Building better feed systems

LINDSAY BELL
CSIRO Sustainable Ecosystems/APSRU, Toowoomba, Queensland, Australia

Summary - Key points

- Better matching feed supply and animal demand can improve efficiency and reduce risks to livestock production systems and natural resources.
- Compare availability and demand in terms of metabolisable energy, as it incorporates both quantity and quality.
- Distinguish between the types of feed gaps that occur, as these will influence the type of management response required.
- Farm feed year planning is a useful approach to investigate strategies for developing better feed systems.
- By combining feed sources it is possible to reduce the frequency of feed gaps and fluctuations in annual forage production.
- 'Marginal value of feed' is an important concept that recognises that forage (or energy) provided when other sources are in short supply (*e.g.* oats or medics) has greater value than when feed is plentiful.

The need to transform our feed systems

Significant improvement of the sustainability and productivity of ruminant livestock systems in Australia is possible through better management of the 'feed-base'. The seasonality of supply in southern Queensland, and many other parts of Australia, means that there is often a mismatch between supply of newly grown forage and the daily demands of livestock (Moore *et al*. 2009). As a result of imbalances between feed supply and demand, there are inefficiencies in production in terms of excess feed wasted or unmet animal demand. Not only do gaps in feed supply limit the rate of forage intake of animals, but also it is inefficient for animals to lose weight and then regain it later. It requires about 50% more energy to support an animal through a cycle of weight gain followed by weight loss and recovery than to produce the same weight gain followed by maintenance (Moore *et al*. 2009).

Mismatches between animal demands and supply of forage, especially periods of feed deficit, also have implications for natural resource management (NRM). For example, pasture over-utilisation reduces ground cover, reduces rainfall infiltration, increases runoff, exposes soil to erosion and can remove desirable species and so allow weeds to invade.

A common way of avoiding feed gaps is to sell stock during periods of feed shortage and buy again when feed supply improves. However, this often results in stock being marketed at a time when market prices are not favourable and buying animals when demand is high and prices are elevated.

Developing feed systems that improve the continuity of feed supply to better match animal demand can minimise costs of supplementation, increase livestock production and profitability, improve NRM outcomes and reduce business risk.

What do we mean by 'Feed-base'?

By the 'feed-base' we mean all the sources of livestock forage grown on the farm (Bell *et al*. 2008). The feed-base of farms in southern Queensland and northern New South Wales is particularly diverse and may include native pastures, sown pastures that grow in winter or summer (*e.g.* subtropical grasses, lucerne, medics), winter or summer forage crops (*e.g.* oats, lablab, forage sorghum), abandoned crops, crop residues and

Correspondence: L. Bell, CSIRO Sustainable Ecosystems/APSRU, PO Box 102, Toowoomba, Qld 4350, Australia. E-mail: Lindsay.Bell@csiro.au

conserved forage (hay or silage). While grain and other supplements can be important components of livestock diets at particular times of the year, they are generally expensive compared with forage grown on-farm. The focus of this article is on improving management of the continuity and quality of supply of forage for grazing.

Feed gaps and matching animal demand and feed supply

A feed gap occurs when the supply of forage (which involves both quality and quantity) is insufficient to meet livestock demands (Moore *et al*. 2009). It is best to compare the availability of and demand for metabolisable energy, because this incorporates both quality and quantity of the forage.

It is important to first understand when and how feed gaps occur, in order to develop better feed systems that reduce their frequency and intensity. We are all aware that forage production is not even throughout the year—there are periods when there are surpluses of feed and periods when there are shortages. In the subtropics, the majority of grass-pasture production occurs between November and March in most years (Figure 1). When grass growth slows or

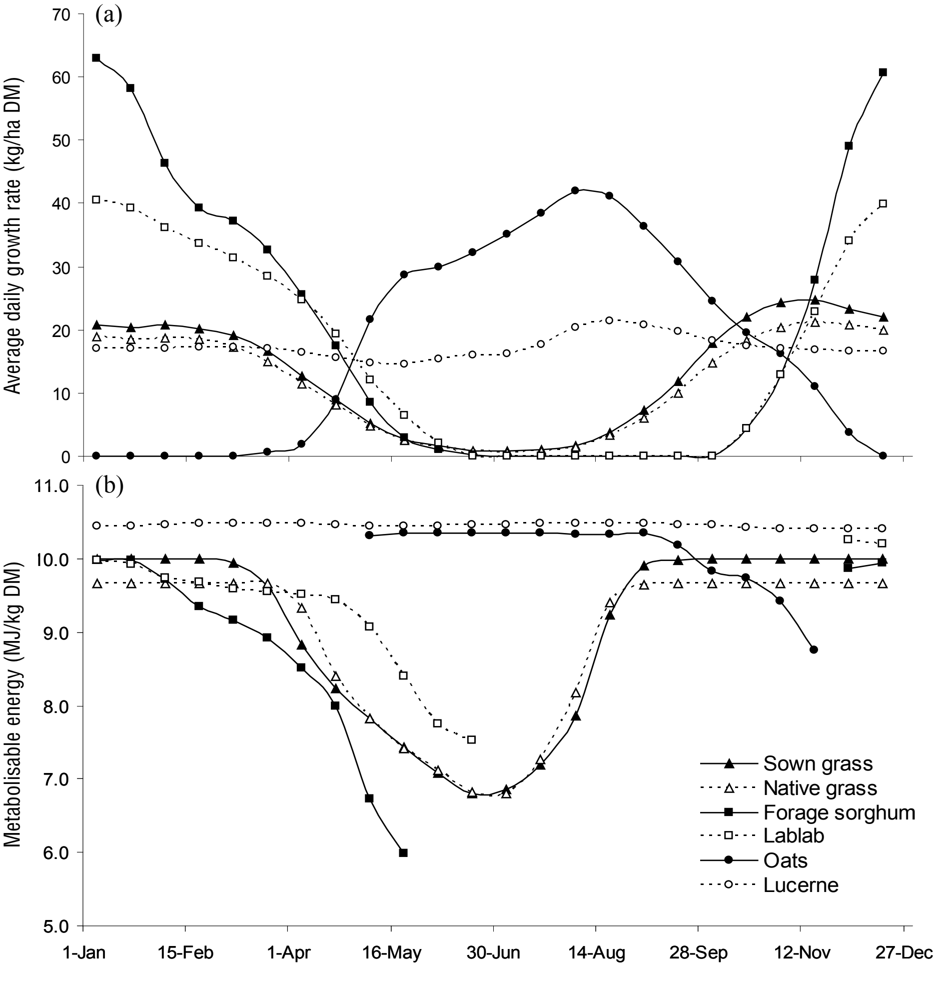

Figure 1. Average growth rates (a) and energy content of feed consumed by livestock (b) from important forage sources in southern Queensland.

stops, stock have to rely on forage carried over from previous months. This feed will decline in quality and so will provide less and less energy for livestock. Importantly, in our subtropical climate, effective winter rainfall in some years can produce significant forage production from high-quality species, such as medics and oats, which can greatly boost the amount of energy available to livestock during the winter-spring period.

Animal demand is also not even throughout the year. The feed requirement per animal will vary depending on the animal's size, its growth rate and any reproductive demand. For example, a lactating cow with a 3-month-old calf will require twice as much energy as a similar dry cow (CSIRO 2007). Adult equivalents (AE) or dry sheep equivalents (DSE) are the standards for measuring the relative feed requirements of various classes of livestock and allow animal demand to be compared for different herd structures. Each AE requires 57 MJ of energy per day (7.6 MJ/day for a DSE) with extra energy needed for weight gain or milk production (CSIRO 2007).

Dealing with variability in feed supply

The variability in forage growth occurs not only within a year but also between years owing to our highly variable rainfall in southern Queensland. Our livestock-feed system needs to consider this variability to reduce exposure to exceptionally dry periods. In order to do this, it is useful to distinguish between the types of feed gaps that occur, as this will influence the type of management response required.

The first type to consider is 'regular' feed gaps that occur in most years. To recognise this, average pasture growth curves can be useful (as shown in Figure 1). However, it is important to also be aware of the variability in pasture growth that may occur within a particular year. Figure 2 shows how monthly growth rates differ between the long-term average and the highest and lowest

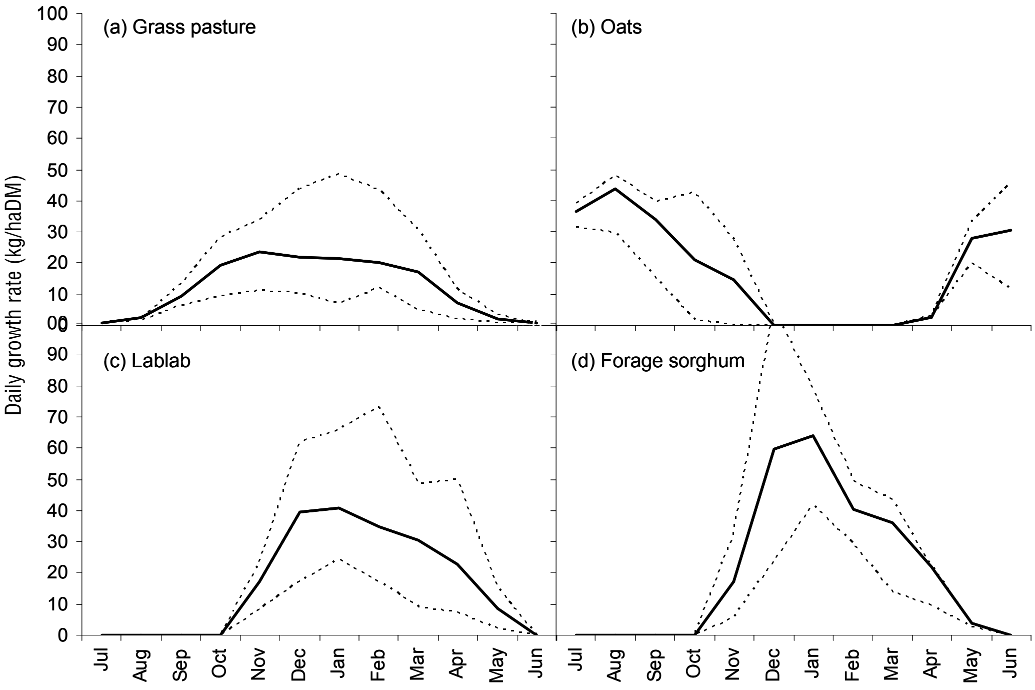

Figure 2. Within-year variation in simulated growth rates of 4 common forage sources at Goondiwindi. Data were modelled using modules in the Agricultural Production Systems Simulator (APSIM version 6.1) and APSIM-Grasp (Grass pasture) from 1906-2005. Solid line = 100-year average, dotted lines = average for the highest and lowest 20% of yielding years.

yielding 20% of years. Highly variable year-to-year changes in pasture growth rates result in the second type of feed gap, that is, an 'irregular' within-year feed gap. This is different from a 'regular' feed gap because it occurs in only some years. A good example of such variability is the spring-early summer growth from summer-active grasses in southern Queensland. Thirdly, variation in annual pasture production is large and can result in feed gaps that have effects at a longer time scale and with greater consequences. Figure 3 shows how much total annual grass production can change between years in the subtropics.

Types of management interventions

There are 2 main approaches for altering the balance of feed supply and demand to overcome a feed gap: tactical responses as needs and opportunities arise (*e.g.* buying or selling stock based on a seasonal feed budget); and strategic responses that usually involve a change to the feed-base or the livestock system (*e.g.* change in joining time or sowing a new feed source). In environments where feed supply is less predictable in terms of its timing and magnitude (*i.e.*, irregular), tactical responses may be more suitable to overcome modest feed gaps. Tactical responses have the advantages that they can generally be implemented within the existing farm enterprise and structures and the opportunity cost tends to be low in years when the tactical option is not exercised. For example, if a grain crop is not grazed, it is not wasted as it can still yield a return of grain; and if conserved forage is not fed out, it is still available for use at some later time.

Strategic responses are most useful where a regular, predictable feed gap occurs, but they can also involve decisions that reduce risk or probability of a feed gap occurring (*e.g.* diversifying the feed-base). Strategic changes to the feed supply are likely to require structural adjustments to the entire farming system. For these to be economically viable, the livestock system often needs to be modified to reflect – and exploit – the altered profile of feed supply.

Table 1 is a summary of my thoughts on how suitable various types of interventions are for dealing with different sorts of feed gaps and the type of management change that is required (*i.e.*, strategic or tactical).

We will now explore in different ways one of these management interventions (*i.e.*, diversifying the feed-base to include forage crops) and the impact it has on reducing the frequency or intensity of feed gaps in southern Queensland. This is intended as an example to encourage thinking about how better feed systems could be

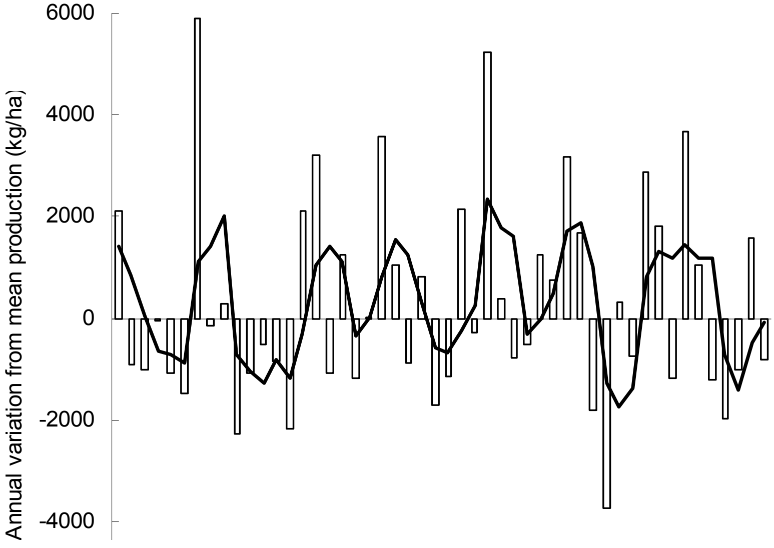

Figure 3. Year-to-year variability in total annual grass pasture production is high. Data are simulated using APSIM-Grasp for 1956-2005 at Goondiwindi in southern Queensland. Solid line shows the 3-year running total.

Table 1. Comparison of the suitability of some management interventions for dealing with different types of feed gaps (*** - good, ** - moderate, * - low, o – nil).

Management intervention	Strategic/ Tactical	Regular within-year feed gap	Irregular within-year feed gap	Annual fluctuation in feed supply
Change livestock system to meet typical feed supply (*e.g.* change time of joining or weaning)	Strategic	***	o	o
Adjust livestock numbers according to seasonal feed budget	Tactical	o	**	***
Diversify the feed-base (*e.g.* sow forage crop)	Strategic	***	**	**
Forage conservation (*e.g.* reserve paddock, hay or silage)	Strategic or tactical	***	***	*
Graze a grain crop or crop residues	Tactical	**	**	*

Table 2. Frequency (% of months) that the 4-month running total of livestock demand exceeds DM production for the same period under grass pasture-based feed systems with and without the addition of 20% forage area of various other forage options (adapted from Bell 2008).

Feed-base	Stocking rate (AE/ha forage area)		
	0.1	0.25	0.4
Grass only	10	16	25
Grass + lablab	9	18	27
Grass + forage sorghum	8	17	25
Grass + lucerne	5	12	16
Grass + oats	3	5	7

Table 3. Optimal mix of forages (% of farm forage area) to minimise variation (CV) in annual DM production for the whole-farm feed-base with different proportions of grass pasture (adapted from Bell 2008).

Grass	Lablab	Oats	Forage sorghum	Lucerne	CV (%)	Mean DM (t/ha/yr)
100	-	-	-	-	44	4.1
90	10	0	0	0	38	4.3
75	18	7	0	0	31	4.7
60	20	20	0	0	27	5.0
50	21	29	0	0	25	5.2

designed. It does not preclude the use of other important interventions such as feed budgeting or forage conservation, which are vital options to respond to fluctuations in feed supply that will continue to occur.

Feed combinations that reduce variability in feed supply

As shown earlier, variability in forage production is a major problem for managing the feed-base in southern Queensland. This often results in more conservative stocking rates to reduce exposure to severe feed shortages that require expensive supplementary feeding or forced sale of stock on a flooded market. For example, from a grass-only feed-base, a 4-month running total of forage growth is less than livestock demand over the same period 10% of the time when stocked at an average of 0.1 AE/ha. If the stocking rate is increased, the frequency of this feed deficit also increases (Table 2).

However, the addition of other forage sources can help to minimise the frequency of feed gaps and reduce the variability in total annual forage production. Table 3 shows that the addition of oats greatly reduced the frequency of a deficit in fresh forage supply, while summer-growing forages such as forage sorghum and lablab were less effective. The addition of 20% oats to the feed-base could even allow higher stocking rates to be applied without greatly increasing the risk of a feed gap.

Diversified feed-bases can also reduce the inter-annual variability in forage production (Table 3). For example, by complementing a grass-based feed-base with a forage crop such as lablab or oats, variations in total yearly production are reduced. A feasible option may be a feed-base consisting of 60% grass pasture, 20% oats and 20% lablab (by area), which would reduce the frequency and size of a feed gap over both 4-monthly and annual timescales. Whilst this suggests that a more diverse feed-base will reduce the irregularity of feed supply, further analysis is required to investigate how this will affect the balance of forage supply and demand throughout the year.

Farm feed-year planning

Whole-farm feed-year planning is a strategic or long-term approach to planning for the availability of particular feed sources relative to the demands of the livestock across the year. The objective is to match periods of maximum livestock demand (*e.g.* first few months after calving) with periods when feed is generally most abundant. The following example demonstrates how the MLA Feed Demand Calculator could be used to investigate options to better match supply of forage and demand from livestock throughout the year (Bell *et al*. 2008).

This example is based on a typical breeding operation in the Roma district of Queensland, with an initial livestock enterprise of 250 breeding cows joined between January 1 and April 1, with weaned calves sold on July 1 the following year. The cattle were assumed to graze 1000 ha of sown tropical grass pasture (*e.g.* buffel grass) and default values for monthly pasture growth rates and quality were used (generated from long-term simulations of production at Roma).

Figure 4a shows that, in an average season (scenario 1), the feed demand of the livestock exceeds the fresh grown supply between May and July, but sufficient feed is carried over from summer to meet animal requirements during this period (Figure 4a; Table 4). Overall annual utilisation of pasture grown is 24%, which is considered to be a 'safe' carrying capacity (Hall *et al*. 1998). However, in a poor season (scenario 2 - the bottom 20% of years), there is a

Table 4. Annual performance indicators generated using the MLA Feed Demand Calculator for various combinations of feed-base and livestock enterprises under different seasonal conditions (refer to Table 1) at Roma, Queensland (570 mm MAR) (Bell *et al*. 2008).

Scenarios				Feed deficit, fresh grown supply (t/yr)	Feed deficit, supply with carry over[3] (t/yr)	Whole-farm beef produced (t LW)	Beef produced per ha grazed (kg/ha)	Feed demand (% of feed grown[4])
No.	Feed-base[1]	Annual growth	Livestock enterprise[2]					
1	Grass	Average	Breeding only	282	0	63	63	24
2	Grass	Poor	Breeding only	353	142	63	63	54
3	Grass + oats	Poor	Breeding only	132	0	63	55	44
4	Grass + oats	Average	Breeding + grow weaners	92	0	131	114	35
5	Grass + oats	Good	Breeding + grow weaners & trade stock	16	0	151	131	26

1 Grass – 1000 ha sown grass; additional 150 ha oats.
2 Breeding – 250 breeding cows joined Jan - Mar; grow weaners –weaned calves grown until 18 months old; trade stock – 200 additional weaners purchased and grown from 250 to 400 kg.
3 2/3 of excess feed (growth + carry over - demand) from previous month carried forward.
4 Total annual demand as % of annual pasture growth.

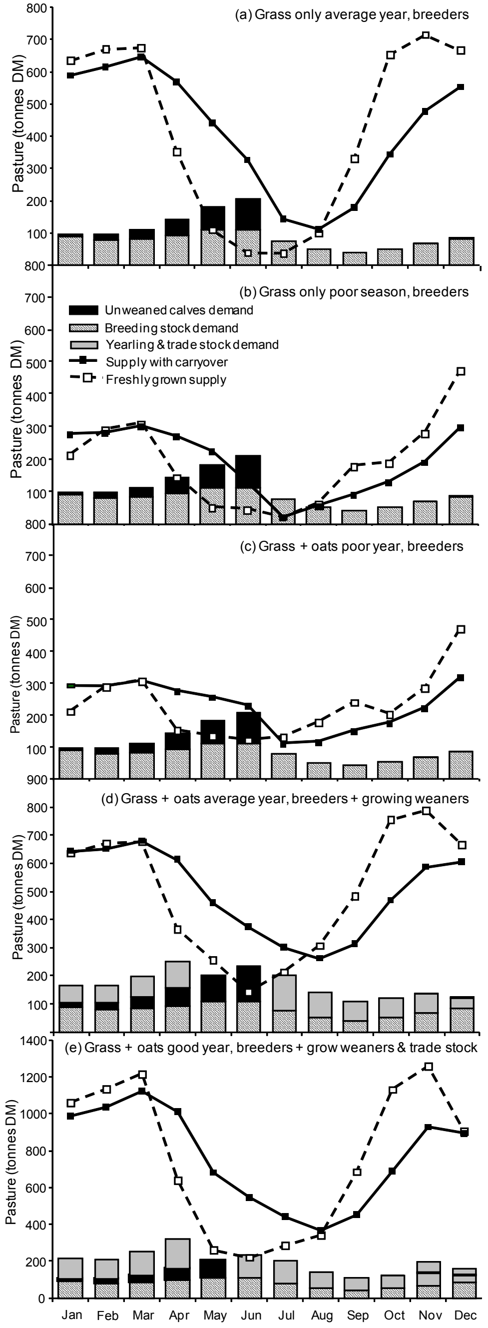

Figure 4. An example of using the MLA Feed Demand Calculator to investigate the balance of feed supply and demand throughout a year for various combinations of livestock (breeders with/without growing weaners and trade stock) and feed-base systems (1000 ha of sown grass, with/without 150 ha oats) under different seasonal conditions for a mixed farm at Roma, Queensland (570 mm MAR) (Bell *et al*. 2008).

large feed deficit during winter (May - August) with insufficient carry-over feed to satisfy livestock requirements. Annual pasture utilisation increases to 54% of pasture grown and all pasture carry-over is utilised by July (Figure 4b; Table 2). Thus, in dry seasons, it is likely that supplementary feeding, sale of breeding stock or earlier weaning, would be required to support animals through the winter.

Alternatively, a winter forage might be incorporated into the system in an attempt to address a winter feed gap in dry years (scenario 3). The success of such a strategy obviously depends on the amount and timing of winter rainfall, but by adding 150 ha of oats into the feed-base the winter feed deficit may be reduced substantially so that sufficient forage is carried to maintain breeder numbers with a reduced reliance on supplementary feed (Figure 4c; Table 4). However, the larger area of forage grown now reduces the beef production per hectare.

Incorporating a winter forage crop into the whole-farm feed system means that adjustments to the livestock system that increase beef production in average and good years may also be possible. For example, owing to the greater amount of forage available in winter, weaned stock in average seasons could be carried through until the following May to allow yearling stock to meet feedlot entry specifications (~400 kg LW) at 17 months of age (scenario 4; Figure 4d). In the 'basic' feed-base system with grass only, these animals would need to be sold at least by June to reduce feed demand during winter (Figure 1a). In good seasons, an additional 200 trade stock (~250 kg) could be purchased and grown to 400 kg by May 1 to capitalise on extra feed grown without compromising the supply of feed for the breeding enterprise and still allowing for moderate utilisation of the pasture resource (scenario 5; Figure 4e). These changes to the livestock enterprise also greatly increase the amount of beef produced and enable greater utilisation of excess pasture during summer when the tropical grasses are most active (Table 4).

Marginal value of feed - an important concept

Finally, I would like to introduce a very important concept – the 'marginal value of feed'. Marginal value of feed is the notion that a feed source has higher value at times when others are in short

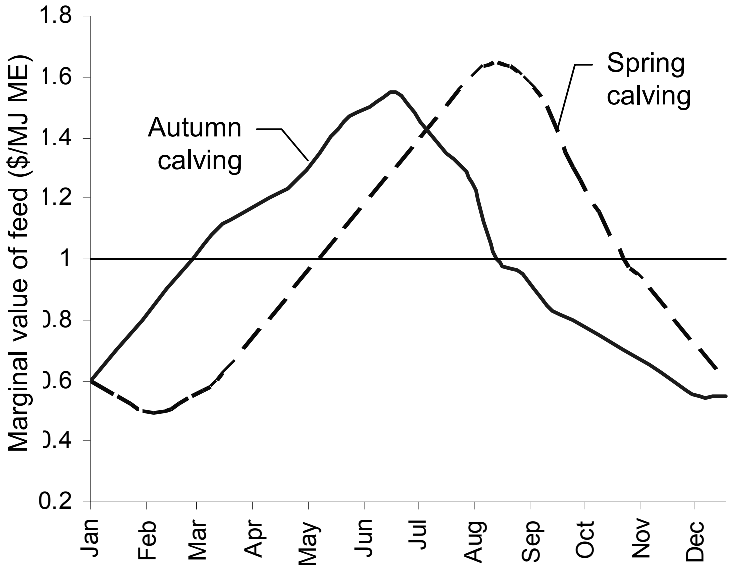

Figure 5. Changes in marginal value of feed throughout the year for breeding enterprises differing in their time of calving. Please note – this figure is illustrative and based on notional values only.

supply or of poor quality. In essence, the marginal value of feed means that an extra kg of feed (or MJ of energy) is highly valuable when there is none available, but has little value when the quantity exceeds the needs of the stock.

From the above two examples, it can be seen that oats and other winter-growing forages are very useful at reducing the occurrence of a winter-spring feed gap and potentially increasing the productivity of the livestock enterprise via the capacity to maintain higher stocking rates or enabling stock to be sold when market prices are typically higher. Feed sources such as oats or medics are often undervalued because these benefits for the whole livestock enterprise are frequently neglected. Similarly, conserving a summer-growing forage (*e.g.* forage sorghum or lablab) until a period of feed deficit would convey greater value than if it were grazed during summer, when other feed sources were plentiful.

Complementary benefits of different feed sources are also important. For example, crops such as forage sorghum can be grazed heavily during summer, which may allow native or permanent pastures to be spelled so that they can seed and regenerate. Many of these benefits are immediately intangible but can be important for future profitability.

It is also important to recognise that the value of feed at different times of the year is different for different livestock systems. That is, additional feed or energy will have more value at times when livestock demand is high (*e.g.* early lactation or for finishing stock). Figure 5 provides an example of how the marginal value of feed may vary throughout the year for 2 different livestock enterprises in southern Queensland.

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