27. Supplementation of Ruminants - Dry Pasture

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Learning objectives

On completion of this topic you should be able to:

- Develop a practical supplementation program for sheep grazing pastures of low digestibility.
- Describe the range of supplement delivery system available to producers and the benefits/drawbacks of each.
- Compare and contrast the situations when NPN and true protein supplementation are appropriate.
- Understand why supplementing sheep and cattle with urea-based supplements will increase feed utilisation and feed consumption.

Key terms and concepts

Basis of Supplementation; Types of Supplementation; Supplementation Strategies; Protein Supplements; Energy Supplementation; Straw Supplementation; Practical feeding issues; Intensive feeding production.

Introduction to the topic

Supplementary feeding of livestock is a wide-spread practice in Australia. Supplementary feeding may be undertaken in drought conditions, for the purpose of survival or for production purposes. Most of Australia's livestock production systems rely on native pasture in regions of low rainfall and low humidity. In many situations, the quality of pasture available to animals is more limiting than the quantity of pasture available. Therefore, supplementation practices are frequently designed to enable greater nutritive value to be extracted from the available feed.

This topic covers some of the common supplementation practices used in Australia and describes the nutritional principles underpinning these practices.

27.1 Basis for supplementation

A decision to ‘supplement’ animals usually implies that a reasonable amount of some basic feed source already exists but the intake of energy and nutrients from this basal diet are inadequate to enable the animals to meet a production ‘target’, i.e. the diet is an indigestible or ‘imbalanced’ (Figure 27.1). In the case of ruminants the basal diet is often pasture, crop stubble or straw. That there is a need for supplementation also implies that there is an over-riding primary dietary deficiency that is often referred to as the ‘first limiting factor’. This limiting factor could be an inadequate intake of energy, protein or NPN, minerals or vitamins. Of course, as one limitation is corrected by supplementation, another limitation will appear.
Pasture–fed ruminant animals

In contrast to the situation with intensively fed animals—where intake depends on management—for pasture–fed animals, intake depends mainly on characteristics of the pasture which determine the animals’ feeding behaviour. Pasture is intrinsically fibrous and bulky. Actual intake of pasture is typically limited by low digestibility, and low rates of fibre digestion and rumen emptying which determine the level of gut distension. Intake of tropical pastures varies from 1–3% of live weight depending on pasture species and season. Intake on temperate pasture is often higher, reflecting differences in digestibility between tropical and temperate species. In addition, tropical pasture species are usually lower in crude protein and mineral content than temperate species at the same stage of maturity.

Grazing ruminants can therefore rarely eat enough to fully satisfy their energy and nutrient needs (they cannot achieve their potential feed intake, i.e. the intake animals would ingest with an ideal diet). Food passes into the rumen after initial chewing, still with quite long particles. However, this feed cannot leave the rumen until the feed pieces how reduced to about 1 mm in length. The indigestible larger particles accumulate in the rumen causing distension that inhibits further feed intake. Prediction of the actual feed intake in grazing animals (which is almost always lower than potential) has proved difficult, and yet a knowledge of the intake from pasture is essential before production from grazing animals can be predicted.

It is not easy to make experimental estimates of intake in the field and it has therefore been difficult to develop predictions of intake. Estimates have been made using animals with fistulas in the oesophagus to enable feed swallowed to be collected, using non–digestible gut markers and, more recently, using plant waxes (alkanes). However, some data are available and the Australian feeding standards (SCA 1991) makes predictions of likely feed intake of grazing animals. Prediction of intake depends on factors such as pasture availability, pasture quality (green or dry; legume or grass) and animal status (pregnant, lactating) that are included in the computer model, GrazFeed, which we will use during the residential school. Prediction of actual feed intake (almost always less than potential intake) in this model depends on these and other factors (genotype,
climate). The program also recognizes that supplementing grazing animals will affect their intake of pasture (substitution effect). Frequently, the intake of pasture will be reduced by 50–90 percent of the weight of the supplement ingested. A simple economic analysis of the value of supplementation is also included in GrazFeed.

27.2 Types of supplements

Typical supplement types for grazing animals include:
- ‘Energy’ concentrates
- ‘Protein’ concentrates
- ‘Mineral’ supplements, e.g. molasses, common salt, phosphoric acid.

‘Energy’ supplements

So-called ‘energy’ supplements, e.g. cereal grains, lupins, protected fats, seldom provide only energy—they also usually contain some crude protein/minerals. Energy concentrates (e.g. cereal grains) usually cause ruminants to decrease intake of pasture to some extent. ‘Substitution’ effects will be greater if the supplement causes the overall diet to become imbalanced.

Protein supplements

The benefit of feeding protein meals in the dry season has been known for many years. In 1932, Marston showed in Queensland that supplementing sheep on dry pasture with blood meal markedly increased their wool growth. ‘Protein’ concentrates include blood meal, cottonseed meal, peanut meal, canola meal and lucerne hay. NPN sources such as urea have a special role as ‘protein’ supplements even though they contain no true protein or amino acids.

Thus, protein supplements for ruminants fall clearly into two categories:

- **NPN supplements** such as urea—these ruminally degradable N-containing materials (RDN sources) provide ammonia to enable rumen microbes to grow, which in turn provides true (microbial) protein to the host.
- **Bypass/protected/escape protein supplements**—these escape degradation in the rumen and amino acids in the intestines. These amino acids supplement the microbial amino acids from the rumen.

NPN/fermentable N supplements

Many mature pastures and crop residues provide insufficient ruminally degradable N to maintain optimum conditions for feed digestion and microbial growth in the rumen. Low rates of digestion of complex feed carbohydrates in the rumen compound the problem of low feed digestibility. Moreover, when ‘protected’ protein concentrates are given—even though they almost always provide some ruminally fermentable N—they may, at times, not provide enough

NPN refers to ‘Non–Protein Nitrogen’ and is usually only a source of rumen ammonia. It contains no amino acids. Urea and sulphate of ammonia are often used as NPN supplements.

NPN to optimise microbial growth in the rumen. Deficiency of rumen fermentable N causes slow fibre digestion in the rumen, increased rumen fill, and consequently reduced feed intake. Urea, which is rapidly degraded to ammonia in the rumen, is commonly used to overcome this problem. It may be provided in drinking water, or be sprayed on straw or even on dry pasture. Urea–molasses blocks are made hard enough to prevent animals overeating them and being poisoned by excessive urea intake. For the same reason, urea–molasses solutions are put out in special dispensers (Figure 27.2).
Figure 27.2 A ‘home–grown’ dispenser made from an empty petrol drum. The drum sits in a trough containing a molasses–urea solution. The animals cannot drink the supplement but they learn to rotate the drum and lick the solution on the drum. This limits intake. Source: McCosker and Winks (1994).

Ewes on dry tropical pasture have been supplemented beneficially with urea via their drinking water. In practice, however, variation in urea intake between animals can be a problem, and ammonia intoxication leading to sudden death of animals is an ever–present threat.

Basal diets that require rumen N supplementation are often also deficient in sulfur for rumen microbial growth. Sulfur supplements are frequently provided in conjunction with urea.

When NPN supplements are needed, it is common for sulphur to be the next limiting nutrient for rumen microbial growth.

Mineral supplements
Mineral supplements need only be used if minerals are indeed deficient. Mineral deficiencies are not easily to predict, or detect. Deficiency depends on plant/ climate, animal and soil factors and may only be apparent in higher producing animals. Deficiencies of calcium and magnesium may be induced by oxalates in tropical pastures. The calcium or magnesium oxalate salts form in the gut and are not absorbable. In high rainfall areas it is often advisable to put blocks out under cover (Figure 27.3).
27.3 Supplementation strategies for ruminants

Protein and NPN supplementation
The principles of protein feeding management can be summarised as follows:

• First, maximize rumen microbial growth and **microbial protein** production using urea or ammonia (NPN) as inexpensive sources of nitrogen to supply the rumen microbial population;
• **Only if** protein supply to the host is inadequate to meet the animal's requirement for optimal production, **then** feed a source of *escape* protein, e.g. fish meal, cottonseed meal, meat meal, palm kernel meal etc.

Escape/bypass protein supplementation is likely to be required when the animal is growing rapidly, during late pregnancy, and especially during lactation. Wool growth, because of its abnormal requirement for sulfur–containing amino acids is likely to be responsive to bypass protein supplementation, but note that fibre diameter and staple length are likely to both be increased.

An example of the feeding strategy put into practice is given in Table 27–1. The cattle in the trials were in northern Queensland and the basal diet was spear grass hay. Dry pasture materials, hays and straws are generally are low in total N (crude protein), and low in Ca and P, S and Co. Na may also be low. Silicates and oxalates may reduce absorption of Mg and Ca, as may the presence of internal parasites.
Table 27.1 Strategy for supplementing pasture hay (0.4 % N, 45 % digestibility) with urea and sulphur to provide optimum conditions, and additional dietary protein to augment intestinal amino acid absorption. Source: Lindsay and Loxton (1981).

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Feed intake (kg/d)</th>
<th>Live weight change (kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>2.26</td>
<td>-0.41</td>
</tr>
<tr>
<td>Urea + S</td>
<td>3.01</td>
<td>-0.32</td>
</tr>
<tr>
<td>Urea + S + bypass protein</td>
<td>4.43</td>
<td>+0.22</td>
</tr>
</tbody>
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Energy supplementation

The major way to increase energy intake of animals given low quality roughages is to increase feed digestibility. This is often achieved by feeding energy concentrates (e.g. cereal grains). If low digestibility roughage is all that is available, this can be chemically treated to increase its digestibility.

Treatment of straw to increase digestibility

In the situations shown in the above table, intake is almost certainly limited by rumen fill and the negative effect of rumen distension on feed intake. The rumen distension occurs because feeds are retained for prolonged periods in the rumen until they are comminuted (reduced in size) sufficiently, by rumination and microbial digestion, to pass out of the rumen. Low digestibility and low intake leads to low digestible DM Intake and low ME Intake. This is often made worse by nutrient (N and S), and P:E ratio imbalance. Fine grinding may increase intake, but decreases feed retention time in the rumen, and decreases digestibility.

A further increase in intake and production could be expected if the straw were treated chemically to increase digestibility.

Chemical treatment to increase digestibility

In Europe, caustic soda (NaOH) has long been used to increase straw digestibility. However, NaOH is hazardous to people and animals. Na+ excreted by animals eating this treated material spoils soil structure.

Ammonia treatment, in contrast, is widely applicable. Urea/chicken litter can generate NH₃ in ‘wet ensiling’. Chemicals such as CaO, acids and acid gases (SO₂) have also been used. Sugar–cane bagasse can be treated with high–pressure steam (at the sugar mill).

Supplements for use with straw

- Rumen degradable N (NH₃, urea, fresh forage, lupins etc);
- Sulfur, other minerals (molasses, salts);
- Small amount of green forage (to increase microbial attachment, activity) e.g. Azolla, tree legume;
- Bypass protein concentrate (cottonseed meal, palm kernel cake, Leucaena);
- Bypass starch (maize, treated products) or LCFA (as insoluble soaps).

Use of legume forages

Production from low–protein grasses, especially in the tropics, is often improved by feeding legume forages, e.g. Gliricidia, Leucaena, Erythrina (Figure 27.4).
Figure 27.4 The effect of inclusion of Glyricidia (a tropical legume) in a basal diet of King grass for weaned bulls with an initial weight of 180 kg. Source: TR Preston, pers. comm.

The effects of supplying green leguminous feeds may be two–fold:

- Provision of RDN and by–pass protein; and
- Possible additional effects of the green material on attachment of rumen microbes to feed particles in the rumen.

### 27.4 Practical feeding issues

#### Supplementation using animal stores

Animals that are in good condition carry stores of nutrients ‘on their backs’. When they encounter a poor season they may lose weight and body condition, but will regain it when the season improves (see compensatory gain below). Using animal stores can be viewed as an alternative, and often a less expensive option, than giving them feed supplements. It is important to evaluate these options in relation to the target levels of production, times of premium markets and their likely economic consequences.

#### Compensatory gain

Compensatory growth is the greater–than–normal live weight observed in animals previously adapted to an extended period of nutritional restriction (e.g. during the dry season in northern Australia (Figure 27–5). The phenomenon is significant because the effects of supplementation of animals during periods of drought can be partially or completely lost due to compensatory growth after the season breaks. Providing supplements in this situation is generally a poor economic proposition unless the animals are to be sold before they have time to compensate.

The expression of compensatory gain depends on:

- The age at which dietary restriction occurs;
- The severity of the restriction; and
- The duration of the restriction.
Figure 27.5 The growth paths of large-framed sheep subject to a period of restricted nutrition in a poor season (dotted line) followed by excellent conditions, and of control sheep continuously supplied with adequate feed. Source: Nolan (2006).

Complete compensation is seen in sheep and cattle of 4–6 months of age if restriction is sufficiently severe, but compensation is generally not complete in younger animals.

There appear to be four mechanisms involved:

- A reduced maintenance requirement;
- Increased efficiency of growth and fattening;
- A reduced energy content of the tissue gain; and
- Increased feed intake.

### 27.5 Intensive feeding for production

Poultry and pigs are generally given single diets, often as crumbles mixes, or as pellets. These diets are formulated to provide an appropriate ratio of the important nutrients relative to ME. The concept used is that birds given well-balanced diets will alter their intake to meet their current energy demands, although this may not be the whole story—they may selectively choose feeds to obtain protein and other nutrients as well. It is generally assumed that amino acid and mineral requirements will be appropriately included in the diet and will not be limiting.

These days, computer programs are used in conjunction with databases that contain information about feed ingredients. Energy and nutrient concentrations are tabulated in these databases along with current costs of the ingredients.

During the residential school, we will undertake some dietary formulation exercises that illustrate how these procedures are carried out for ruminants and pigs/poultry.

Some of the principles of supplementary feeding of roughage–fed animals also apply to grain–fed animals.

Ruminants animals in feed lots are also managed more like pigs and poultry. Again, the requirements of the animals must be known. Computers and large databases are increasingly being used to perform diet formulations. However, for simple diets, the job can be done quite easily without the aid of a computer.
Some basic principles apply. Generally, Australian feed lot diets are based on about 70–90 % grain. The balance, 10–30 %, usually contains roughage, a protein source and minor ingredients. Many feedlots do not use roughage after an introduction period of 2–3 weeks. Some NPN source such as urea is often used to increase ammonia supply for rumen microbes, and true protein sources such as cottonseed meal may also be used. However, in the fattening phase, protein supply from the rumen microbes may provide sufficient amounts of amino acids for maximum growth rates. (Ruminants do not, strictly speaking have any requirement for dietary true protein, because rumen microbes can synthesise all 20 amino acids in common proteins from urea or other NPN sources.) Diets should also include a source of calcium because most gain–based diets are deficient in calcium. The usual source of calcium is limestone. A mineral and vitamin pre–mix is often used and should include sodium chloride. Other ingredients include buffers (such as sodium bentonite, bicarbonate) and growth promotants such as monensin or virginamycin.

Readings
The following readings are available on CD:

Activities

Multi-Choice Questions

Self Assessment Questions

1. What are the different types of supplements commonly offered to grazing animals?
2. What overall strategies or ‘rules’ would you apply to the general problem of supplementing ruminants on straw-based diets?
3. What nutritionally useful components are supplied in a urea–molasses block?
4. When are urea supplements not likely to improve ruminant production?
5. What types of supplements would you consider giving to animals on a basal diet of rice straw?
6. What is meant by ‘compensatory growth/gain’?
7. What is meant by the ‘substitution effect’ when supplements are offered to grazing animals?

Useful Web Links

Assignment Questions

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

Summary

Summary Slides are available on CD

References

McCusker, T. and Winks, L., 1994. ‘Phosphorus nutrition of beef cattle in northern Australia’. Department of Primary Industries, Queensland