Proc. Fourteenth Ann. Conf. Grassld. Soc. NSW, 1999, pp. 30-36.

Supplementation as a strategy for sheep and cattle producers

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Abstract: The supplementary feeding of ruminant livestock is considered against a background of forage grazing. The pasture conditions under which supplementation may be effective and economically viable are described, with reference to the limits of intake imposed by the ruminant digestion system. Specific needs for metabolisable energy and protein for both maintenance and various forms of livestock production are examined as indicators of the appropriate ingredients to be included in supplementary rations for ruminants.

Supplementary feeding may be practised for one of three basic reasons: to keep stock from losing weight (*e.g.* drought feeding); to enhance production through moderate weight gain at a strategic time (*e.g.* flushing of ewes, weaner growth, increased milk production, increased fibre production); or to optimise growth rate of stock to be marketed.

Supplementary feeding of ruminant livestock can mean anything from the provision of one mineral that is deficient in the diet, to the offering of a compounded ration that is designed to produce optimum growth rate. In this paper, the emphasis will be on hay, silage and cereal grain that may be readily available on farms, and inexpensive sources of protein or protein-precursors such as urea that may be purchased for inclusion in a supplementary ration.

To Feed or Not to Feed ?

We can examine supplementary feeding systematically by considering **why** we might feed, **when** we might feed, and **what** we might feed. The aspect of **how** we should feed is a large topic beyond inclusion in this paper. It is one, however, that producers should look into when implementing supplementary feeding, because management pract-ices which overcome such things as wastage, shy feeders, grain poisoning, urea poisoning *etc.*, can be very important to the success of the nutritional management programme.

In considering whether there is a need (or desire) to supplementary feed, a producer should review the immediate objectives associated with each aspect of his livestock enterprises. As indicated, the most likely reasons for supplementary feeding are: to arrest or slow the rate of liveweight loss, to boost reproductive performance, to ensure optimum grow-th rate in stock destined for market, or to improve the appearance of stock.

The arresting of liveweight loss is usually associated with feeding during drought or a pro-longed seasonal trough, and basically involves holding a flock or herd at close to maintenance for a given time. Survival feeding at maintenance may mean that stock are given the entire ration they require to survive. Alternatively, it may mean they are given feed in addition (supplementary feed) to the intake they can derive from grazing.

Enhancing reproductive performance in sheep usually involves promotion of moderate liveweight gain in young ewes prior to their first joining, enhancing the condition of all ewes prior to joining (i.e. flushing), building up ewes prior to lambing to enhance lamb survival and/or ewe milk production, or ensuring that rams are in good condition for joining. In most of these cases the animals are likely to be grazing an ample quantity of pasture, but it may be inadequate in quality. The question then becomes one of whether to offer a supplement that might boost the intake of the base pasture, or to give one that will inevitably replace the intake of some of the base pasture.

Production feeding involves optimising the protein and metabolisable energy intake of the whole ration to ensure optimum rate and efficiency of liveweight gain. The first consideration is the requirement of metabolisable energy for growth, that is, the absorbed energy in excess of maintenance that can be converted to production of tissues (bone, muscle or fat) to cause growth, liveweight gain or 'finish-ing', or products such as milk or fibre. This pro-duction energy is related to three factors: the weight of the animal, the quality of the ration it is consum-ing, and the rate (liveweight gain per day) at which the animal is to grow.

The final case may be associated with the preparation of stock (particularly stud stock) for sale where appearance, as much or more than performance, is important in determining value. The whole scale of determining efficiency of nutrient use, or return on money expended, can change when producers are selling stud stock. The application of supplementary feeding just to enhance the appearance of stock in a paddock, without any known relationship to production of a saleable product, is however, unlikely to be economically valid and will receive no direct consideration here.

Nutritive value of forages and ingredients for supplements

Whilst the need of ruminant animals for vitamins and minerals cannot be overlooked, and they can be important components of supplements provided to boost production, the details of their function and use is beyond the scope of this paper. However, to consider any aspects of supplementary feeding it is necessary to appreciate the key roles of energy and protein in ruminant nutrition.

Metabolisable energy

When feed components are digested, they release energy in varying amounts and forms. In the case of ruminants most of the energy they absorb is in the form of volatile fatty acids absorbed from the rumen, or sugars, amino acids and fatty acids absorbed from the small intestine. Together, these nutrients contribute to the energy that the animal has available for metabolism (its 'metabolisable energy'). Metabolisable energy is expressed in terms of megajoules (MJ) and, using the system widely adopted in Australia, we can describe feedstuffs in terms of the quantity of metabolisable energy they will contribute to an animal if con-sumed and digested by it. Thus, feeds are described as having 'x' MJ of metabolisable energy per kilogram of dry weight (their M/D value).

For pastures, the general range in digestibility is from 40% for very poor quality mature pasture to just over 80% for the early leafy growth of newly germinated or regrowing plants. As a guide, we can recognise that low digestibility, low quality roughage (mature, dried-off pasture, poor quality hay or straw – LQR's) has an M/D value of about 6, whereas good quality, highly digestible, legume-grass pasture might have a value of 10, and cereal grains may have a value of 12 (Table 1).

Protein

Protein is an important characteristic of virtually all forms of livestock production (meat, milk, fibre) and, hence, there is a need for the livestock to be absorbing adequate amino acids as these are the building-blocks of protein. In the case of ruminants, the amino acids do not need to be derived from dietary protein, as the micro-organisms which live and multiply in the rumen serve as a suitable source of protein to be digested by the ruminant animal and so provide the amino acids it requires. A feature of this mechanism that is particularly relevant to supplementary feeding is that a high proportion of the nitrogen which micro-organisms require to produce their microbial protein can be derived from chemically simple (and hence relatively inexpensive) sources such as urea. This is because many rumen micro-organisms can use ammonia as their primary source of nitrogen, and they do not differentiate between ammonia derived from urea and ammonia derived from expensive forms of dietary protein.

As the needs of the animal can largely be expressed in terms of metabolisable energy and protein, it is important to examine the characteristics of feedstuffs (particularly forages) which determine the supply of these needs to grazing and/or supplemented sheep or cattle. There are two main groups of nutrients and some specialised terms associated with them. The first group is related to the fibrous portion of the ration - soluble carbohydrates, cellulose/hemicellulose, lignin, dry matter digestibility and intake. The second group is related to the protein content of the ration - degradability of protein, ammonia, microbial protein and absorbed amino acids.

Most forages in a dry form consist of about 10% minerals and 90% organic matter. The components of the organic matter portion can vary with plant species, growing conditions and soil fertility, but they consist mainly of carbohydrates of varying complexity (mainly sugars, starches, cellulose and hemicellulose); crude protein of between 5% (for low quality roughages) and 45% (for meals made from legume seeds); and 4 to 8% lignin (Weston and Hogan, 1973; MAFF, 1984; McDonald *et al*, 1988; Pearson and Ison, 1989; Cottle, 1991). As examples, actively growing, green pasture at an early stage of development might have 10% minerals, 23% protein, 4% lipid, 3% lignin, 40% soluble carbohydrates and 20% fibre. In contrast, the same grass species after flowering and drying-off may contain 8% minerals, 9% protein, 7% lignin, 2% lipid; 40% soluble carbohydrate and 34% fibre. In the mature plant material the higher amount of lignin is particularly significant, both because it is indigestible and because it can combine chemically with the other components of fibre (cellulose and hemicellulose) to slow down their rate and extent of digestion by micro-organisms in the rumen. These effects on digestibility mean the animal derives less energy from each unit of intake and, also, the overall capacity of the animal to consume low quality material is reduced.

When might supplementary feeding be necessary?

As this paper is for an audience predominantly of producers from south-eastern Australia where the preferred form of sheep and cattle production is direct grazing of pastures or forage crops, the topic of supplementary feeding must focus on the conditions under which additional or alternative feed might be

Table 1. The intake of dry matter (g/day) of rations with M/D's of 8.5 to 12.5 MJ/kg DM, required to supply the energy to sustain growth rates of 0 (maintenance), 100, 200 or 300 g/day, for lamb live weights from 22.5 to 52.5 kg (Source: Robards, 1998).

Lamb weight	Growth rate	Metabolisable energy (M/D) values								
		8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5
22.5	0	492	459	430	404	380	359	340	322	306
	100	985	899	824	760	703	653	609	569	534
4%= 900 g	200	1556	1408	1281	1172	1077	994	921	856	798
5%=1125 g	300	2160	1947	1765	1609	1473	1355	1251	1159	1077
25.0	0	532	497	465	437	412	388	368	348	331
	100	1034	947	869	801	742	689	643	601	564
4%=1000 g	200	1620	1468	1336	1223	1125	1039	963	894	834
5%=1250 g	300	2239	2020	1832	1670	1531	1407	1301	1205	1120
27.5	0	572	534	501	469	442	417	395	374	355
	100	1088	994	914	842	780	725	677	633	594
4%=1100 g	200	1686	1528	1393	1274	1172	1082	1003	933	870
5%=1375 g	300	2319	2092	1899	1731	1587	1460	1349	1251	1163
30.0	0	610	561	533	501	472	445	421	400	379
	100	1138	932	956	883	818	760	709	665	623
4%=1200 g	200	1750	1478	1445	1324	1219	1126	1044	972	906
5%=1500 g	300	2397	2164	1964	1793	1643	1512	1398	1297	1206
32.5	0	648	605	566	532	501	473	447	424	403
	100	1188	1087	999	922	855	796	742	695	653
4%=1300 g	200	1814	1645	1500	1375	1265	1169	1084	1009	942
5%=1625 g	300	2477	2237	2030	1854	1700	1565	1446	1342	1249
35.0	0	685	639	599	562	530	500	473	448	426
	100	1238	1132	1042	961	892	830	775	725	682
4%=1400 g	200	1878	1704	1554	1424	1312	1213	1125	1047	978
5%=1750 g	300	2557	2309	2097	1914	1757	1618	1496	1387	1291
37.5	0	721	673	631	592	564	527	498	472	449
	100	1287	1178	1084	1001	935	865	807	756	711
4%=1500 g	200	1942	1762	1609	1474	1364	1256	1165	1085	1014
5%=1875 g	300	2636	2382	2164	1976	1819	1671	1544	1433	1335
40.0	0	757	707	662	622	585	553	523	496	471
	100	1336	1233	1125	1040	964	899	839	787	739
4%=1600g	200	2007	1822	1662	1525	1404	1299	1206	1123	1049
5%=2000g	300	2717	2455	2231	2038	1869	1723	1594	1479	1377
42.5	0	792	740	693	651	613	578	547	519	493
	100	1384	1268	1167	1079	1001	932	871	816	767
4%=1700 g	200	2071	1881	1717	1575	1451	1342	1246	1161	1084
5%=2125 g	300	2797	2529	2299	2100	1927	1776	1643	1525	1420
45.0	0	827	772	723	679	640	604	571	541	514
	100	1433	1313	1208	1117	1037	966	902	845	794
4%=1500 g	200	2135	1939	1771	1624	1497	1385	1286	1198	1119
5%=2250 g	300	2879	2603	2366	2162	1985	1830	1692	1571	1463
47.5	0	861	804	753	707	666	629	595	564	536
	100	1481	1357	1250	1155	1073	999	934	875	823
4%=1900 g	200	2200	1998	1825	1675	1543	1429	1327	1236	1155
5%=2375 g	300	2961	2677	2434	2224	2042	1883	1742	1618	1507
50.0	0	895	835	782	735	692	653	618	586	557
	100	1530	1401	1290	1194	1108	1032	965	905	851
4%=2000 g	200	2265	2057	1879	1725	1590	1471	1367	1274	1191
5%=2500 g	300	3044	2752	2502	2288	2100	1936	1792	1664	1551
52.5	0	928	866	812	763	718	678	641	608	577
	100	1578	1445	1332	1232	1144	1066	996	934	877
4%=2100 g	200	2330	2117	1934	1776	1637	1515	1407	1312	1225
5%=2625 g	300	3127	2828	2572	2352	2159	1991	1841	1711	1594

offered to stock that ideally would be raised entirely on pasture. The four main pasture conditions, and the form(s) of supplementation most relevant to each are:

- pasture sparse and poor (low/low)
- pasture scarce but green (low/high)
- pasture ample but poor (high/low)
- pasture ample and good quality (high/high)

Low/Low

A pasture which is deficient in both quantity and quality is usually associated with a regular seasonal trough such as a hot, dry summer in south-eastern Australia, or an abnormally long dry period or drought. The consequences of drought, overstocking or poor management, can leave as grazing for stock only sparse pasture which is high in fibre, of low digestibility and low in protein. If stock are to be fed to keep them alive until a break of season or some other event, then it is necessary to determine how much feed is required to maintain them at a critical minimum weight. Each breed and strain of livestock has a characteristic mature size and weight, and this is directly related to the minimum weight they can decline to and yet survive. Having determined the appropriate survival weight of a flock (Oddy, 1978) or herd (SCA, 1990), the next question is, "What ration are the stock to be fed"? There are two main forms of supplementation that can be considered.

One form of supplementation to sparse LQR is to provide the first limiting nutrient, that of nitrogen, with the aim of stimulating the activity of micro-organisms and hence increasing digestion of fibre in the rumen and so stimulating intake. The success of this technique is sometimes enhanced by including molasses in the supplement as this provides the micro-organisms with a ready source of energy, and sulphur which is the second most likely element to be deficient in the LQR. The scientific literature reports very mixed responses to urea supplementation, with the variation appearing to be less with LQR's of lower digestibility, and also to be related to the difficulty of providing the supplement in a form that ensures relatively equal intake by the animals.

The second form of supplementation to sparse, low quality pasture is to provide a cereal grain or a mixture of grain, hay, salt and limestone. To keep cost down, unprocessed grain is often provide as the whole ration in self-feeders, open troughs, or even trailed on the ground. Although it is relatively easy to determine how much grain to provide to maintain the animals if their average weight is known, it is difficult to know what to reduce this value by to allow for pasture that will be consumed. More complex mixtures are inappropriate when feeding for survival of adult stock, as cost must be kept to a minimum and more complex mixtures are unnecessary for survival. Also, the inclusion of roughage in the ration is not an issue which needs to be considered as it does in total feedlot rations, or rations designed to feed lactating animals where the roughage portion is essential to aid milk fat synthesis and therefore to boost overall milk production.

Low/High

When there is green pasture available but there is insufficient to meet the animal's needs, supplementation with grain can be the most appropriate option. The grazing, even of sparse green pasture, should provide the stock with protein nitrogen and a reasonable supply of minerals and vitamins, and therefore the main requirement is for energy, which for cost effectiveness generally means a cereal grain. The use of hay as a supplement to green pasure can be inefficient, as wastage occurs, because where possible the stock will preferentially graze the green pasture.

High/Low

At times, such as a summer following a good spring, there may be a large amount of dried-off plant material (either pasture or crop stubble). Such material has potential for supplementation with urea, urea plus energy (molasses or grain) or a protein source such as good quality hay or a high-protein seed meal. The major problem in utilising abundant LQR is that the supplement can become a substitute for the mature plant material. Only the direct spraying of urea onto the LQR can overcome this possibility. The range of values in the literature indicates that the substitution rate is generally between 40 and 60%. That is, if sheep were eating 400 g of LQR daily prior to supplementation, once supplemented they will reduce their grazing intake to about 200 g. However, 200 g of material with an M/D of 6 does not contribute much to the energy needs of the animal, and so not much reduction is required in the amount of supplement required for maintenance or a predetermined level of production. As a 40 kg wether requires about 6.5 MJ of ME daily for maintenance, 200 g LQR represents about 18% of daily requirements and the amount of supplement needed would be about 4.3 MJ per day (500 g of grass-legume hay, or 350 g of wheat grain). Similarly, for production feeding for even a modest gain of 100 g per day, the energy required would be about 11 MJ per day, and then the LQR would represent only about 10%. In this case, the calculated amount of supplement may not be reduced, but the LQR would be playing an import-ant role in preventing 'grain sickness' if the supplement was all grain (in this example about 920 g per day) or a ration mix with a high proportion of grain.

High/High

If ample green pasture is available but stock are not meeting a production objective, any thought of supplementation must turn to means of getting nutrients past the rumen for direct absorption in the small intestine. In the case of energy, we know that some of the starch of maize and sorghum is more likely to escape fermentation in the rumen than the starch of other grains. Another way of enhancing energy supply is to protect lipid so that it isn't fermented in the rumen and increased amounts can be added to a ration without causing any problems to the micro-organisms. Techniques for protecting lipid have been developed by CSIRO and incorporated into commercial ration ingredients that are available for use if the cost is justified relative to the value of the product.

The protection of some of the protein in a diet can be achieved by a number of means. Plant proteins have a range of natural protection, with sainfoin being noted for its relatively high proportion of 'bypass' protein. Sources of concentrated protein such as cottonseed meal, soya bean meal and linseed meal have relatively high natural protection, and fishmeal is renowned as having the highest proportion of bypass protein. Protection of the protein in ration ingredients can be increased by the effect of heat during processing, and particularly by treating the protein meal portion of a ration with formaldehyde (here again, CSIRO technology has been commercialised).

Increasing the amount of bypass (protected) protein in a ration is the main way of increasing productivity in ruminants, particularly as many animals (particularly dairy cattle, and highly selected beef cattle and meat sheep) have a genetic capacity for production that exceeds their capacity to absorb nutrients from digestion of even the highest quality grass-legume pasture. However, any processing treatment, special protein ingredients or feeding procedure costs money, and each supplementation strategy should be costed against the value of any additional product. For example, it is certainly possible to boost wool production by feeding sheep protected protein, but extremely unlikely that the practice would be economically viable.

Some basic principles upon which supplementary feeding depends

When supplementary feeding is practised there should be an aim to ensure that the value of extra product will exceed the cost of feeding. To achieve this, the first step is to determine how much supplement is required to achieve the production objective. This requires three basic steps: estimating how much the animal can derive from paddock grazing; calculating how much the animal needs for maintenance and; calculating how much extra the animal needs to fulfil the production objective.

Intake

Estimating grazing intake is extremely difficult. However, when stock have unlimited access to good quality forage, daily intake can be estimated as 3% of the live weight for mature animals. For young, growing weaners a value between 4 and 5% may be more applicable. Once pasture quantity is restricted by a factor such as seasonal conditions, stocking rate or grazing management, grazing intake will usually decline. When quality of forage declines (generally from the commencement of flowering for grass and legume species) intake is often markedly restricted.

Forage quality may decline so much that, regardless of the quantity of forage available, stock cannot consume enough each day to meet their requirements for maintenance (*i.e.* to maintain a constant live weight). That is, the high levels of fibre (including lignin) in low quality roughages reduce the rate of dry matter digestibility in the rumen. This slow digestion in the rumen means that feed material stays there longer and hence overall intake is restricted. Furthermore, if stock are supplemented with cereal grain or pellets containing a high proportion of cereal grain, they will almost always decrease their intake of low quality pasture even further. This is because cereal grains with their high levels of starch change the rumen conditions and subsequently the mix of rumen micro-organisms so that the ability to digest fibre is reduced. Thus, if the amount of supplement to be offered is to be corrected for grazing intake, the correction should be about 50% of the estimate of pasture intake prior to the commencement of supplementation.

Maintenance

An animal's maintenance requirement is the amount of energy it must digest and absorb to meet its needs for basic functions such as breathing, eating, ruminating and a small amount of physical activity. The maintenance requirement is largely dependent on the animal's live weight and the quality of feed it is consuming. Maintenance values for sheep and cattle can be calculated from equations (ARC, 1965; Oddy, 1978; ARC, 1980; SCA, 1990), or by using nomograms such as the excellent ones produced by Oddy (1978). As examples of estimates for sheep, the 0 values in Table 1 show the maintenance requirements for sheep from 22.5 to 52.5 kg live weight.

Production

The growth and fattening of animals, the secretion of milk and the growth of fibre all have an energy cost in addition to the animal's maintenance requirements. The energy cost of each of these production functions varies and there are different equations for calculating each of them that are beyond the scope of this article. It is important, however, that producers seek the information relevant to their livestock enterprise(s) (Oddy, 1978; ARC, 1980; MAFF, 1984; McDonald *et al.* 1988; SCA, 1990).

In relationship to production feeding, there are a number of fundamental points to emphasise. The first is that an animal's daily intake must firstly provide its maintenance requirements and then excess energy will be used for production. If intake is only marginally above maintenance the rate of growth achieved will be low and the overall efficiency of feeding for growth will be very low. If intake can be elevated to 2 to 3 times maintenance, the rate of growth will be much higher. Also, efficiency will be much better as a higher proportion of the total intake is directed towards production.

A second point is that as the nutritive value of the ration increases less weight of feed is required to meet maintenance needs, and if its intake is high, then a high level of production is possible. Examples of this can be found in Table 1. Thus, for a 30 kg sheep to grow at 200 g per day, it would need to consume 1324 g of green pasture (M/D = 10) which is near its limit of intake. On the other hand, the same sheep would only need to eat 972 g of a cereal grain such as wheat or sorghum (M/D = 12) to grow at 200 g per day. If, however, it ate 1324 g of a ration with an M/D of 12 it could grow at up to 300 g per day.

A final point of emphasis is that the limits to intake imposed on sheep and cattle by the digestion of fibre in the rumen can often restrict the animal's ability to grow rapidly (even if it has the genetic potential to do so). Again an example from Table 1 can illustrate the point. For instance, a producer may have mixed pasture with an M/D value of only 9 available for grazing, but calculate that to market 30 kg lambs by a given date they would need to grow at 200 g per day. In this case, it is unlikely the sheep could consume the 1478 g of pasture necessary to meet the growth objective as this amount exceeds their intake limit of about 1200 g (even at 4% of LW). That is, supplementary feeding will be required if the production target is to be achieved.

A system for determining supplementary feeding levels

The following is a scheme that a producer or advisor might systematically apply to individual flocks or herds, or to all the livestock on a property to determine a level of supplementary feeding:

- Define the animal enterprise, particularly identifying the products or outcomes with economic value (*e.g.* meat production from young sheep; joining of crossbred ewes; lact-ation of beef cows)
- Measure or estimate the present average weight (Wp) of the mob, flock or herd
- Define the target weight (Wt) for the group (Wt could the same as Wp {= M}; a target weight for joining ; or a target market weight)
- Determine the average of Wp and Wt to give a "calculation" weight of Wc.
- Decide the time scale for the feeding, *i.e.* the number of days, weeks or months to the end-point of the activity (*e.g.* the sale of lambs; weaning of calves; joining of ewes, *etc.*).
- Define the product: M = no body composition change, no reproduction
  - ♦ liveweight gain of 'x' g/day
  - ♦ milk production of 'y' L/day
  - ♦ ovulation rate of 'z' ova/ewe
- Define the pasture situation (nil, low/poor, low/green, high/poor, high/green
- List the available, or procurable, feeds and their most likely cost (or the opportunity cost in the case of conserved forage or grain held on farm)
- Calculate the requirement for maintenance based on Wc.
- In the case of some pasture grazing, estimate the intake of pasture before supplementation.
- Multiply the pasture intake value by 0.5 to determine the likely intake when supplementary feed is available and a substitution effect occurs.
- Subtract 0.5 x pasture intake from the maintenance value to give an amount of supple-ment, such that the intake of pasture + supple-ment will satisfy maintenance requirements.
- In the case of growth and/or finishing, calculate the time available to reach the market objective.
- Nominate the required market weight and subtract the present average weight to give the gain which needs to be achieved.
- Divide the gain required by the days available, to give the required weight gain/day.
- Consider whether the required growth rate is within the potential rate achievable by the stock (*e.g.* up to 250 g/day for unselected meat sheep; 250 to 350 g/day for meat sheep from a flock with a history of selection of sires and/or dams for growth rate)
- Determine the quantity of feed required to produce the desired growth rate (Note, the amount may need reassessment at intervals because, as the animal's weight increases, the production part of the ration needs to increase to maintain the same rate of weight gain)
- Add the 'production' requirement to the maintenance requirement to give the daily feed requirement (Note 1. Table 1 values include both the maintenance and production needs. Note 2. In a feedlot situation where the aim is to maximise growth rate, the ration is offered at or close to *ad libitum*).
- Check that the required daily intake is within

the limits of the particular age and size of animals (3% of Wp for mature animals on average quality grazing; 4% of Wp for young sheep on good grazing; 5% of Wp for high production stock on a high quality ration).

- Compare the expected $ return with the cost of feed/day x days x unit cost of ration.

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