CEREAL OR LEGUME GRAINS AS SUPPLEMENTS FOR ANIMALS GRAZING STUBBLE OR DRY PASTURE

J. B. Rowe *, G.D. Tudor**, R.M. Dixon[t] and A.R. Egan†

SUMMARY

A principal role of supplements for grazing sheep and cattle in Australia is to control liveweight loss when pasture is available but of low quality. Much of the information published on supplementary feeding is based on studies in which animals have been fed in pens for moderate to high levels of liveweight gain. This information is of limited applicability to situations of animals losing weight under grazing conditions. This review discusses some of the practical factors associated with animal responses to supplements and the interpretation of supplementary feeding experiments.

The cost of supplementary feeding is an important factor influencing the profitability of grazing livestock enterprises in Australia. For this reason it is important to review the reasons for recommending the more expensive protein-based supplements. There appears to be little evidence that liveweight loss in young animals can be reduced by additional absorbed amino acids when substrates for rumen microbial fermentation have been adequately provided. Supplements with high levels of true protein (oilseed meals, grain legumes) are convenient to use since adverse effects such as acidosis are not usually encountered. However, similar responses can be obtained with supplements based on cereal grain provided sufficient NPN/S are present and strategies are adopted to alleviate detrimental effects associated with the presence of starch.

INTRODUCTION

While there is general agreement that the nutritional value of supplements for roughage based diets cannot be described as a function of any single parameter such as metabolisable energy or total protein, there are various schools of thought on the relative importance of factors such as the content and the form of rumen degradable nitrogen and the need to supply specific amino acids as undegraded dietary protein (UDP). The different conclusions are in large part due to different experimental conditions between studies, and-differing perceptions of the extent to which specific studies reflect conditions commonly encountered in grazing situations. An interpretation of the available information on supplementary feeding needs to take account of the following factors: (i) the nutrient requirements of the animal; (ii) nutrients provided by the basal roughage; (iii) nutrients provided by the supplementary feed;

* Department of Agriculture, Baron-Hay Court, South Perth, W.A. **6151,**
** Department of Agriculture, P.O. Box *1231,* Bunbury, W.A. *6230*
t School of Agriculture & Forestry, University of Melbourne, Parkville, Vic. *3052*

and (iv) the effect of the supplementary feed on the digestion and utilization of the basal roughage.

In this review we have tried to define the importance of some factors which may affect the results of supplementary feeding experiments with particular reference to young sheep losing liveweight when grazing dry pastures or cereal stubble. This approach is then used as the basis for discussing the importance of high protein supplements and the development of more cost effective alternatives based on cereal grains.

Nutrient requirements of the animal

The single most important factor affecting nutrient requirement is the animal's physiological state since this will determine what nutrients. are required and the amount of each nutrient needed for optimal production. In the case of animals losing liveweight and mobilizing body tissue to provide energy for maintenance, any dietary nutrient which can provide metabolisable energy (ME) will be used in lieu of that derived from metabolized tissue and will be used with an efficiency reflecting its ability to provide ME. While it is evident that different substrates are used with varying efficiencies for tissue synthesis it appears that ME determines the efficiency with which they are used for maintenance. Furthermore it is likely that in young sheep losing liveweight there will be a considerable amount of muscle mobilisation since fat reserves are relatively small (Dove et al. 1991). It is also likely that requirements for specific amino acids for metabolic processes can largely be met by re-utilising mobilized amino acids. It therefore appears unlikely that in young sheep losing liveweight there would be a need for additional amino acids in the diet in the form of UDP. This is supported by data presented by Dixon et. al. (1989) where it was shown that cereal grain plus NPN/S was as effective as oilseed meals (providing UDP) to decrease liveweight loss in young sheep – although differences between. these supplements were observed for sheep gaining liveweight.

The requirement for additional absorbed amino acid in pregnant and lactating animals is likely to be much higher than in young sheep losing liveweight. Under these conditions responses to supplements providing UDP are more likely and have been reported by Hall (1.989) and Lynch et al. (1990).

The nutritional history of the animal may also influence its response to supplements. From experiments simulating drought feeding rations and from direct measurements (Briggs et al. 1957; Gingins et al. 1980), it appears that maintenance energy requirements of animals which have had a prolonged period of undernutrition is considerably less than for equivalent animals which are well fed. In addition, animals which have had a reduced rate of growth or a period of weight loss may have a different pattern of tissue deposition when improved nutrient intake allows net tissue deposition to resume. Therefore reduced metabolic rate and compensatory growth patterns can be

important factors in any supplementary feeding trial and need to be considered in the design and interpretation of these studies.

The basal roughage diet

Wide variation in the nutritive value of senesced pasture and stubbles are to be expected as a result of environmental conditions, different pasture species and the conditions of pasture growth. Even within one pasture species wide variation occurs in proportions of morphological components contents of essential nutrients and digestibility (Pearce et al. 1987). The ability of grazing animals to select certain plant species as well as different morphological components within plants species has an important effect on the actual nutritive value of a pasture or stubble being grazed. The prediction of nutrient supply from an analysis of the pasture is therefore very difficult and can lead to inappropriate conclusions (Hodgson 1982; May and Barker 1984; Hogan et al. 1987). Variation in factors such as the leaf:stem ratio, resistance of various types of fibre to prehension, large particle breakdown, microbial fermentation and contents of es'sential nutrients can all influence the supply of nutrients to the animal. Discussion here is limited to the effect of digestibility and the effect of substrates for rumen microbes.

Substrates for rumen microbes Rumen microbial substrates, particularly nitrogen and sulphur, are essential for the rumen fermentation. Since they can be provided economically if necessary as NPN and inorganic S, it is useful to consider whether responses to concentrate supplements can be explained simply by the fact that they also provide these essential substrates. Under pen-feeding conditions the supply of nitrogen and sulphur to roughages deficient in these minerals has usually had a greater positive effect on the intake of the basal diet than any other nutritional or dietary manipulation. For 'example in the experiments of: Bird (1974); Lindsay and Loxton (1981); Hennessy (1987); and Lee et al. (1987), roughage intake was increased by between 25 and 150% through addition of rumen degradable nitrogen (RDN') and S. This illustrates how other effects associated with concentrate supplements may be masked by the effect of these substrates on rumen fermentation and feed intake. In conducting supplementary feeding experiments using pen-fed animals should the basal diet contain sufficient RDN and S to remove these as possible confounding factors? To answer this we need to ask whether or not adequate nitrogen and sulphur would be available under the grazing conditions for which the results will be applied. This question has been the subject of reviews by Loosli and McDonald (1968), Leng et al. (1973), Round (1976), Mulholland (1980) and Fels (1986). In all of these reviews it was concluded that there was no evidence for an economic response to supplements of NPN. Based on the conclusions of these reviews it is suggested that under dry-season grazing conditions there is nearly always sufficient "green pick" and seeds available which provide adequate levels of rumen nitrogen and sulphur for efficient rumen function.. There are exceptions to this general conclusion as responses to NPN have been reported for cattle losing weight (eg Winks et

1979). It is however suggested that in pen-feeding experiments, to examine responses to concentrate supplements, adequate RDN and S should be provided to remove the possiblility of this being a confounding factor. Preferably this should be provided in a form such as high-protein legume or grass hay similar to that occurring in the paddock.

Characteristics of the basal roughage Among the characteristics of basal roughages, digestibility has been associated with a marked effect on the response in feed intake to supplementation. Fig. 1 summarizes data from a number of experiments where supplements were fed with basal roughages of different digestibility. When roughages of low digestibility (around 45%) were used there were increases in roughage intake in response to the additions of supplement up to a' level representing around 20% of the total diet. This is quite a different pattern to that seen when better quality roughages (digestibilities of around 60%) were fed. With better roughages there appeared to be substitution even when relatively low levels of supplement were fed. This effect on feed intake is possibly explained by the increase in digestibility of the whole diet (including that of the roughage fraction) as a result of adding small amounts of readily fermented supplements to poor quality roughages. There is evidence (Dixon 1985, 1986 a, b) that poorer quality roughages are more affected than are better quality roughages by low availability of microbial substrates and by starch/fibre interactions. It is therefore possible that differences between roughages of different quality may not only be due to digestibility per se but also to other factors correlated with digestibility. From Fig. 1, it appears that the major effect of roughage quality on the substitution rate occurs when supplements comprise up to 20% of the total diet which is the range within which most supplements are fed under commercial conditions and a closer analysis the relationship between roughage quality and substitution rate when the intake of supplement constitutes up to 20% of the total diet indicates a positive relationship ($R^2 = 0.80$) between roughage digestibility and substitution rate.

Although there is obviously no universal answer as to what is the most appropriate type of roughage to use in supplementary feeding experiments a roughage which is of better quality than the "average" composition of pasture available for selection may often be most appropriate. In this way the roughage which is offered under pen feeding conditions may more closely relate to that which is ingested under paddock conditions.

Interval of feeding

Under most field conditions supplements are fed once or twice a week. Daily feeding under commercial conditions requires more labour and transport and is also likely to be less satisfactory in terms of achieving uniform intake of supplement. An obvious consequence of increasing the interval between feeding supplements is that each time the supplement is fed the amount offered is far higher than that offered as part of a daily ration. For example feeding sheep a supplement at a level

equivalent to *200* g/d (approximately *20%* of the total diet) twice weekly the amount offered is actually 600 to 800 g on the day it is fed out (60 to 80% of the average daily intake). A second important consequence of an increased interval of feeding is the uneven supply of nutrients to the rumen microbes and to the animal.

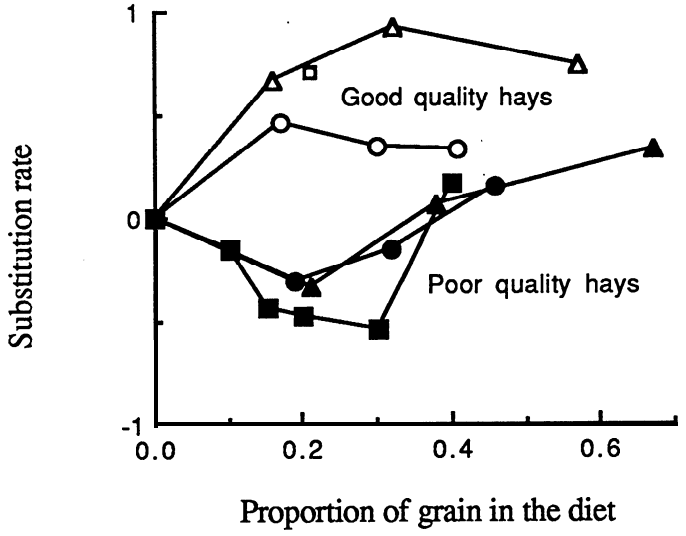

Fig. 1. *The effect of roughage quality on the response to different levels of grain supplementation given daily or twice daily. The data is taken from: Eadie and Lamb (1976), (-o--●-); Suiter* (1980) *(-Δ-, -▲-) Godfrey et al.* 1991 *(-□-) and Mulholland et al. 1976 (-■-). Enclosed symbols indicate data for roughages of* 40 -45% *digestibility and open symbols hay of around* 60% *digestibility. All diets represented here were balanced for nitrogen and sulphur and the supplements were either mixed into the basal diet or fed daily.*

Egan et al. (1987) examined effects on rumen fermentation when supplements were provided daily or each third day. Rumen pH was more adversely affected by an amount of triticale grain, lupins or sunflower meal supplement when fed every third day rather than daily. Rumen ammonia substrate levels were not maintained throughout the 3 day feeding cycle even by the high protein supplements. In addition nylon bag digestibility measurements indicated that, on average, roughage fermentation was 17 per cent lower when triticale was fed each third day rather than daily.

The effect of interval of starch or sugar based supplements on substitution rate in several experiments is shown in Fig.2. It appears that in most experiments increasing interval of feeding supplements was associated with increases in substitution rate although this did not occur in all experiments.

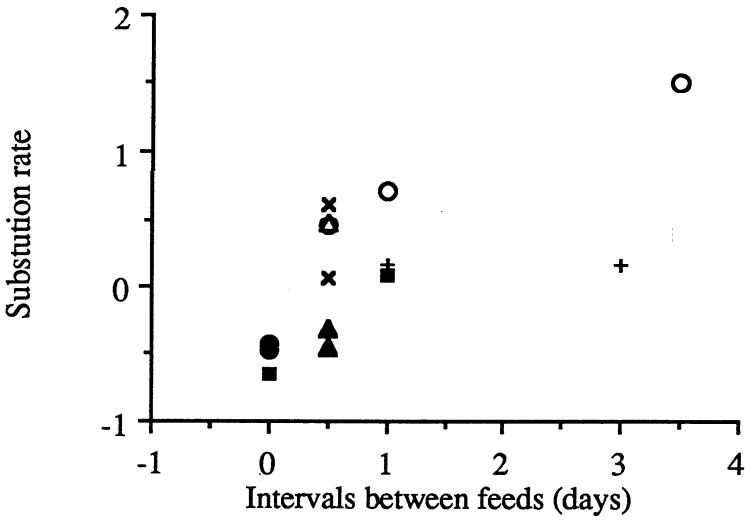

Fig.2. *Relationship between the interval of feeding a supplement based on starch or soluble carbohydrate and the level of substitution which occurs. Data is taken from Lamb and Eadie 1979 (A, A), Godfrey et al. 1991 (o) Mulholland et al. 1976 (●), Leibholz and Kellaway 1984 (■), Fredericks et al. 1986 (+), Lee et al. 1987 (x) and Rowe and Aitchison 1987 (*).*

There are only a few reports of production trials where supplements have been fed daily or less frequently and the results of these are inconsistent. Godfrey et al. (1991) (Figure *3)* observed decreases in liveweight gain when supplementation interval was increased for both barley or lupin feeding. The effect was greater in the case of barley than for lupins and was not accounted for by roughage intake. This suggests that increasing interval of providing the barley supplement was associated with larger depressions in roughage digestibility and/or imbalance of absorbed nutrients for utilization in liveweight gain than when lupins were fed. Rowe and Aitchison (1987) also observed much lower responses in liveweight gain with barley supplements than lupin supplements which were not explained by changes in roughage intake. In contrast to these results Egan et al. (1987) observed greater improvement in liveweight gain and wool growth when cereal grains were fed each third day rather than daily but no difference associated with lupins or oilseed meal supplements. However in this latter experiment pasture availability was limited and may explain the fact that the results were different from those of Godfrey et al. (1991).

Overcoming the adverse effects of starch on rumen fermentation

It is well known (Terry et al. 1969; Mulholland et al. 1976; Aitchison et al. 1986) that the inclusion of readily available carbohydrate in the diet decreases the digestibility and intake

of roughage. These effects appear to be particularly large in gramineous roughages of low digestibility (Dixon 1985, 1986a) and could be markedly affected by the interval of feeding the supplement. It appears that this interaction between interval of feeding and the type of supplement is a key factor affecting the animal response to high protein or high cereal grain supplements. Comparisons of "protein" supplements with "energy" supplements is often difficult because the "protein" supplements also provide appreciable amounts of digestible energy. This digestible energy, even when rapidly fermented, does not have the same adverse effect on rumen fibre digestion as is observed in association with the fermentation of cereal grains high in starch.

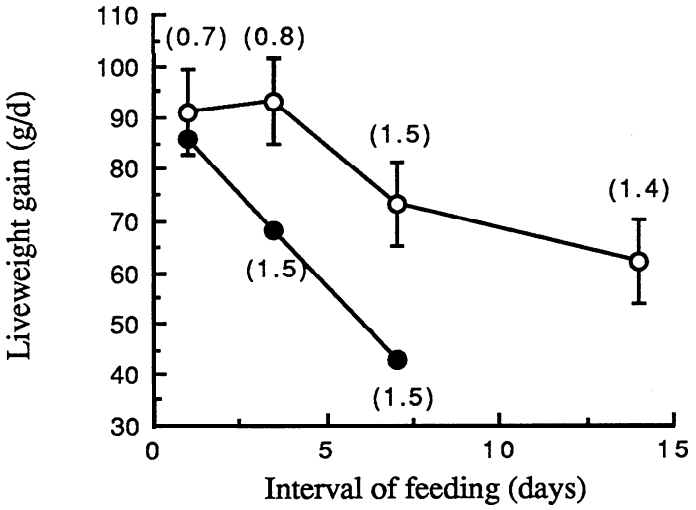

Fig. 3. *The relationship between the interval of feeding a supplement at a level equivalent to 200 g/d. Data are shown for lupin (-o-) and barley (-●-). The figures in brackets indicate the substitution rate (supplement for roughage) for each treatment. (from Godfrey et al. 1991).*

There are a number of possible ways to alleviate the adverse effects of the high starch supplements. These include: (i) the addition of urea to the supplement in order to provide a more balanced set of nutrients for the rumen microbes; (ii) manipulation of the rate of fermentation through processing; (iii) manipulation of the rate of cereal grain consumption by using limiters; (iv) treatment with formaldehyde; (v) maintenance of rumen pH with buffering agents; (vi) inoculation of the rumen with fluid from animals adapted to a starch-based diet; or (vi) through manipulation of fermentation away from the pathways associated with rapid starch fermentation and in particular to avoid lactic acid accumulation. The group at the Western Australian Department of Agriculture has undertaken a number of studies on the use of buffering agents and the use of compounds which manipulate rumen fermentation and control the end-products of starch breakdown (McDonald et al. 1986;

Aitchison et al. 1986). These studies indicated that antimicrobial feed additives provided a far better control of rumen pH and lactic acid production than that achieved with bicarbonate or bentonite. Further work by Nagaraja et al. (1987) and Rowe et al. 1989) identified virginiamycin as an effective compound for controlling the adverse effect of starch fermentation, particularly that of lactate production. The use of this feed additive was investigated by Godfrey et al. (1991) in an experiment where barley grain and lupins were fed as supplements with chaffed hay. The barley was fed with or without virginiamycin *(40* mg/kg) and all supplements were fed at a rate equivalent to *200* g/d daily, twice weekly, weekly and, in the case of lupins and barley with virginiamycin at 14 day intervals. The effect of the different supplements on intake and liveweight gain are shown in Table 1.

TABLE 1 The effect of virginiamycin on the utilization of a barley supplement by sheep. The supplement was fed at a rate equivalent to *200* g/d at various intervals. The liveweight gains are for 9 weeks after a gradual stepwise introduction of animals to the supplement which lasted *3* weeks (Godfrey et al. 1991).

Interval of Feeding (days)	Barley	Barley + Virginiamycin	Lupins
Roughage intake (g DM/d)	SED 46.7	Control 1232	
1	1084	1026	1078
3.5	939	1038	1086
7	927	974	934
14		950	948
Liveweight gain (g/d)	SED 7.9	Control 48	
1	86	85	91
3.5	68	81	93
7	43	70	73
14		56	62

The results of this experiment indicate that if the adverse patterns of fermentation can be controlled by virginiamycin then barley may be as good a supplement as lupin grain in terms of its effect on roughage intake, the digestion and utilization of nutrients and the convenience of feeding at less regular intervals than daily or twice weekly. The improved response to feeding a high-starch grain in combination with virginiamycin provides further evidence for the importance of starch and other sources of readily fermentable carbohydrate as negative factors in traditional "energy" supplements and provides another means of determining whether protein is such an important component in supplements for grazing animals. More work is needed to explore the use of virginiamycin in other dietary situations and to

investigate other options for the control of the adverse effects of the readily fermentable carbohydrate.

IS PROTEIN IMPORTANT IN SUPPLEMENTS FOR GRAZING ANIMALS?

Responses to high protein supplements have been widely observed in pen feeding experiments and grazing trials. The question asked here is whether these responses as alleviation of weight loss are due to supply of nutrients for rumen microbial fermentation or whether there has been a response specifically to additional amino acids derived from UDP. The available evidence suggests that supplements based on readily fermentable carbohydrates, with adequate RDN and S, can be as effective as high protein supplements in feeding to maintain liveweight. It appears that practically all situations where superior responses are reported in favour of the high protein supplements this is associated with one of the following: (i) inadequate RDN and S provided under pen feeding conditions; (ii) discontinuous supply of high-starch, or soluble carbohydrate supplements; or (iii) supplements being fed to achieve growth rates or milk production. It is suggested that since RDN is available under most grazing conditions and/or it can be economically supplied in inorganic forms this should not be a reason for feeding the more expensive protein-based supplements. On most farms in Australia animals are only fed supplements for survival – not production. It is suggestedthat the main problem with supplements containing high levels of starch and soluble carbohydrate is the negative effect associated with the interval of feeding and not the fact that these feed are low in protein.

CONCLUSIONS

Conditions in supplementary feeding experiments should obviously reflect as closely as possible the field situation of interest. We suggest that in the interpretation of experiments there has often been insufficient attention given to variables such as the selection of roughage of higher quality than the average of the pasture on offer, to the consequences of feeding supplements 'at intervals of twice or once per week, and to the type and nutritional history of animals used in the experiments. Much of the disagreement in the literature about the responses to be expected from grazing animals to various supplements appears to be associated with assumptions on the extent to which specific experiments reflect "normal" conditions for grazing animals.

When supplements are fed under grazing conditions to prevent an excessive rate of liveweight loss there appears to be no evidence for UDP being essential to stimulate feed intake or to make nutrient utilization more efficient. It appears that this belief has arisen from the negative effects of starch or sugar-rich supplements on the digestion and utilization of the basal diet and from experiments where insufficient nitrogen has been included in the basal diet to reflect the true status of the feed actually ingested under grazing conditions.

There are significant differences in the cost of high protein supplements and energy supplements such as molasses and

the cereal grains. Research in the area of supplementary feeding should concentrate on developing ways of feeding these low-cost energy supplements in order to overcome the problems associated with the intermittent intake of large quantities of readily fermentable carbohydrate. The use of virginiamycin appears to offer a practical and economical starting point for this line of research.

REFERENCES

AITCHISON, E.M., GILL, M. and OSBOURNE, D.F. (1986) Br. J. Nutr. 56: 477-486.

AITCHISON, E.M., MCDONALD, C.L.CASSON, P. and ROWE, J.B.(1987) Proc. Nutr. Soc. 46: 41A.

BIRD, P.R. (1974). Aust. J. Agric. Res. 25: 631-642.

BRIGGS, P.K., FRANKLIN, M.C., and MCCLYMONT, G.L. (1957) Aust J. Agric. Res. 8: 75-82.

DIXON, R.M. (1985). In "Recent Advances in Animal Nutrition in Australia", paper 5, editor R.B. Cumming. (University of New England Publishing Unit, Armidale).

DIXON, R.M. (1986a). Proc. Nut. Soc. Aust. 11:110.

DIXON, R.M. (1986b). Anim. Feed Sci. Tech. 14:193.

DIXON, R.M., KARDA, W., and HOSKING, B. Oilseed meals or fortified barley grain supplements for young sheep fed roughage diets. In "Recent Advances in Animal Nutrition in Australia 1989", p. 15, ed. D.J. Farrell, (University of New England Publishing Unit, Armidale).

DOVE, H., DOYLE, P.T., HART, F.J., DIXON, R.M., FREER, M. and EGAN, A.R. (1991). In "Proc Third International Symposium on the Nutrition of' Herbivores", Malaysia (In press).

EGAN, A.R., FREDERICK, F. and DIXON, R.M. (1987) Improving efficiency of use of supplements by manipulation of management procedures. In: "Ruminant Feeding Systems Utilizing Fibrous Agricultural Residues - 1986." pp 69-81, ed R.M. Dixon, (IDP: Canberra).

FELS, H.E. (1986) Urea Supplements in Licks Blocks or Drinking Water. In: "Nutrition of Sheep - Principles and Current Research" (Sheep and Wool Branch, Department of Agriculture, Western Australia).

FREDERICKS, F., DIXON, R.M. HOLMES, J.H.G. AND EGAN, A.R. (1986) Proc. Aust. Soc. Anim. Prod. 16: 207-10.

GINGINS, M., BICKEL, H. and SCHURCH, A. (1980). Livestock Prod. Sci. 7: 465-471

GODFREY, S.I., MURRAY, P.J. and ROWE, J.B. (1991) Unpublished.

HALL, D.G. (1989). PhD. Thesis, The University of Melbourne.

HENNESSY, D.W. (1987). The role of nutrition in the genotype x environment interactions of Bos taurus and Bos indicus cattle in New South Wales. In "Recent Advances in Animal Nutrition in Australia 1987", pp. 64-71, ed. D.J. Farrell, (University of New England Publishing Unit, Armidale).

HODGSON, J. (1982). In "Nutritional Limits to Animal Production from Pastures", p. 153, editor J.B. Hacker. (Commonwealth Agricultural Bureaux, Farnham Royal, UK).

HOGAN, J.P., KENNEY, P.A. and WESTON, R.H. (1987). In "Temperate Pastures: Their Use and Management", p. 317, eds J.H. Wheeler, C.J. Pearson and G.E. Robards (CSIRO:Australia).

LAMB, C.S. and EADIE, J. (1979) J. agric. Sci. Camb. 92: 235-241.

LEE, G.J., HENNESSY, D.W., NOLAN, J.V. and LENG, R.A. (1987). Aust. J. Agric. Res 38: 195-207

LEIBHOLZ, Jane and KELLAWAY, R.C. (1984). The utilization of low quality roughages I. The role of nitrogen and energy supplements. AMRC Review No. 49

LENG, R.A., MURRAY, R.M., NOLAN, J.V. and NORTON, B.W. (1973). Supplementing grazing ruminants with urea-molasses mixtures. AMRC Reviews No. 15.

LINDSAY, J.A. and LOXTON, I.D. (1981). Supplementation of tropical forage diets with protected protein. In "Recent Advances in Animal Nutrition in Australia 1981, p. 1A, ed. D.J. Farrell (University of New England Publishing Unit, Armidale).

LOOSLI, J.K. and McDONALD, I.W. (1968). Non-protein nitrogen in the nutrition of ruminants. FAO Agric. Studies No. 75. (FAO: Rome)

LYNCH, J.J., LENG, R.A., HINCH, G.N., NOLAN, J.V., BINDON, B.M. and PIPER, L.R. (1990). Proc. Aust. Soc. Anim. Prod 18:516.

MAY P.J. and BARKER, D.J. (1984) Aust. J. Exp. Agric. Anim. Husb. 24: 15-19.

MCDONALD, C.L., AITCHISON, E.M. and ROWE, J.B. (1987) Proc. Nutr. Soc. 46: 40A.

MULHOLLAND, J.G. (1980) Response of grazing sheep to urea supplements. In: "Urea Licks and Blocks for Sheep and Cattle" pp 36-48, ed D.J. Barker, (Australian Society of Animal Production, WA).

MULHOLLAND, J.G., COOMBE, J,B, and McMANUS, W.R. (1976). Aust. J. Agric. Res 27: 139-153

NAGARAJA, T.G., TAYLOR, M.B., HARMON, D.L. and BOYER, J.E. (1987) J. Anim. Sci. 65:1064-76.

PEARCE, G.R., SIMPSON, R.J., BALLARD, R. and STEPHENSON, D. (1987). In "Temperate Pastures: Their Use and Management", p. 427, eds J.H. Wheeler, C.J. Pearson and G.E. Robards (CSIRO:Australia).

ROUND, M.H. (1976) Technical Information Circular No 28. Department of Agriculture and Fisheries, South Australia.

ROWE, J.B. and AITCHISON, E.M. (1987) In: "Herbivore Nutrition Research" ed Mary Rose, pp 185-6.(Australian Society of Animal Production).

ROWE, J.B., WINSLOW, S.G. and P.J. MURRAY (1989) Asian-Aust. J. Anim. Sci. 2: 346-8

SUITER, R.J. (1980) Principles of grain feeding in the paddock. In: "Grain feeding of sheep for survival an growth" ed. R.A. Hunter (Australian Society of Animal Production, WA Branch).

TERRY, R.A., TILLEY, J.M.A. and OUTEN, G.E. (1969). J. Sci. Food Agric. 20: 317-320.

WINKS, L., LAING, A.R. O'ROURKE, P.K. and WRIGHT, G.S. (1979). Aust. J. Exp. Agric. Anim. Husb. 19: 522-529.