NUTRITION OF RUMINANTS AT PASTURE IN THE TROPICS: IMPLICATIONS FOR SELECTION CRITERIA

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SUMMARY

Ruminants in the tropics, because of the quality of the forage resources are dependent for nutrients only on the end products of fermentative digestion in the rumen. These are the volatile fatty acids (VFA) and the components of microbial cells which are made available when these cells are digested in the intestines. Microbial cells which contain 50-60% protein provide the animals major source of essential amino acids.

The ratio of microbial protein and VFA energy absorbed (called P:E ratio here) by ruminants has a major impact on the efficiency of utilisation of forage for production.

The P:E ratio for cattle fed tropical forage is dependent on the efficiency of microbial cell growth which is sensitive to the availability of critical microbial nutrients such as ammonia, sulphur, phosphorus and trace minerals. The level of ammonia in the rumen is critical and may be increased in some feeding situations by the ability of the animal to (1) select a high protein diet from a pasture or (2) recycle urea from the body efficiently. The efficiency of microbial growth on fibrous carbohydrates and hence the P/E ratio appears to be stimulated when rumen turnover rate is slow.

The P:E ratio can be increased considerably by feeding a supplemental protein meal that has physical and chemical characteristics which allow it to escape from the rumen to be digested in the intestine.

Thus there are two kinds of supplements that alter the P/E ratio. The first contain urea, trace and macro minerals that improve the P/E ratio in nutrients arising from the rumen and the second is processed or naturally protected protein meals that escape rumen fermentation.

Under tropical conditions where animals are heat stressed any inefficiency of feed utilisation (which stimulates metabolic heat production) will reduce feed intake. Conversely increasing the P/E ratio in the nutrients absorbed decreases the metabolic heat load and will often allow animals to increase voluntary feed intake.

Thus any differences between animals in P/E ratio resulting from differences in their digestive physiology may show up as large differences in productivity in cattle in the tropics. These differences may disappear when animals are supplemented.

A comparison of Brahman, Brahman X Hereford and Hereford cattle showed that the Brahman (which maintains a higher rumen ammonia levels then the Bos taurus animal) was the most efficient animal on an unsupplemented poor quality hay. However this advantage was removed when the P:E ratio in the nutrients was adjusted by supplementation with a protein meal that escaped rumen fermentation.
INTRODUCTION

Classical approaches to evaluation of the feeding value of a forage for ruminants, based on its metabolisable (ME) or digestible energy (DE) content, are proving to be highly inaccurate for predicting production of large and small ruminants (see Preston & Leng 1987; Leng 1989, 1990).

Under applied conditions the requirements for nutrients by ruminants for productive purposes are affected by: (1) provision by the feed of adequate microbial nutrients to maintain an efficient fermentative digestion in the rumen, (2) ability of the animal to select feeds (particularly high in protein) from a pasture (3) ability to recycle nutrients such as sulphur and urea back to the rumen (4) physiological state (maintenance, growth, pregnancy, lactation and the amount of work undertaken) (5) climate, and (6) health and previous disease or nutritional history.

To achieve a high feed conversion efficiency the balance of nutrients absorbed by ruminants must be closely similar to its requirements. To meet these requirements in the long term, the animal depends on the nutrients arising from fermentative digestion in the rumen but imbalances in the absorbed substrates can be augmented in the short term by mobilisation of body reserves of fat, protein and glycogen.

In cattle fed forage based diets the balance of essential amino acids absorbed (those arising from microbial and dietary protein digested in the intestines) to the volatile fatty acids (VFA) produced in the rumen determines the efficiency of utilisation of metabolisable energy (or ME) (see Leng 1989).

In this presentation, the factors in feed and in the animal that affect the P/E ratio are reviewed. The P/E ratio is defined as the protein available for digestion in the intestine to VFA energy absorbed.

The ruminal and metabolic factors that affect the efficiency of feed utilisation have implications for selection criteria for cattle and sheep breeding programmes. The discussion will show that relatively small differences between diets and small physiological differences between animals can markedly change the ratio of P/E and therefore the efficiency of feed utilisation and production of ruminants. These differences between animals may disappear when supplementary feeding aimed at creating an efficient rumen and improving the P/E ratio is introduced (see Hennessy and Williamson 1988).

NUTRIENT AVAILABILITY TO RUMINANTS

The quantities and balance of nutrients absorbed from the digestive tract of ruminants on forage based diets depend on:

(1) the intake and the efficiency of fermentation of organic matter in the rumen, which provide VFA for absorption directly and amino acids, from microbial cells that are digested in the lower tract when these pass from the rumen.

(2) the chemical composition of the feed ingredients which controls the extent to which feed materials (particularly insoluble protein) escape from the rumen to be digested in the intestines.

Because the substrates fermented in the rumen are either partitioned into microbial cell constituents or VFA production there is an inverse relationship
between protein (from microbial cells) and energy substrate (from VFA) produced.

The theoretical relationship between microbial cell growth and VFA production over a theoretical range of efficiencies of microbial growth rates in the rumen is shown in Figure 1.

**Figure 1** Theoretical relationship of microbial cell synthesized and VFA production. Y-ATP (g cell synthesized/mole ATP available in VFA production) is an index of the efficiency of microbial cell growth.

The ratio of microbial cells to VFA produced in rumen fermentation is highly variable on most natural forages. When the rumen microbes are not deficient in any critical nutrients the microbial growth efficiency probably is between 10 and 14 g dry cells produced per mole of ATP generated when VFA were produced (i.e. Y-ATP). If the diet is deficient in a critical microbial growth factor the microbial growth efficiency will decrease possibly to values as low as 4-6 g dry cells produced per mole of ATP available. This alters the P/E ratio markedly (See Figure 2)

The P/E ratio is also altered by supplementing an animal on a forage based diet with a protein meal that escapes the fermentative processes in the rumen and augments the amount of protein digested in the lower tract. Most soluble proteins of forage origin are degraded quickly and readily in the rumen (Nugent and Mangan 1981) with a large loss of potential amino acids to the animal. Insoluble proteins however tend to escape fermentative digestion (see Figure 2). The amount of any protein that escapes the rumen depends mainly on (1) its solubility (2) the presence of di-sulphide bonds in the protein (3) the presence of secondary plant compounds that bind with the protein to make it insoluble (see Leng and Nolan 1984) (4) the voluntary feed intake and the rate of passage of digesta from the rumen.

Most tropical forages have a low crude protein content (6-8%) and digestibility rarely exceeds 55% (see Minson 1982). The combination of low protein content and low digestibility results in little or no protein escaping fermentation in the rumen in grazing ruminants. Most tropical pastures, whether actively growing or mature have insufficient crude protein to supply the rumen organism with their requirements for ammonia-N. Tropical pastures that have matured are 40-45% digestible and contain less than 6% crude protein which is insufficient to provide rumen microbial requirements for ammonia. The forage is often severely deficient in microbial nutrients in addition to ammonia to support efficient microbial growth in the rumen.
Figure 2 Some theoretical relationships of VFA production and microbial cell synthesis in the rumen when microbial growth is efficient or limited by a deficiency of an essential nutrient such as ammonia (the major N substrate for cellulose-fermenting organisms in the rumen). The degradation of protein in the rumen is also shown. The rate and extent of protein breakdown depends largely on its solubility. A soluble leaf protein may be totally fermented to VFA at one extreme and an insoluble protein from a processed oil seed meal such as cottonseed meal may not be degraded at the other. The degradation of 1 kg of carbohydrate (CHO) in an inefficient rumen (say low ammonia) or an efficient rumen (no deficiencies) is shown. The products of fermentative digestion are also shown for the degradation of 1 kg of either insoluble protein or soluble protein.

On a year-round basis cattle grazing tropical pastures are unlikely to digest and absorb amino acids from dietary proteins and often there is a deficiency of fermentable N for efficient rumen digestion. The overall conclusion is that cattle on tropical forages are often protein deficient (i.e. low P/E ratio in the nutrients absorbed).

The quality of a tropical pasture cannot be judged by its growth stage or its 'greenness'. For example the growth rate of cattle grazing green Brachiaria decumbens pasture (in a vegetative growth phase) in Los Llanos, Colombia, S.A. was increased considerably when given a supplement of urea in molasses fortified with minerals (Table 1)

Table 1: Liveweight (LWt) change of Bos indicus heifers grazing Brachiaria decumbens pastures in Colombia (Los Llanos) during the wet season and given a molasses/urea liquid supplement sufficient to provide 70g urea/day in approximately 500 g molasses (Informe Anual, La Libertad 1988).

<table>
<thead>
<tr>
<th>Supplement</th>
<th>No. of animals</th>
<th>Initial Wt. (kg)</th>
<th>Final Wt. (kg)</th>
<th>LWt gain (kg)</th>
<th>Lwt gain (g/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>6</td>
<td>194</td>
<td>244</td>
<td>580</td>
<td></td>
</tr>
<tr>
<td>+Molasses/urea</td>
<td>6</td>
<td>203</td>
<td>269</td>
<td>751</td>
<td></td>
</tr>
</tbody>
</table>

Two points need to be emphasized from the above discussion:

* The P/E ratio in the nutrients arising from digestion in the rumen of
cattle on tropical forage diets may vary from as low as 7g protein/MJ VFA produced, where the rumen microbes are deficient in critical nutrients such as ammonia, sulphur and a number of minerals, to about 20g protein per MJ VFA when the rumen microbes are supplemented to correct these deficiencies.

* The protein availability from rumen microbes is not augmented by dietary protein that escapes the fermentative processes in the rumen in cattle on most tropical pastures, as the protein content in the pasture is usually low and readily degraded in the rumen. A supplement containing protein that bypasses the rumen can however increase the ratio P/E in the nutrients absorbed many fold (by up to 60g protein/MJ VFA).

**CONSEQUENCES OF ALTERING THE P/E RATIO**

Supplementation of a forage based diet fed to cattle and sheep to increase the P/E ratio in the nutrients absorbed can dramatically increase the metabolic efficiency of utilisation of nutrients for production. Where supplementation increases intake of the basal diet by cattle there is an additional production response to the increased total nutrient availability (see Leng 1989).

The order of improvement in production that can be made by cattle on poor quality forages is well illustrated by the results of Lindsay and Loxton (1981) (See Table 2). In these studies, supplementation with nutrients for rumen microbes (ie urea and sulphur) increased the intake of a low quality hay and increased the efficiency of feed utilisation. Supplying additional protein that escaped fermentation in addition to the urea/sulphur improved hay intake further and also stimulated the efficiency of feed utilization for growth.

Table 2 Dry matter intake and liveweight change of cattle (170g liveweight) fed a mature native pasture hay of low protein and low digestibility supplemented with urea and sulphur and/or 1 kg/d formaldehyde-protected cottonseed meal (protected-CSM) (Lindsay and Loxton 1981).

<table>
<thead>
<tr>
<th></th>
<th>Dry matter intake (kg/d)</th>
<th>LWT change (kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture hay</td>
<td>2.26</td>
<td>-0.41</td>
</tr>
<tr>
<td>Pasture hay + urea/sulphur</td>
<td>3.01</td>
<td>-0.32</td>
</tr>
<tr>
<td>Pasture hay + protected CSM + urea/sulphur</td>
<td>4.43</td>
<td>+0.22</td>
</tr>
</tbody>
</table>

Preston & Leng (1987) and Leng et al. (1987) have reviewed the literature of research on strategic supplementation and have reported that all productive functions of ruminants fed on low quality forages and strategically supplemented as discussed here, are improved to levels that are far in excess of that predicted by the ME (MJ/kg DM) of the forage (see Leng, 1990) The production indices that are improved include reproductive efficiency in the females (fertility, growth of foetus and survival of the new born) and fertility in the male (semen volume, sperm concentration and total sperm per ejaculate), growth of young animals, milk production in the mature female and ultimate body size.

Cattle given poor quality forages and strategically supplemented with small amounts of urea/minerals and a bypass protein meal are often 4 to 10 times more efficient in body weight gain then would have been predicted from the ME content of the basal diet (Leng, 1990). The efficiency of weight gain of cattle given poor quality hay or crop residues (straws), supplemented with urea and then
incremental levels of bypass protein are shown in Figure 3. The classical scheme relating metabolisable energy content of a basal diet to the expected and actually obtained efficiencies of use of the ME for liveweight gain (Webster 1989) is also shown in Figure 3.

**Figure 3**: A schematic relationship between diet quality (ME/kg dry matter) and food conversion efficiency (g live-weight gain/MJ ME) (from Webster 1989). The relationships found in practice with cattle fed on straw or ammoniated straw and supplemented with incremental amounts of bypass proteins in Australia (O,●,◊) (Perdok et al. 1988). (▲) (Hennessy et al. 1983). (■) (Hennessy et al. 1989) Thailand (▲) (Wanapat et al. 1986) and Bangladesh (□) (Saadullah 1984) The response in efficiency to increased levels of bypass protein illustrate the marked differences between theoretical and actual feed utilisation efficiencies when nutrients are balanced. (from Leng, 1990)

In conclusion, supplementation of ruminants on low quality forage with bypass protein and non protein nitrogen, because they increasing the P/E ratio in nutrients absorbed, increase the efficiency of utilisation of the forage. These increases are much greater than the increases that may be achieved by increasing digestibility of the feed (see Figure 3). It is thus hypothesized that any physiological, digestive or environmental factor that influences the P/E ratio in the nutrients absorbed by ruminants will have large effects on their efficiency of feed utilisation and therefore rate of production.

**EFFECTS OF CLIMATE ON FORAGE INTAKE AND EFFICIENCY OF UTILISATION**

As this paper is aimed at tropical animal production the interaction of climate and nutrition is discussed. This has been reviewed elsewhere (Leng 1989; Leng 1990).

Ruminants oxidise mainly acetate to keep warm in a cold environment (Graham et al. 1959). This substrate arises from fermentative digestion of forage in the rumen or from mobilised fat deposits within the animal. Ruminants subjected to periodic cold weather use a considerable amount of acetate preferentially for heat production. Grazing animals in the tropics or subtropics seldom need to
oxidise acetate to keep warm. Therefore on the same diet the ratio of amino acids relative to VFA in the nutrients absorbed that are available for anabolic purposes is lower but the total nutrients available are greater in cattle in a warm/hot climate when compared with animals which, in temperate countries, are periodically cold stressed. Therefore cattle in the tropics will require more bypass protein to balance the P/E ratio to maximise the efficiency of production than cattle in temperate countries.

Conversely in unsupplemented animals the substrate that would have been oxidised by an animal to keep warm under temperate conditions may have to be disposed of by synthesis into fat. Where there is an imbalance of nutrients which inhabits fat synthesis the supply of acetate must be reduced or it has to be oxidised wastefully to produce heat (for discussion see Leng 1989, 1990). This metabolic heat may not be tolerated at times of high environmental heat load, as it will contribute to an increase in deep body temperature. The only recourse is for the animal on a poor quality forage to reduce its overall forage intake.

It is often observed that cattle fed only poor quality forages have lower intakes in the tropics as compared to temperate countries (see Figure 4). Intake of forage by cattle at high environmental temperature may be stimulated by strategic supplementation to levels equal to that in unsupplemented animals given a similar forage in temperate conditions (see Figure 4).

**Figure 4:** Intake of low quality forage by cattle (studies are only considered from Australia) in relation to intake of the forage following supplementation with a bypass protein meal or bypass protein meal plus urea in different climatic zones (Leng 1989). The research of Lindsay and Loxton (1981), Lindsay *et al.* (1982) Hennessy and his colleagues (1983,1984,1986,1988,1989) and Lee *et al.* (1987) was done at sites in the tropics or subtropics, whereas the research of Kellaway and Leibholtz (1981) and Perdok (1987) were done under more temperate climatic conditions.

Thus under harsh tropical conditions where forage intake by cattle is low, a small change in the P/E ratio not only stimulates the efficiency of feed utilisation but also relieves a limitation on feed intake and the total availability of nutrients. The production responses in cattle to strategic supplements are thus often greater in tropical as compared to temperate climates (see Leng 1989).
The overall conclusion is that the P/E ratio in nutrients absorbed by ruminants establishes the efficiency of liveweight gain and therefore production levels. In tropical countries, climate is likely to have an important role as the lack of any need in cattle to oxidise acetogenic substrate to keep warm increases the requirements for bypass protein. When the latter is given to ruminants under these conditions they produce at a much higher rate in the tropics than ruminants on similar diets in temperate countries.

**REPRODUCTION RATE AND OVERALL EFFICIENCY OF GRAZING RUMINANTS**

Any assessment of the efficiency of utilization of feed for growth in meat animals must consider the feed costs to maintain the parent population (Webster 1989). In a temperate-country beef cattle system the cow first breeds at 9-18 months of age and produces a calf every year. Under these conditions the feed cost are approximately 50:50 in maintaining the dam and producing a calf for slaughter (Large 1976; Webster 1989). In the tropics the "unfavorable environmental" conditions, usually result in age at puberty of cattle at 4-5 years of age and an intercalving interval of 1.5 - 2 years. Therefore a large proportion of the forage requirements of a cow/calf system in the tropics is used by the dam. Thus in any exercise aimed at improving livestock production from tropical pastures, the major objective should be to reduce the costs of maintaining the dam by increasing numbers of calves in a life time in addition to decreasing age at slaughter of the offspring.

The reason for introducing this, is that improving the P/E ratio in nutrients absorbed by cattle on pasture has major effects on all aspects of reproduction of sheep and cattle particularly under tropical production systems. For example Lindsay et al. (1982). demonstrated that when cows were given a basal diet of low quality hay over the last 60 days of pregnancy and additional nutrients to correct any rumen deficiencies (i.e. increase P/E ratio) the birth weight of their calves was improved from 22 to 32 kg Similarly Stephenson et al. (1981) showed that putting urea in the drinking water of sheep on dry pasture improved lamb birth weight. In recent studies single and twin lambs were 10% heavier and 20% more survived when their dams on poor pasture were fed 120g of a protein meal designed to provide bypass protein (Lynch et al. 1990).

Hennessy (1986) showed that anoestrus cows (with calves) grazing on a mature pasture in the subtropics reproduced when supplemented with a bypass protein. Cows supplemented with an equivalent amount of "energy" (i.e. molasses) did not respond to supplementation.

In India, long term anoestrus in cattle and buffalo given straw based diets was eliminated by simply introducing a molasses/urea multinutrient block into the diet (John, A.R., see Leng 1989).

**PHYSIOLOGICAL FACTORS THAT EFFECT THE P/E RATIO**

Are there physiological differences within and between breeds that could establish a better balance of nutrients for the unsupplemented animal at pasture and which may be selected for in a breeding programme? The answer to this is clearly in the affirmative.

There are several factors that effect the P/E ratio in the nutrients absorbed by ruminants which will have large effects when cattle and sheep are subject to low-protein nutrition. These include: 1) ability to select a higher N diet from a pasture and therefore preserve a higher rumen ammonia level, 2) the ability to maintain a higher rumen ammonia concentration through the recycling of nitrogen
as urea to the rumen and 3) a larger rumen and a slower turnover of rumen contents combined with a ability to recycle urea-N to the rumen.

Although there are interspecies comparisons of the influence of these physiological factors there are few within species comparisons.

Feed Selection: Sheep and goats will graze selectively on different species of plants within a pasture. Sheep will select green material from pasture (Langlands and Sansom 1976) and goats preferentially graze browse (Devendra and Burns 1983) Cattle and sheep grazing the same pasture, select quite differently and the rumen ammonia concentrates in sheep maybe 2-3 times higher then that in cattle on the same pasture (Negussie 1985, see Preston and Leng 1987).

Recycling of urea N: There is now considerable evidence that Bos indicus cattle have a greater ability then Bos taurus cattle to recycle urea to the rumen and thus they maintain a better N balance for microbial growth and digestion of forage when the protein content of pastures are low Hunter and Siebert (1985).

The buffalo also appears to have a capacity to recycle more urea to its rumen than cattle and thus maintain a higher rumen ammonia concentration than cattle on the same feed intake (Kennedy et al. 1987).

Slower rumen turnover rate. Microbial growth efficiency has recently been shown to increase on cellulose as turnover rate of the fluid phase digesta in an artificial rumen was decreased (Maeng et al. 1989). This is quite contrary to the effects when starch or sugar in the substrate. The effects of increased turnover rate of fluid in an artificial rumen on the microbial cell growth per unit of carbohydrate fermented is shown in Figure 5.

Figure 5 Microbial cell produced per mole of carbohydrate fermented and the turnover rate of contents of incubation vessel in an artificial rumen. The microbial cell yields on cellulose (o) and on starch (■) are shown with increasing turnover rate of the fluid in the incubation cell (after Maeng et al. 1989).

If these results reflect the situation in vivo they have important implications. Animal species with rumens that are large and in which the turnover of digesta is slow, will have a higher P/E ratio in their absorbed nutrients then another animal with higher rumen digesta turnover rate. An animal fed a poor quality forage and that was able to recycle significantly higher amounts of urea and perhaps sulphur and phosphorus to the rumen would be able to digest more of the forage in the rumen and the P/E ratio in the nutrients absorbed would be greater than an animal without these attributes. In a tropical situation such an animal would also have a higher feed intake.
Such mechanisms (physiological advantages) could account for a considerable proportion of the variation in growth rates of animals at pasture particularly when feed quality is poor (i.e. tropical pasture). However, these physiological advantages may be removed when small inputs of protein and urea are given to animals on such diets. For example, Hennessy and Williamson (1988) showed that the advantage of *Bos indicus* over *Bos taurus* cattle fed a poor quality hay was removed when the animals were given a bypass protein supplement. The data are shown in Figure 6 together with (Webster 1988) the theoretical relationship between diet quality (M/D) and food conversion efficiency (g gain per MJ) for three types of temperate beef cattle with known variable efficiencies of feed utilisation.

**Figure 6.** The metabolisable energy content of poor quality hay and the efficiency of liveweight gain with and without supplements of a bypass protein meal fed to Hereford, (■) Hereford/Brahman (○) and Brahman cattle (▲). Supplementation removed apparent 'genetic difference' in the efficiency of feed utilisation (see Table 3). The relationship of ME and efficiency of its use by the three breeds as calculated by Webster (1988) is also shown in this diagram. (Lm - Limousine, Fr-Friesian, He-Hereford).

When cattle were given only a low quality forage, the Brahman cattle were the most efficient, with Hereford × Brahman the least and the Hereford being intermediate. However, when all animals were given 1 kg/day of a bypass protein supplement based on cottonseed meal, their efficiencies of liveweight gain were increased and were not apparently different. There was some differences in the rates of gain which were associated with high intakes by the BrahmanXHereford cross (see Table 3). When the supplement was based on formaldehyde treated sunflower seed meal, the Brahman were apparently not able to utilise the second protein meal to the same extent as the other two cattle types.
Table 3: The effects of supplementation with cottonseed meal (1kg/d) on the utilization of a poor quality pasture hay by Hereford (H), BrahmanXHereford (BXH) and Brahman (B) cattle (Av. LWt 250-300kg) (after Hennessy and Williamson 1988).

<table>
<thead>
<tr>
<th>Breed</th>
<th>Hay intake (kg/day)</th>
<th>ME* (MJ/kg)</th>
<th>M/D* (MJ/kg)</th>
<th>LWt gain (g/d)</th>
<th>Efficiency Lwt. gain (g/MJ ME)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsupple.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>5.0</td>
<td>40.0</td>
<td>8</td>
<td>270</td>
<td>6.8</td>
</tr>
<tr>
<td>BXH</td>
<td>5.9</td>
<td>47.2</td>
<td>8</td>
<td>200</td>
<td>4.2</td>
</tr>
<tr>
<td>B</td>
<td>5.0</td>
<td>40.0</td>
<td>8</td>
<td>390</td>
<td>9.8</td>
</tr>
<tr>
<td>Supple.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>5.5</td>
<td>54.0</td>
<td>8.3</td>
<td>760</td>
<td>14.1</td>
</tr>
<tr>
<td>BXH</td>
<td>6.6</td>
<td>62.8</td>
<td>8.3</td>
<td>880</td>
<td>14.0</td>
</tr>
<tr>
<td>B</td>
<td>5.2</td>
<td>51.6</td>
<td>8.3</td>
<td>750</td>
<td>14.5</td>
</tr>
</tbody>
</table>

* ME intake includes the hay plus supplement and assumes hay contains 8.0MJ ME/Kg DM (M/D) and protein meals 10 MJ ME/kg DM.

CONCLUSION

Grazing ruminants, are subjected seasonally to many nutritional deficiencies which affect the efficiency of both digestion and of anabolism absorbed nutrients.

Ruminants at pasture, particularly in tropical areas, produce well below their genetic potential because of these deficiencies. Fermentable - N appears to be the major limiting nutrient for microbial growth and protein synthesis, although both trace and macro mineral deficiencies also occur and affect the rumen microbial growth efficiency. Deficiency of a microbial nutrients coupled with pastures that are low in protein is the reason for a low P/E ratio in the nutrients absorbed. In turn this directly affects the efficiency of conversion of absorbed nutrients into live weight gain. Variation in the ability of animals to (1) selectively graze pasture and secure a high intake of protein or other critical nutrients, (2) to recycle N.S. and P. etc. from the body to the rumen and (3) variation in rumen turnover time, may be major sources of variation in the balance of nutrients available to ruminants.

The P/E ratio in the nutrients absorbed by an animal, is highly correlated with efficiency of feed utilisation and therefore production. A small variation in P/E can thus have very large effects on productivity.

Balancing a forage diet for ruminants with non protein-nitrogen and minerals and with a bypass protein meal may remove the apparent advantages of ruminants selected for growth rate without supplementation. Other responses will occur to such improvements in nutrient balance in grazing animals. These include higher reproduction rate, increased survival of the young animal and increased milk production.

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