SOME THEORETICAL CONSIDERATIONS ON DROUGHT FEEDING RECOMMENDATIONS

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SUMMARY

Drought feeding recommendations have generally emphasised feeding strategies based on the metabolisable energy requirements of livestock. It is suggested that the metabolisable energy system is an outmoded concept (see Graham 1983) and is generally not applicable because resources fed in drought such as grains, molasses, straws and dry pastures are generally deficient in nutrients that support microbial growth in the rumen and also do not provide the balance of nutrients to the animal that ensures their efficient utilisation by the animal.

The balanced nutrient approach to feeding livestock in drought potentially saves 30% or more of feed for productive purposes which would otherwise be wasted as heat.

INTRODUCTION

Drought is possibly the greatest single factor that influences the economics of livestock production enterprises in Australia. The fear of drought is the single most important factor that prevents stocking rates from approaching those theoretically possible particularly on improved pasture.

Prediction of drought, appears now to be more of a reality with the improved knowledge of the El. Nino phenomenon. However, in the backs of the mind of all farmers there is continuous nagging recognition that drought is unpredictable and imminent. Therefore the consequences of drought monopolises much of the thought that goes into the forward planning of a property particularly where drought situations are predictable, such as occurs with annual dry seasons.

There seems to be three major rules when considering a strategy for drought feeding. These are:

1. When a drought is present, if you have to think about what you are doing you will be in no position to obtain the necessary resources to apply modern concepts. You have to know what you are doing and having planned it be thinking about what you will do next if the situation gets worse.

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2. The aim of a drought feeding strategy should always be to optimise the efficiency of utilization of the available least-cost resource. This is nearly always dry pasture early in a drought but becomes more and more a grain, hay/straw or molasses based diet as available pasture is reduced.

3. When a drought is prolonged and pasture is virtually absent, or the animals have grazed as much as is possible without excessive soil erosion occurring, then it is important to use combinations of supplements to optimise utilization of the least expensive (in dollars and labour) feed resource.

From a land conservation point of view these options should be planned so that land (soil) is conserved.

In this paper I discuss aspects of the nutrition of ruminants under drought feeding conditions and emphasise the balanced nutrient approach to drought feeding.

In this presentation I cannot take much cognizance of the overall, overriding problem of soil conservation in periods of drought. Retention of soil and soil fertility is likely to be the ultimate factor affecting the continuing livelihood of Australian farmers, but not the one most pertinent to their needs in the time of drought. This latter fact is sufficient reason for government assistance in order to protect land during droughts.

FEED UTILIZATION BY GRAZING LIVESTOCK

In the past twenty-five years or so, scientists have 'indulged' in intensive research to define the metabolisable energy required for maintenance and production of ruminants. This has largely stemmed from the predominance of these scientists working or being trained in the colder temperate countries, where nutritional problems are few and production diets are seldom deficient in bypass nutrients. In temperate countries nutritional problems tend to be associated more with excessive use of feeds with high nutrient densities then being imbalanced.

These traditional approaches to feeding standards and methods for evaluation of the feeding value of a diet have little or no role to play where ruminant diets are based on forages of variable nutrient densities and where the efficiency of utilisation of metabolisable energy is widely variable and apparently unpredictable (see Leng 1985).

It cannot be emphasised enough that, ruminants do not use energy for maintenance or production but use an array of nutrients which arise primarily from fermentative digestion in the rumen (VFA and the microbial cells) but also intestinal digestion of feed materials that escape microbial degradation in the rumen.

Although the ruminant consumes a wide variety of feeds with variable composition, the nutrients available are reduced to:
- simple organic acids (i.e. volatile fatty acids [VFA], acetic, propionic and butyric acids),

- amino acids arising from microbial proteins (synthesised in the rumen) and from escape or bypass protein digested in the intentines, and
- long chain fatty acids from the feed which are generally unchanged in the rumen and in the digestive system and also microbial fat, synthesised largely from acetate in the rumen.

Because of the rainfall patterns in Australia it seems highly probable that there are only a few occassions throughout the year where the grazing animal obtains a sufficiently well balanced array of nutrients to maximise the efficiency of feed utilisation for a particular productive function. It could be speculated that it is only the suckling animal with its parent at pasture that is ever supplied with sufficient bypass nutrients. For example even the highest quality pasture, as examplified in New Zealand by clover/rye grass at an immature stage, may be used inefficiently when compared with a grain based diet (Table 1). I believe that, ruminants on, both pasture and diets based on grain (but without additional bypass protein) are probably producing considerably more heat than is necessary for maintenance of homeostasis, or the heat increment of production. The evidence for these statements are contained in two reviews (these can be made available to members of this seminar) (Leng 1985; Leng 1987).

Table 1 Efficiency and utilization by lambs of grain/hay diets as compared to green clover/rye grass cut and fed ad lib. (diets were about 80% digestible).

Diet	Liveweight gain g/day	ME intake (MJ/d)	Protein intake (g/day)	F.C.E. (g/g)
High grain/protein pellet	253	13.5	226	4.5
High grain pellet	130	9.7	118	6.4
Clover (60)/rye grass (30)	143	13.0	292	7.7

(after Geenty et al. 1987)

Nutrients needed to balance feeds for production

These are essentially nutrients needed in the diet that are available directly to the animal because they are either protected from rumen fermentation (e.g. insoluble proteins providing intestinal amino acids or certain grains [sorghum, maize and rice] which because of their structure are not fermented completely) or are not metabolised by anaerobic microbes in the rumen (e.g. long chain fatty acids).

The actual nutrients required are glucose, essential amino acids and perhaps long chain fatty acids which are essential in various combinations for growth, growth of the uterus and foetus and for milk synthesis. The evidence for this is discussed elsewhere (see Leng 1987). In practical terms these requirements are often met by feeding a bypass protein meal containing some residual oil (Leng and Brumby 1986).

BALANCED FEEDING AS APPLIED TO MAINTENANCE OR SURVIVAL FEEDING

In very few instances do we wish to feed for maximum production in drought. In most situations we wish to use, as efficiently as possible, a restricted amount of feed to maintain animals or to feed for survival. With pregnant and lactating animals it is always necessary to feed for the maintenance of foetus and for maintenance of a minimal milk production.

As few graziers can afford to miss a crop of young animals, consideration must also be taken of the need to feed for high fecundity.

Research in which animals are fed for maintenance has illustrated that these animals are highly inefficient in utilizing feeds, if the nutrients available are not in balanced quantities. Some examples are given in the tables. The effects of balancing the rumen with urea/sulphur is illustrated in Table 2 and of feeding the animal extra bypass proteins on low digestibility roughage based diets is illustrated in Tables 2 and 3. The effects of providing a bypass protein in a diet high in soluble protein is shown in Table 4.

The point that must be stressed is that adding a bypass protein to an imbalanced feed improves the efficiency of feed utilization or conversely decreases the amount of heat generated by animals under these circumstances.

The evidence presented in these tables indicate the principles of ruminant feeding which involves providing nutrients for the two systems (i.e. the rumen organisms and the animal).

When the ruminant is deficient in nitrogen or sulphur (or any growth factor) microbial growth efficiency in the rumen is low. That is, the quantity of microbial cells systhesised relative to VFA produced is low. It is emphasised that the feed presented to the microbial fermentation system in the rumen provides the precursors for both microbial cells (the major amino acid source for the animal) and for VFA (Leng 1981).

Table 2 The effect of feeding urea/sulphur and bypass protein on hay (45% digestible, 0.4% N) intake and production of growing or pregnant cattle (Lindsay and Loxton 1981; Lindsay et al. 1982)

Supplement	Intake (kg/d)	Liveweight Change (kg/day)
Growing cattle (170 kg liveweight)		
None	2.26	-0.41
Urea/sulphur	3.01	-0.32
Urea/sulphur plus bypass protein (500 g/d)	4.43	+0.22
Pregnant cattle (last 60 days)		
None	4.2	-0.81
Urea/sulphur	6.2	-0.31
Urea/sulphur plus bypass protein (1 kg/d)	8.1	+0.75

Table 3 Efficiency of utilisation of straw by sheep with and without protein and N supplements (Sudana and Leng 1986)

Diet	Intake g/d	Liveweight gain (g/d)	FCE.
Straw	333	-53	?
Straw/cottonseed meal/(urea/molasses)	691	90	7.7

Table 4 The effect of feeding a bypass protein (cottonseed meal) with whole cottonseed on bodyweight change of mature cows under drought feeding conditions.

	Body weight		Weight
Ration	Initial (kg)	Final (kg)	Change (g/day)
Whole cottonseed (3 kg/d)	452	461	48
Whole cottonseed (2 kg/d) plus cottonseed meal (1 kg/d)	471	501	575

(Thompson & Dixon 1986, N.S.W. Dept. of Agriculture, Glenn Innes, Pers. comm.)

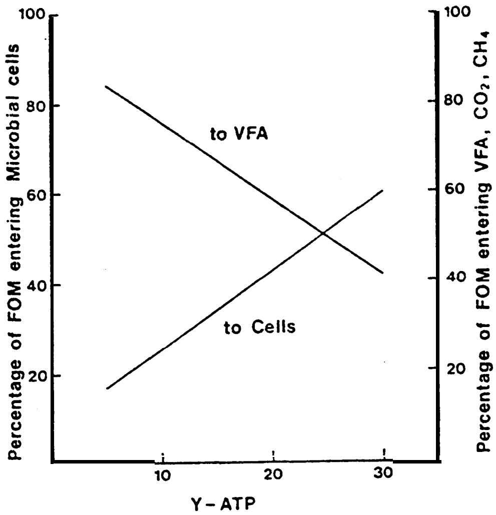

Fig. 1 Relationship between the efficiency of microbial growth (Y-ATP) and the percentage of fermented feed synthesised into microbial cells and converted to VFA, CO_2 and CH_4.

There is therefore an inverse relationship between microbial protein production and VFA production (see Fig. 1). A slight inefficency in microbial growth changes the protein (P) to energy (E) ratio in the end products quite markedly, as illustrated in Table 5. There is also a concomitant increase in heat and methane production as microbial growth efficiency decreases (see Leng 1982).

Balancing nutrients for the rumen microbial ecosystem

The effect of a deficiency of a major microbial nutrient (e.g. ammonia or sulphur) leads to a low microbial protein to VFA energy (P:E ratio) in the nutrients arising in fermentative digestion. If the deficiency is severe, then digestibility of feed in the rumen will also be reduced.

Table 5 The effect of different efficiencies of microbial growth (i.e. Y_{ATP} in g dry cells produced per mole ATP available) on ratio of protein to VFA energy (P:E) available to ruminants

Y_{ATP}	Microbial protein produced (g/d)	VFA energy (MJ)	Methane energy (A) (MJ)	Heat (B) (MJ)	Total energy losses (A+B)	Energy lost (% Dig. energy)	P:E (g/MJ)
8	498	55.5	9.4	6.4	15.8	22	9
14	798	46.8	8.5	5.1	13.6	19	17
19	1008	40.8	8.0	4.3	12.3	17	24
25	1212	34.9	7.6	3.1	10.7	15	34

Example is for a steer consuming 4 kg fermented organic matter (Leng 1981).

Calculation of the effects of a changing efficiency of microbial growth in the rumen on the P:E ratio in absorbed nutrients is shown in Table 5. This indicates how inefficient the rumen could be if there was a major deficiency of a microbial metabolite.

Whilst the efficiency of microbial growth alters the P:E ratio in the nutrients absorbed quite markedly, protein that is undegraded in the rumen will also have a pronounced effect on P:E ratio. For example at a normal microbial growth efficiency in the rumen the P:E ratio might be 17:1 however feeding say 400 g digestible bypass protein would alter this ratio to 26:1 (see Table 5).

The contributions of microbial and dietary protein to amino acids absorbed

It is pertinent here to point out that a protein protected from rumen fermentation may be 75% digestible and therefore supplies approximately 75g amino acids per 100 g protein fed to the animal. If protein were not protected and therefore fermented in the rumen the supply of amino acids to the animal is approximately one tenth of this (i.e. 7.0 g/100 g protein fed). This results because microbial degradation of protein in the rumen yields approximately half the ATP of an equivalent amount of carbohydrate fermented. Assuming that the efficiency of microbial growth on carbohydrate in the rumen is 30g N (188g protein) fixed into microbes per kg OM fermentation, then the efficiency of microbial growth or protein synthesis will be half this (i.e. 1 kg of protein degraded gives rise to 15gN (94 g protein) fixed into microbes.

Thus if digestibility of microbial and dietary protein is 75% in the intestines, the nett yields of amino acids will be approximately 140g, 70g, 750g from carbohydrate and protein fermented in the rumen and protein bypassing the rumen respectively or the quantities of amino acids available from a soluble versus a bypass protein is roughly in the ratio of 1 to 10. This indicates how wasteful it is to feed rumen-degradable proteins to ruminants.

Balancing nutrients in the animal

If the absorbed nutrients are imbalanced relative to the animal's needs, then the animal must adjust these nutrient balances. As the largest proportion of the feed is converted in the rumen and intestinal tract to non-glucogenic substrates, then the likely imbalance will always tend to be the availablility of acetogenic VFA (acetate and butyrate) to glucogenic substrate (largely propionate) and essential amino acids. The animal has little option but to either wastefully oxidise (in futile cycles) the acetogenic substrate (burn off) or it may decrease its feed intake. If the amount of extra heat generated is similar to that produced in fasting animals over and above basal metabolic heat, as shown by Fattet et al. 1984, this would mean that 30% of the energy in a diet is lost in wasteful cycles of metabolism due to an imbalanced nutrient supply (or in practical terms due to lack of sufficient bypass protein in a diet).

,A heat load due to the oxidation of 30% of the nutrients absorbed would impose a critical heat load in animals at high environmental temperatures or moderate temperature and high humidity. It would however impose little stress on animals at low ambient temperatures, and may even by beneficial, as the heat would be used for maintenance of body temperature.

This emphasises that ruminants in the hot or the hot-humid tropics require different approaches to feeding standards. More importantly however where nutrients are balanced there is a large potential reduction in total feed requirements in order to maintain animals. Balancing diets for ruminants in hand feeding situations will result in animals in much better condition at the end of the drought because they use the available feed more efficiently.

Future Directions

Feeding ruminants in drought, must consider that optimisation of the efficiency of feed utilisation is of major economic importance and can only be achieved by a balanced nutrient approach.

This balanced nutrient approach to drought feeding needs considerable research so as to provide farmers with sets of feeding guidelines. In this respect the role of the applied nutritionist is to be able to identify the limiting nutrients in a diet, to formulate feeds on the basis of this knowledge; the applied researcher needs also to identify primary limiting nutrients but his role must be to produce locally applicable response relationships for economic evaluation of supplements and feeding systems (see Figure 2). The role of the more basic scientist is to research the mechanisms by which the nutrient deficiencies in feeds can be identified so as to provide information on appropriate supplements.

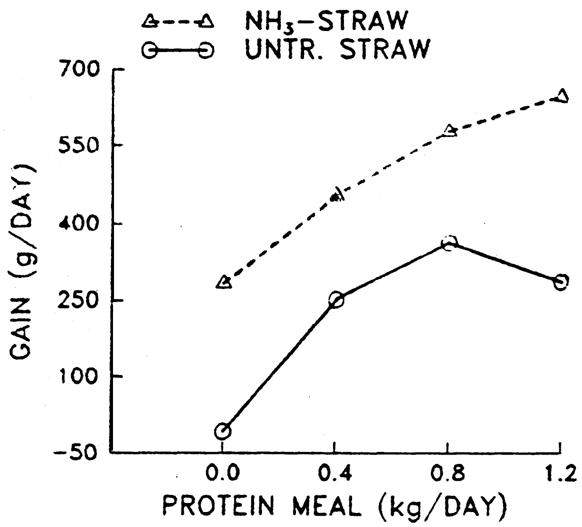

Fig. 2 The effects on body weight gain of cattle of supplementing untreated or treated straw based diets with a bypass protein meal (Perdok and Leng 1987).

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