

## References

APRU (Animal production Research Unit). 1978. Ann. Rept. APRU. Botswana Min. Agric. Gaborone.

Dicko, M.S. 1980a. Measuring the secondary production of pasture: An applied example in the study of an extensive production system in Mali. In *Browse in Africa: The current state of knowledge*. ILCA, Addis Ababa, p. 247.

Dicko, M.S. 1980b. Les sous-produits agro-industriels au Mali. Paper presented at the AAASA/ILCA Workshop on the Utilisation of Agricultural, Forestry and Fisheries Waste Products, Douala, Nov. 1980.

Dicko, M.S., Lambourne, L.J., de Leeuw, P.N. and de Haan, C. Voluntary intake and livestock productivity. Paper presented at the 32nd Annual Meeting of the European Association for Animal Production, Zagreb, Aug. - Sept. 1981.

I.N.R.A. 1978. In *Alimentation des ruminants*. France, Institut National de Recherches Agronomiques. p. 579.

van Keulen, H., Seligman, N.G. and Benjamin, R.W. 1981. *Agric. Symp.* 6:159.

Konandreas, P.A. and Anderson, F.M. 1982. *Cattle herd dynamics: An integer and stochastic model for evaluating production alternatives.* ILCA Research Report 2, Addis Ababa.

Milford, R. and Haydock, K.P. 1965. *Aust. J. Exp. Agric. Anim. Husb.* 5 : 13.

Smith, G., Carles, A., Schwarz, J., Blackburn, H., Ruvuna, F. and Cartwright, 1982. In *Proc. Small Ruminant C.R.S.P. Workshop,* Nairobi.

van Soest, P.J. 1976. In *Feed Energy Sources for livestock.* Ed. Swan and Lewis, Butterworth, London. p. 83.

Wilson, R.T. 1982. *Livestock production in central Mali.* ILCA Bulletin 15, Addis Ababa.

## Nutrition animale

**Résumé**

Les pâturages arides et semi-arides caractérisés par des périodes pluvieuses courtes et irrégulières, assujettissent les animaux et leurs conducteurs à de longues périodes de contraintes nutritionnelles. Les travaux du CIPEA mettent en relief l'interaction de la nutrition et de la santé dans la productivité globale. Des efforts ont été déployés pour diagnostiquer les principales maladies, pour étudier leur épidémiologie et leur impact sur la production et pour tester les mesures de lutte disponibles. Les méthodes utilisées pour enregistrer les données sur la nutrition sont examinées. Elles incluent des méthodes relatives à l'enregistrement de la quantité et de la composition du disponible fourrager et du fourrage consommé.

L'étude a confirmé les contraintes nutritionnelles qui font obstacle aux performances des bovins au cours de la saison sèche et a montré que celles-ci comportaient plusieurs aspects. La contrainte principale semble être la faible qualité du fourrage sec qui oblige les bovins à faire du pâturage sélectif pendant de longues périodes et à dépenser beaucoup d'énergie. Des échantillons de fourrage prélevés de diverses manières ont confirmé des découvertes antérieures selon lesquelles la teneur en protéines du fourrage était plus étroitement liée à la performance animale que ne l'était sa digestibilité.

Ces découvertes mettent en relief la valeur particulière des compléments azotés protéiques ou non protéiques pour les ruminants et contribuent à expliquer la meilleure performance des animaux qui consomment les légumineuses à forte teneur en protéines au cours de la saison sèche. S'il est vrai que la teneur en protéines constitue le facteur déterminant et qu'elle intervient dans la plupart des mesures visant à améliorer la qualité de l'affouragement, alors l'accroissement de la teneur en protéines devrait être recherché, même au prix d'une certaine baisse de la production brute de matière sèche. La teneur en protéines de la biomasse peut être augmentée, même malgré les contraintes relatives au climat et à la fertilité des sols, par une gestion visant délibérement à accroître le rôle des légumineuses, des graminées et des ligneux plutôt que celui des graminées de qualité inférieure, quelle

que soit l'importance de la production de matière sèche. Etant donné le rôle que jouent la teneur en azote et la digestibilité dans la détermination de l'ingestion et de la performance des ruminants, le CIPEA a entrepris de recueillir des données sur celles-ci et sur une vaste gamme d'échantillons de fourrage et de ligneux. La pratique courante en Afrique de donner du sel sous diverses formes au bétail suggère que les sols et les plantes peuvent être déficients en certains éléments minéraux. Le CIPEA a procédé à l'échantillonnage d'une vaste gamme de fourrages sur divers sols pendant toute l'année dans le Nigéria du nord et propose d'étendre cette enquête aux pâturages sahéliens du Mali et du Niger et aux terrains de parcours de l'Ethiopie et du Kenya.

La connaissance des caractéristiques nutritionnelles qui déterminent la sélection par les animaux du fourrage ingéré revêt une importance capitale dans les travaux de modélisation du CIPEA. Des descriptions mathématiques et des modèles de prévision ont été mis au point pour l'utilisation de l'eau et la croissance des plantes ainsi que pour la performance des animaux. Un point faible cependant dans cette série: le manque de connaissances sur l'ingestion fourragère et la sélectivité du bétail dans les conditions pastorales en Afrique.