25. Principles of Supplementary Feeding in Grazing Systems

Hugh Dove

Learning objectives

On completion of this topic you should be able to:

• Explain the differences between the processes of supplementation, substitution and complementation
• Discuss why true supplementation does not often occur under grazing conditions
• Define the factors which influence the level of substitution between pasture and supplement
• Define the grazing situations in which substitution and complementation are likely to occur
• Use this information and information about the nutrient requirements of grazing animals to devise supplementary feeding regimens for different classes of livestock

Key terms and concepts

Intake, supplementation, substitution, complementation, nutrient requirements.

Introduction to the topic

In many grazing systems, there are times of the year when animals will require supplementation because the nutrient supply from grazing does not meet their demands for nutrients. Feed supplements used in the various grazing industries include not only feed purchased off-farm, but also feed grown on-farm (e.g., wheat) or formulated on-farm from a mixture of grown and purchased commodities. In grazing enterprises, the cost of supplementary feeding is one of the major discretionary expenditures faced by farmers and, equally importantly, is also a major contributor to the so-called ‘down-side risk’ in farm income. This is the increased year-to-year variability in farm income generated by the costs of extra supplementary feeding in bad seasons which, because stocking rates are frequently suboptimal, is often not compensated for by the extra income generated in good years. Increases in the efficiency of supplementary feeding are of thus economic importance and will have a major effect on farm income.

25.1 The supplement response

A supplement might be thought of, at the simplest level, as ‘something added to remedy a deficiency’. However, the frequency of erratic responses to or complete failures of supplementary feeding suggests that often in the grazing situation, there is something more complex going on than simply overcoming a deficiency. This should not be a surprise. The interaction of the ruminant with its grazed pasture represents the meeting point of two extremely complex ecosystems: the sward itself, responding to soil nutrients and water, to climatic variables and to the grazing process; and the animal, with its complex control of diet selection and intake, and its nutrient demands both for production and for the support of its resident population of rumen microorganisms. The introduction of a supplement into this complex interaction may ‘remedy a deficiency’, but in the process it may also have positive effects (increased forage intake or increased digestion of forage) or negative effects (depressed intake and/or decreased digestion of major constituents of the forage). The nutritional mechanisms generating these positive and negative effects have to be understood (or at least appreciated) in order to unravel the response of the animals to supplements and thus increase the efficiency with which supplements are used.
In general terms, we can consider at least three reasons for offering livestock supplementary feeds, as outlined in Fig. 1. Occasionally, the supplement is given in order to negate the effects of something which is already present in the diet. For instance, the high content of condensed tannins in browse species such as *Acacia* spp. can severely limit intake and performance by livestock (see below). Supplementation with the polymer polyethylene glycol under these circumstances can result in the formation of a complex between the condensed tannins and the polyethylene glycol and overcome the negative effects of the tannins. These situations arise mainly under rangelands or browse conditions.

More usually, the supplement is offered either to overcome the deficiency of a key nutrient (e.g., the supply of nitrogen, N, to the rumen, or of micronutrients such as trace elements or vitamins) or to improve total nutrient supply or the efficiency of utilization of nutrients. In this context, ‘total nutrient supply’ can refer to increased intakes of metabolizable energy (ME), metabolizable protein (MP), or both. Similarly, the increased supply of MP can be due to increased microbial protein synthesis, increased supply of undegraded dietary protein, UDP, or both.

**Figure 25.1 Schematic description of major reasons for supplementary feeding in grazing systems. Source: Dove (2002).**

<table>
<thead>
<tr>
<th>Reason for feeding</th>
<th>Example</th>
<th>Effect on intake of diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negate effects of a substance in diet</td>
<td>Polyethylene glycol to overcome tannin effects</td>
<td>Usually increased</td>
</tr>
<tr>
<td>Overcome a frank deficiency</td>
<td>Deficiency of vitamin, mineral, rumen-degradable N</td>
<td>Intake increased (complementation)</td>
</tr>
<tr>
<td>Contribute to energy, protein supplies</td>
<td>Increase ME and/or increase amino acid supply as either microbial protein, UDP or both</td>
<td>Intake decreased to variable extent (substitution).</td>
</tr>
</tbody>
</table>

In trying to unravel exactly which nutrients are responsible for the response to the supplement, attention should thus concentrate on the nutritional interactions which underpin supplement responses under these varying circumstances.

### 25.2 Interactions between herbage and supplement intakes

When animals consuming roughage also eat supplements, this alters the total amount of digesta in the rumen (fill), the amount of dry matter, DM, in the rumen (load), the rate of digestion of cell-wall constituents, the pH and the ammonia concentration in the rumen, the rate of synthesis of microbial protein, the rate of outflow of liquid and particulate material from the rumen and the amount of energy and amino acids available at the tissue level. All of these have the potential to influence the intake of the basal roughage. At the extreme (e.g., pH and ammonia concentration) there can also be pathological consequences.

Under most grazing situations, we can define three basic outcomes when livestock are offered supplements.
1. Supplementation: strictly speaking, this only occurs when the supplement is eaten and the intake of pasture is not reduced. This is usually the desired outcome of the manager, but is a rare event.
2. Substitution: most or all of the supplement is consumed and as a result, pasture intake is reduced. This is what usually happens when supplements are given to grazing animals, and there are times when the reduction in pasture intake may be enough to counteract the effects of the supplement.
3. Complementation: the consumption of the supplement actually increases pasture intake. This usually occurs in situations where the supplement makes good a frank deficiency of a nutrient (e.g., a mineral, or rumen-degradable protein, RDP). Deficiencies in most of the minerals required by livestock will result in reductions in feed intake, with the extent of reduction varying with the mineral concerned. It follows that supplementation with the mineral will overcome the constraint to intake and increase feed consumption. An analogous situation is commonly encountered when animals grazing low-quality roughages are given protein supplements which make good a deficiency in RDP.

Appreciating that these can be the outcomes is helpful, but the real need is to know why and especially to use this knowledge to predict the likely outcomes of supplementation, so that this can be done more efficiently and profitably.

Substitution
When ruminants consume energy-rich supplements, they are likely to reduce their intake of the herbage component of the diet – this is defined as ‘substitution’. In general terms, the extent of substitution between supplement and herbage will depend on the following factors, though it is still not easy to use these generalized responses to quantify the expected response to the supplement.

1. Substitution is likely to be greater when more pasture is available. For example, in early work near Armidale, NSW (Langlands 1969), the calculated level of substitution was 38.0% when only 760 kg herbage DM/ha was available, but rose markedly as herbage availability increased until, at an availability of 4788 kg DM ha\(^{-1}\), calculated substitution between herbage and supplement was 66.7%. An important point to note is that substitution can occur even when pastures are sparse; even at the lowest pasture availability, substitution was still 38%. This may be an effect of grazing behaviour, with the sheep showing a disinclination to graze when supplement is freely available.
2. The quality of the pasture on offer affects the degree of substitution, which appears to be greater when herbage quality is high. However, the interaction between the nature of the supplement and the quality of the herbage is not simple. Supplements which contain high levels of starch (e.g., wheat or barley) can depress the rate of digestion of cell wall material in the rumen. This has been described as the ‘associative effect’; the mechanisms involved have been reviewed recently by Dixon and Stockdale (1999). The provision of large quantities of starch perturbs rumen microbial ecology in the direction of amylolytic organisms rather than cellulolytic organisms and may thus decrease the rate of digestion of cell wall constituents. As a consequence, rumen outflow will slow and intake of the roughage component will decrease. However, two further points need to be stressed. First, the reduction in whole-tract digestibility may not be as great as the reduction in cell-wall digestibility in the rumen, indicating that there are compensating increases in digestibility elsewhere in the digestive tract. Second, the degree of substitution occurring with high-starch supplements is frequently larger than the extent of depression in cell-wall digestibility, indicating that other factors are involved in causing the substitution between roughage and supplement.
3. Substitution is usually greater when high-quality supplements are fed, partly because of associative effects between high-quality supplements such as grains, and the roughage component of the diet. However, the effect is also apparent with high-quality, non-starchy supplements such as lupins or oilseed meals.
4. Substitution rate may be greater when more supplement is fed, though this is not a universal finding. An example is shown in Table 1, derived from the data reported by Freer et al. (1988), for yarded lambs offered supplements of 2:1 oat grain:sunflower meal and a basal ration of poor-quality pasture hay. With each successive increase in the supplement intake up to 446 g DM per day, both the overall and especially the incremental rates of substitution increased markedly.
5. For a given amount of pasture and supplement, the degree of substitution can also alter depending on the physiological state of the animal. In general, animals with a greater demand for nutrients, such as rapidly growing weaners and lactating ewes, will show a lower degree of substitution than say, wethers or ewes in early pregnancy.

6. The method and particularly the frequency of feeding may influence the rate of substitution, though this may only be observed with certain classes of livestock. For example, McCrabb et al. (1990) reported that when lean ewes in late pregnancy were given lupin grain supplements at rates of either 250 g d$^{-1}$ or 875 g twice weekly, substitution was greater in the latter case.

Compared with concentrate supplements, it is much more difficult to obtain data about substitution rates between pasture and hay supplements. Again, this is related in part to the difficulty in obtaining field estimates of the intake of both. In part, the unpredictable effects of hay supplementation on herbage intake and animal performance can be related to interactions between the quality of the hay and the pasture itself. In general, there are unlikely to be economic benefits from supplementing livestock with hay which is of lower quality than the pasture itself, except when pasture availability is very low.

Although there might be substitution between herbage and supplement, this does not mean that there has been no response to the supplement, only that the response is less than might have been expected had supplement been consumed without an effect on herbage intake. This is clear in the data in Table 1; despite substantial substitution, the total intake of supplemented animals was increased and overall, the liveweight gain was improved by a 79 g day$^{-1}$ (25+54) compared with unsupplemented lambs. Note that there can also be a ‘pasture response’ to supplementation, to the extent that reduced pasture intake because of substitution means that less pasture is eaten and more is ‘spared’ for future consumption.

**Table 25.1** Intakes of low-quality hay and supplement by lambs in yards, together with estimated rates of substitution and liveweight gain. Sources: Adapted from tabulated data in Freer et al. (1988) and Dove (2002).

<table>
<thead>
<tr>
<th>Intake:</th>
<th>Weight of air dry supplement offered (g day$^{-1}$)</th>
<th>Intake:</th>
<th>Weight of air dry supplement offered (g day$^{-1}$)</th>
<th>Intake:</th>
<th>Weight of air dry supplement offered (g day$^{-1}$)</th>
<th>Intake:</th>
<th>Weight of air dry supplement offered (g day$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>0</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Supplement (g day$^{-1}$)</td>
<td>75</td>
<td>176</td>
<td>313</td>
<td>446</td>
<td>Supplement (g day$^{-1}$)</td>
<td>386</td>
<td>366</td>
</tr>
<tr>
<td>Hay (g day$^{-1}$)</td>
<td>-</td>
<td>19.8</td>
<td>48.3</td>
<td>73.3</td>
<td>Substitution (% total)$^A$</td>
<td>-</td>
<td>19.8</td>
</tr>
<tr>
<td>Total (g day$^{-1}$)</td>
<td>-</td>
<td>19.8</td>
<td>69.3</td>
<td>118.0</td>
<td>Weight change (g day$^{-1}$)</td>
<td>-25</td>
<td>-17</td>
</tr>
</tbody>
</table>

Supplement was 2:1 oat grain:sunflower meal on DM basis. $^A$Total substitution calculated relative to lowest level of supplement offered. Incremental substitution calculated relative to previous level of supplement offered.

from supplementing livestock with hay which is of lower quality than the pasture itself, except when pasture availability is very low.

**Complementation**

Assuming that there are no deficiencies of essential minerals or vitamins, the phenomenon of complementation is most likely to occur when livestock consuming poor-quality, low-N roughages are given supplements which increase the supply of N required for microbial fermentation of fibre in the rumen. Increased soluble-N supply to the rumen increases the rate of digestion of the roughage component of the diet, which in turn increases rumen outflow rate and thus intake. As an example, in the work of Freer et al. (1988) (Fig. 2), lambs grazing mature pasture (OM digestibility 50-52%, N content 1.2%) were supplemented with increasing quantities of a supplement consisting (2:1) of oat grain (1.3% N): sunflower meal (6.5% N). Consumption of 160 g DM d$^{-1}$ of this supplement increased pasture intake by 49% and total intake by 78%. A doubling of supplement intake resulted in further, though smaller increases in both pasture and total intakes. Note that as supplement intake was doubled from 324 to 640 g DM d$^{-1}$, the relationship between supplement and pasture intake became substitution rather than complementation, and at the rate of 110%.
The ‘switch’ from complementation to substitution suggests that rumen requirements for soluble N had been met and that other constraints on intake were operating. This emphasizes the point that substitution and complementation must be regarded as parts of the same continuum, rather than as separate effects. Despite the fact that complementation gave way to substitution, total intake was not decreased (Fig. 2) and ME intake was actually increased (Freer et al. 1988). As a result, animal performance continued to improve with each successive increase in supplement intake.

### 25.3 Types of supplementary feed and their nutritive value

A wide range of supplements is fed to livestock and to a large extent, any classification of these can only be in general terms. However, in production systems based on sown pastures in temperate areas, it is convenient to classify supplements into the general categories in Table 2.

**Energy/high-carbohydrate supplements**

Cereal grains such as barley, wheat, oats, sorghum and maize typify the ‘energy’ or ‘high-carbohydrate’ supplements. These contain large amounts of readily digestible carbohydrate, primarily as starch. It follows that an understanding of the starch content and degradability between grains, and the factors which influence these, will lead to better understanding of the differences in nutritive value of different grains for different classes of livestock. However, recent research has also indicated that more attention needs to be paid to the non-starch polysaccharide, fibre and protein contents of cereal grains, as they influence the processes of digestion and as they are themselves influenced by grain processing such as cracking, steam-flaking or pelleting (see review by van Barneveld, 1999).
This work suggests that in future, more attention needs to be paid to the following points.

1. The rate and extent of starch fermentation, between and within feed grain species, and in different compartments of the gut.

   The contribution of fibre to the nutritive value of feed grains, and especially clarification of the contribution of cellulose and hemicellulose components. For example, it is apparent that there are major differences in the contribution of fibre to the energy value of oat, wheat, barley and triticale grains (see van Barneveld, 1999).

2. Protein solubility in the rumen, its variability across species, cultivar and growing conditions, and the extent to which protein solubility interacts with the rate of release and fermentation of starch.

3. The lipid content of feed grains as a contributor to their total ME contribution, and as a possible negative influence on efficient fibre digestion.

4. Fermentation patterns of non-starch polysaccharides in both cereal grains (e.g., the β-glucans of barley) and legume grains.

It is clear that grain processing can alter or negate some of the differences between grains in the above characteristics, but it is also clear that the nutritive value of feed grains would be better predicted with more information on the above points.

Energy supplements such as the cereal grains have the added advantages of being readily produced and stored on farm, and being easily fed out to animals. This means that they are relatively cheap supplements, especially when evaluated in terms of cost per MJ ME, which is the appropriate criterion to use.
Table 25.2 General classification of supplementary feeds for use in sheep grazing systems, with their advantages and disadvantages. Source: Adapted from Dove (2002).

<table>
<thead>
<tr>
<th>Example</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Energy’ or high-carbohydrate supplements</td>
<td>Cereal grains, crop by-products (e.g., bran, molasses)</td>
<td>Highly digestible, easy to store, feed. Relatively cheap ME source. Can be produced on farm.</td>
</tr>
<tr>
<td>‘Protein’ or N supplements</td>
<td>Grain legumes, pulses, oilseeds and oilseed meals. Non-protein N sources such as urea</td>
<td>Grain legumes, pulses, oilseed meals palatable, easily handled or mixed with cereals. Pose few rumen problems.</td>
</tr>
<tr>
<td>Conserved forage</td>
<td>Hay, silage</td>
<td>Most farmers have capacity to produce, especially hay. Cheap per kg DM.</td>
</tr>
<tr>
<td>Forage crops</td>
<td>Forage brassicas (rape, kale) and root crops (turnips, swedes, chou moellier); chicory. Forage oats, winter wheats. Forage maize, sorghums, Japanese millet</td>
<td>Produce large quantities of highly digestible forage. Forage brassicas and root crops can be held in paddock for future use. Feed grain from winter cereal can pay for crop costs.</td>
</tr>
</tbody>
</table>
By contrast, their relatively low and variable protein contents (especially in oat grain) mean they are likely to be expensive supplements when costed per kg of crude protein, CP, and they are thus both inefficient and expensive protein supplements. Perhaps the major difficulty encountered in using the high-starch cereal grains is the need for animals to be introduced to them gradually, in order to avoid problems with excessive lactic acid production in the rumen.

**Protein supplements**

‘Protein’ supplements are fed either to increase the supply of RDP in the rumen and thereby improve the efficiency of fibre digestion (e.g., protein supplements for livestock grazing low-quality roughages), or to effect an increase in the amount of MP leaving the rumen for digestion in and absorption from the small intestines. Increased MP supply can itself result from either increased microbial protein production in the rumen or an increase in the rumen outflow of undegraded dietary protein, UDP, or more commonly, from a combination of these.

The most widely used of the non-protein N supplements is urea, which is rapidly degraded to ammonia in the rumen. Provided there is a source of readily available carbohydrate (e.g., molasses), the ammonia can then be incorporated into the protein of rumen microbes. Positive responses to urea supplements are more erratic in grazing sheep than cattle, partly because the greater grazing selectivity of the former can result in their consuming a higher-quality diet, containing sufficient RDP to support rumen fermentation. Another feature of urea supplementation is large between-sheep variability in intake from the block or lick. This has two consequences. First, some animals might consume enough of the mix to receive a toxic dose of urea. Second, large variability in intake results in only some animals responding, so that the mean response is low and the cost of supplementation may be higher than might have been the case with a true protein supplement (e.g., lupins).

The true protein supplements include plant protein sources such as grain legumes (e.g., lupins, vetches), pulses (e.g. peas, faba beans), oilseeds and oilseed meals (e.g., whole cottonseeds, cottonseed meal, soyabean meal, sunflower meal), plus animal protein sources such as fish meal. It is likely that the importance of plant protein sources will increase, with increasing world-wide concern about transfer of disease into human populations through the feeding of animal proteins to animals. This is already banned in several livestock-producing countries.

Plant protein supplements such as those listed in Table 2 differ in their protein, starch, non-starch polysaccharide and lipid contents, depending on species and degree of processing, but all have much higher protein contents than the cereal grains (30-40% CP cf. 7-14% CP in cereal grains). The rumen degradability of the protein varies with the extent of processing, particularly degree of grinding and of heat treatment. Fishmeal usually has a higher protein content (60-70% CP) than the plant protein supplements and considerably lower protein degradability in the rumen. The lipid and protein content of the oilseed meals depend on whether oil has been removed by mechanical expellers or by solvent extraction, and the extent to which the seeds have been de-hulled.

All of these protein sources thus provide ME, RDP and UDP; the extent of animal response will depend on the animal's requirement for these and their interaction with nutrients provided by the rest of the intake. These supplements are usually more expensive than cereal grains but may be cheaper per kg CP. If their protein content is judged to be too high for the purpose, they are readily mixed and fed together with cereal grains, which reduces costs. The storage carbohydrate of the plant protein supplements is either starch at a lower concentration than in cereal grains (e.g., peas), or is a non-starch material such as the β (1-4)-galactan of lupins. This results in a different pattern of storage carbohydrate digestion than with cereal grains (see van Barneveld 1999) and means that these supplements, especially the legume grains, can be fed to livestock with much less likelihood of the major disturbances to rumen function which can occur with over-rapid introduction of cereal grains.

**Conserved forages**

There is an extensive literature on the production and feeding of hay and silage, especially the former, in grazing systems. As a generalization, it is very difficult to make a hay or silage which has a nutritive value equivalent to the pasture from which it is made. This means that while conserved fodder may not be regarded as expensive per tonne of DM, the cost per MJ ME or per kg CP may
be much higher and may compare unfavourably with the energy or protein supplements. In addition, substitution effects with hay can sometimes be very large, depending on the relative digestibilities of the hay and pasture. Silage is often used as a supplement in dairy systems, but the use of silage in the various sheep production systems of the world is highly variable. For example, it is used in feeding systems in the United Kingdom, but is relatively unimportant in grazing systems in Australia.

Forage crops
These are not strictly ‘supplements’, because they are not fed to animals which are grazing some other source of fodder. Rather, the forage crops are the principal source of fodder. However, they will be discussed here as supplements, since their role is to provide a fodder resource at a time when pasture supplies would be expected to be reduced (e.g., a winter or a summer ‘feed gap’). They thus obviate the need to buy and feed other supplements, though fodder crops themselves may need supplementation (see below).

Forage crops are sown annually for use in a specific season, and fall into several categories: cereal crops grazed in their vegetative stage; forage brassicas, root crops or special-purpose species such as chicory; and summer-growing species such as maize, sorghum and its hybrids, and Japanese millet.

Cereal crops can be used in grazing systems as a source of forage. In Australian grazing systems, for example, forage oats are used as a feedbank for winter grazing or perhaps for hay production, with the possibility of grain production being of lesser importance. More recently, with the successful breeding of winter wheats suitable for southern Australia, there has been widespread use of these as a dual-purpose crop that is, as a source of both grazing and feed grain. Theoretically, the grain crop which is ultimately harvested pays for the costs associated with the crop, so that the grazing value of the crop can be regarded as pure profit.

Forage brassicas and related root crops are used extensively in European and New Zealand grazing systems, but to a lesser extent in Australia. They are high-yielding crops producing material of high digestibility (75-90%) but low DM content (10-20%), which is grown and held for later use by animals with a high demand for nutrients (e.g., finishing young stock). They offer the added advantage that fodder quality does not alter significantly over a period of months, which confers flexibility in their management.

Forage crops for use in spring-summer include forage maize, sorghum and millet. These grass species exhibit the C4 pathway of photosynthesis, which can produce large quantities of high-quality herbage. Given the structure of the crop which they produce, they may be more suited to grazing by cattle than by sheep. Interest in chicory is more recent and the species has potential as a spring-summer fodder crop for sheep.

A frequent observation with forage brassicas is that liveweight gains are less than might have been expected from pasture of the same quality. This can be related to effects on intake, to possible nutrient deficiencies and to the effects of secondary compounds in the plant tissues, especially leaf laminae.

The intake of brassica forage crops can be reduced both by their high water content and by their content of glucosinolates, which affect both preference and total intake (Prache 1994). The glucosinolates, via their conversion to isothiocyanates during chewing, can disrupt thyroid function and cause both clinical (goitre) and subclinical symptoms which reduce growth rate. Forage brassicas also contain S-methylcysteine sulfoxide (SMCO). This is converted in the rumen to the secondary toxin dimethyl disulfide, which is responsible for the haemolytic anaemia that can develop in animals grazing forage brassicas, especially kale. The adverse effects on animals of secondary compounds in forage brassicas are discussed in more detail by Prache (1994). Forage brassicas can also disturb mineral metabolism, especially copper and selenium metabolism (Nicol and Barry 1986; Prache 1994). These can be addressed by the appropriate supplementation.

The rumen degradability of CP in forage brassicas is very high (Dove and McCormack 1986) and at the intakes likely to prevail in animals grazing this forage, could result in a deficiency of MP, and a need for further protein supplementation. For example, when lambs grazing forage rape were
offered small supplements (50 g d\(^{-1}\)) of formaldehyde-treated soyabean meal, a source of UDP, liveweight gain and protein gain in grazing lambs were increased, without any increase in carcass fatness (Table 3). The effect was especially evident in lambs grazing ‘stemmy’ rape, which itself had a lower protein content.

Table 25.3 Influence of type of forage rape crop (‘leafy’, ‘stemmy’) and supplementary feeding on weight gains and carcass characteristics of weaned lambs.

Source: Adapted from Dove (2002).

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Leafy crop</th>
<th>Stemmy crop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nil</td>
<td>RB</td>
</tr>
<tr>
<td>Weight gain (g day(^{-1}))</td>
<td>167</td>
<td>157</td>
</tr>
<tr>
<td>Carcass protein gain (g day(^{-1}))</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Carcass fat (%)</td>
<td>23.0</td>
<td>23.5</td>
</tr>
</tbody>
</table>

‘Leafy’ and ‘stemmy’ crops obtained using a leader-follower grazing system. Herbage availabilities were 4-5 t DM ha\(^{-1}\) (leafy) and 1-2 t DM ha\(^{-1}\) (stemmy). RB = rolled barley offered at the rate of 275 g DM day\(^{-1}\) per lamb. RB/FSBM = rolled barley at the same rate plus 50 g DM day\(^{-1}\) per lamb of formaldehyde-treated soyabean meal.

Energy and protein supplements revisited

It will be clear from the above discussion that the distinction between ‘energy’ and ‘protein’ supplements is only a general distinction, and one of convenience. Ultimately, both types of supplement have the capacity to alter ME supply to the animal, the efficiency of utilization of ME, the amount of microbial protein synthesized and the amount of dietary protein which escapes rumen degradation. In addition, once nutrients are absorbed from the gastrointestinal tract, there can be a further nutrient flux, principally energy, in the form of mobilized reserves of body fat. A good example of such interactions between grazed herbage, supplement and body fat reserves is shown in Table 4.

In unsupplemented, twin-suckling ewes, the pasture supported a milk yield of about 2 kg per day. Ewes maintained weight over 80 days of lactation, due mainly to increased pasture supply in later lactation. The provision of the ‘energy’ and the ‘protein’ supplements increased digesta flow at the abomasum by about 21% and 26%, respectively. The ‘protein’ supplement resulted in a large increase in CP flow in digesta (56%), of which significantly less was of microbial origin, as might be expected from a supplement which had been treated to resist rumen degradation. However, the ‘energy’ supplement also resulted in increased digesta CP flow, which may be related in part to increased ‘capture’ of rumen ammonia (16.4 cf. 24.1 mM) and conversion into microbial protein. Both supplements improved milk yield and lamb liveweight gains. This was especially so with the ‘protein’ supplement, upon which ewes lost weight slightly over the lactation. By contrast, ewes given the energy supplement gained substantially. Whilst some of these observations are consistent with the description of the supplements as ‘energy’ or ‘protein’ supplements, note that the ‘energy’ supplement influenced N transactions in the rumen, and the ‘protein’ supplement influenced the mobilisation of body energy reserves.

Table 25.4 Influence of ‘energy’ and ‘protein’ supplements on digesta flow, milk yield and liveweight change of grazing ewes, and the weight gains of their lambs.

Source: Dove et al. (1985).

<table>
<thead>
<tr>
<th></th>
<th>Nil</th>
<th>‘Energy’</th>
<th>‘Protein’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumen ammonia mM</td>
<td>24.1</td>
<td>16.4</td>
<td>20.1</td>
</tr>
<tr>
<td>DM flow (g d(^{-1}))(^{a})</td>
<td>1065</td>
<td>1288</td>
<td>1340</td>
</tr>
<tr>
<td>CP flow(^{a})</td>
<td>276 (0.934)</td>
<td>344 (0.851)</td>
<td>431 (0.772)</td>
</tr>
<tr>
<td>Milk yield (g d(^{-1}))</td>
<td>2048</td>
<td>2133</td>
<td>2846</td>
</tr>
<tr>
<td>Lamb weight gain (g d(^{-1}))</td>
<td>254</td>
<td>308</td>
<td>331</td>
</tr>
<tr>
<td>Ewe weight change (kg)(^{b})</td>
<td>0</td>
<td>5.1</td>
<td>-0.9</td>
</tr>
</tbody>
</table>

\(^{a}\)Energy supplement 600 g d\(^{-1}\) (air dry) of molassed sugarbeet pulp (CP 9%). Protein supplement 600 g d\(^{-1}\) (air dry) of a mixture (1:1) of molassed sugarbeet pulp and formaldehyde-treated soyaabean meal. Ewes grazed perennial ryegrass pasture of 750-850 kg DM ha\(^{-1}\) and digestibility >85%. \(^{b}\)All flows measured at abomasum and expressed in g d\(^{-1}\). Values are means of measurements in weeks 3, 5 and 7 of lactation. \(^{c}\)Values in parentheses are the proportion of CP flow which is of microbial origin. \(^{d}\)Weight change to day 80 of lactation.
Readings

The following readings are available on CD:

   - Doyle, P.T., 1987 ‘Supplements other than Forage’.

   See in particular the following chapters;


Activities

Multi-Choice Questions

Useful Web Links

Assignment Questions

Available on WebCT

Submit answers via WebCT

Available on WebCT

Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCT

Summary

When grazing animals are supplemented, their herbage intake rarely stays the same and usually decreases when the supplement is eaten (substitution). If the supplement makes good the supply of a nutrient which was limiting intake (e.g. rumen-degradable protein for animals grazing low-quality roughage) then roughage intake may increase (complementation). These processes help explain the variability in response to supplements. While supplements can be classed as energy or protein supplements, conserved forages or fodder crops, this is only a classification of convenience.

For wool growth, the main limitation is protein and especially sulphur-amino acid supply. The upper limit of the wool-growth response to protein supplementation is set by energy intake. In reproducing animals, ovulation rate can be increased by short-term protein supplementation but excessive supplementation in early pregnancy can reduce embryo survival. Severe under-nutrition during mid- to late pregnancy can reduce milk production in lactation. In early lactation, protein supplements may increase milk yield but in females with good body fat reserves, may also increase weight loss. Under rangeland conditions, energy supplements are too expensive and the need is usually for cheap supplements of rumen-degradable N (e.g. urea). Young animals can be ‘trained’ to eat supplements either by exposure to them at a very early age or by offering them when ‘experienced’ animals are also present. Problems with ‘shy feeders’ can be overcome with less frequent feeding of supplements. In all supplementation programs, it is important to control intestinal parasites.
References


