Grassland improvement in subtropical Guangdong Province, China.
4. Development of a whole-farm grazing system

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Abstract

A whole-farm feed management system was developed for beef cattle in north Guangdong Province centred around the growth cycles of adapted pasture and forage species. For every 100 breeding cows, about 250 animals (or 154 AU) must be supplied with forage from pasture throughout the year. Late winter–early spring is the critical period of feed shortage for a breeding enterprise in this region. Integration of pasture types (tropical–temperate–forage crops) will reduce this period of feed shortage. Based on these assumptions, managers should aim to establish areas of tropical pastures, temperate pastures and forage crops in the ratio 8.5:4:1. Adjustment for year-to-year variation in supply can be made by implementing short-term management practices such as strategic selling of stock, urea–molasses supplementation, and extension of tropical pasture growth using deferred grazing and nitrogen application. Guidelines are presented in pasture and herd management plans to assist Chinese farm managers co-ordinate operations for breeding-and-fattening enterprises in north Guangdong Province. However, the plans will need to be adjusted as more technical and economic information becomes available.

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Introduction

Seasonality of pasture production both within and between years is the most important limitation to animal production from pastures (Christian 1987). In previous papers (Michalk and Huang 1994a, 1994b; Michalk *et al.* 1994), aspects of management (including species evaluation and fertiliser strategies) of pastures in north Guangdong Province have been outlined. The object of this paper is to provide guidelines for the integration of different pasture types into a grazing system on a whole-farm basis to supply the forage requirements of grazing cattle. The work was undertaken at Lechang Farm (25°09′N, 113°21′E) which is located in Shaoguan Prefecture (Michalk and Huang 1994a).

To ensure a continuous supply of high quality forage in north Guangdong Province, it is necessary to utilise both tropical and temperate pasture types as the growth cycle of neither alone provides quality forage throughout the year. A similar situation exists in the subtropical, north coast region of New South Wales where climatic conditions are similar to those of south China (Michalk and Huang 1994a). During the 1960s, a feed-year pasture system for dairying, based on many of the introduced tropical and temperate species tested in north Guangdong Province (Michalk and Huang 1994a; 1994b) was developed to provide a more continuous feed supply for this region (Colman *et al.* 1966).

Another approach to the problem of variable feed supply is to manage livestock to ensure that periods of peak feed demand coincide with peak pasture production. This can best be achieved in north Guangdong Province by strategic mating and selling programs, coupled with the use of

urea-molasses supplements to improve utilisation of low quality, tropical pastures in autumn and winter (Michalk and Ryan 1989).

Strategic sale and slaughter prior to winter is already an established practice in sheep operations in north China (Ren 1978), but for cattle herds in south China, where draft power rather than meat has been the traditional production goal, strategic selling is not widely used to reduce annual feed requirements.

Response to urea-molasses supplements is governed by the nature of the base-pasture residues, but is likely to be high as the quantity of green herbage in setaria-based pasture in winter is minimal. Trials have been conducted in Guangdong Province to assess the value of urea-molasses supplements (Li Yung-Lu, personal communication), but the technology has not been widely used because, until recently, molasses was difficult to obtain as it was used for alcohol production.

The most difficult task in integrating various pasture types into a "feed year" is to decide the area of each pasture type to establish and how to use them more efficiently for the benefit of the cattle herd. This integration requires a detailed knowledge of the growth characteristics of each pasture type and the specific nutritional needs of each class of animal. When feed demands of the cattle herd are compared with the production curves of various pasture types, periods of feed deficit and feed surplus become obvious.

Characteristics of Yellow ox cattle

Cattle in China are called "Yellow ox" (Huang Niu) irrespective of their colour or size (Epstein 1969). In the subtropics, cattle are of zebu origin and are similar to the native breeds of Thailand and Malaysia (Maule 1982). They are small, averaging only 260 kg for bulls and 210 kg for cows (Epstein 1969). These cattle can withstand heat and humidity, and graze year round on hard feed conditions. They are excellent draught animals for their size.

Requirements of the breeding unit

The various cattle classes and feed requirements for a 100-cow breeding-and-fattening unit are given in Table 1.

Such a 154 animal unit[1] (AU) herd requires an annual feed supply of 562 t DM forage, assuming an average daily intake of 10 kg DM/AU/day. However, special nutritional needs must be provided at specific times throughout the year for some classes of cattle (Table 4). These include:

(1) Pregnant cows need *ad libitum* feeding from 6–8 weeks prior to calving through to the end of joining (February-September);

(2) Replacement heifers (12–18 months) require *ad libitum*, good quality feed for growth, especially in April, 6 weeks prior to joining; and

(3) Weaners require *ad libitum*, good quality forage from weaning (November) to 12 months of age for growth.

These special nutritional requirements must be provided by temperate pastures and forages in the winter-early spring months when summer carry-over tropical pastures are dormant. Carry-over tropical pasture should provide adequate feeding requirements for breeders, although this depends on the legume content of the pastures.

[1]An animal unit (AU) is equivalent to a 400 kg steer.

Table 1. Herd structure for a 100-cow breeding unit.

Cattle class	Liveweight mean/range	Number	AU equivalent[1]	Total AUs
	(kg)			
Cows[2]	210	100	0.80	80
Replacement heifers	140-180	35	0.60	21
Weaners[3]	50-100	76	0.35	27
Steers (>12 months)	100-200	35	0.65	23
Bulls	260	4	0.80	3
Total		250		154

[1]AU = animal unit (equivalent to 400 kg steer).
[2]Suckling calves are included in the AU rating for cows.
[3]Number of weaners is based on an 85% calving rate and 10% mortality from birth to weaning.

Integration of pasture types

Supplementary sources of feed are required when growth of the base pasture is restricted by either temperature or moisture stress (Murtagh 1980). Evaluation studies at Lechang Farm have identified some legumes (Michalk and Huang 1994a) and grasses (Michalk and Huang 1994b) capable of growth on the highly aluminium-saturated Hapludult soils in north Guangdong Province, provided moderate to high levels of fertiliser are applied (300–600 kg/ha superphosphate; 100–150 kg/ha muriate of potash). Legumes such as lotononis (*Lotononis bainesii*) and white clover (*Trifolium repens*) require additional nutrients such as Ca, Mg and possibly B (Michalk and Huang 1992; 1993a) and lime application may be important for the productivity and persistence of other legumes (Michalk and Ryan 1989; Michalk and Huang 1994a)

Based on these evaluation studies, a setaria (*Setaria sphacelata*)-round-leafed cassia (*Chamaecrista rotundifolia*)-lotononis sward is defined as the base improved pasture for Lechang County (legume choice depending on fertiliser policy) with white clover pastures and winter forage crops providing supplementary sources of feed. Growth curves for these pasture types are given in Figure 1 and are based on harvests undertaken over a 3-year period at Lechang Farm.

Setaria is the easiest of these pasture types to establish and maintain because of its greater tolerance of acid soil conditions and its ability to extract adequate K from soil with low levels of exchangeable K (Fergus *et al.* 1972; Michalk and Huang 1993b). However, reliance on setaria-based pasture to supply all feed requirements would create a severe feed shortage in March–April once carry-over feed was consumed (Figure 1). Even before the onset of this deficit period, cattle would lose weight due to a decline in quality of dry feed unless supplemented with urea-molasses. This feed shortage would restrict cattle enterprises to trading (buy, fatten and resell) in the summer months.

For pregnant cows, replacement heifers, and weaners, February, March and April are critical months when high-quality pastures are needed. Since setaria does not regrow until April, it must be integrated with other pasture types to support cattle breeding enterprises in north Guangdong Province.

When established on limed soil, white clover-ryegrass (*Lolium perenne*) pastures grow sufficiently well in spring (March–May) to fill the feed supply deficit of setaria-based pastures (Figure 1). Grazing temperate pastures during this period also allows setaria pastures to regain vigour before being required for grazing over summer. However, slow growth from white clover–ryegrass and poor quality of carry-over setaria in February still leave a deficit in forage of appropriate quality for pregnant cows and growing weaners. Forage oats (*Avena* spp.) sown in October should be ready to graze in late January to fill this deficit (Figure 1). For other classes of cattle (*e.g.* steers, bulls), setaria pasture supplemented with urea-molasses provides

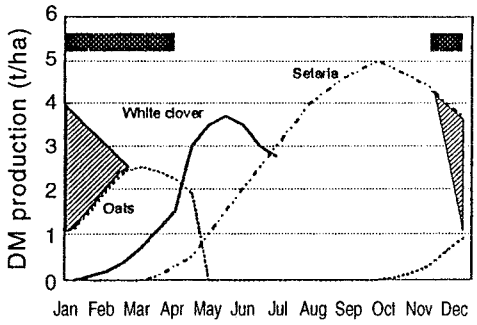

Figure 1. Integrated production curves of different pasture types: setaria, white clover, and forage oats.

adequate nutrition for maintenance during February.

By integrating the 3 pasture types into a feed-year program, it is feasible to provide a continuous supply of forage to meet the needs of a breeding-and-fattening enterprise.

Area of each pasture type required

From the information in Table 1 and Figure 1, the area of each pasture type needed to provide adequate forage for a 100-cow breeding herd can be calculated (Table 2).

Table 2. Area of each pasture type required to support a 100-cow breeding herd.

Pasture type	Fertiliser inputs mantained		Fertiliser inputs NOT maintained[1]	
	Yield	Area	Yield	Area
	(t/ha DM)	(ha)	(t/ha DM)	(ha)
Setaria-based	6	104	3	209
White clover	4	45	< 2	91
Forage oats	3	12	< 2	18
Total		**161**		**318**

[1]These yields represent situations where fertilisers are applied at sowing but no maintenance fertiliser applied in subsequent years. These yields will decrease more rapidly as soil fertility declines.

Temperate pastures

For the 92-day grazing period from March–May, a total of 118 t DM forage is needed from temperate pastures for pregnant cows, replacement heifers and weaners (a total of 128 AUs), assuming a daily intake requirement of 10 kg DM/AU. White clover grown on limed soils can yield 2–4 t/ha DM (Figure 1), depending on inputs of P, K and Mg fertilisers (Michalk and Huang 1993a). Assuming that 65% of the pasture is utilised by cattle, an area of 45-91 ha of white clover–ryegrass pasture would be required to meet the nutritional requirements of the 100-cow herd.

Forage oats

Forage oats yield 2-3 t/ha DM, but higher yields are possible with timely sowing, improved sowing techniques, and higher soil fertility. For grazing in February, an area of 12-18 ha should be planted in October to supply the 36 t DM feed required to supplement the temperate pastures.

If the yield of oats can be increased significantly, the area sown to winter pasture could be reduced because oats can substitute for winter pasture to provide quality feed from February to mid-April. Winter temperate pasture cannot be substituted for oats because of its slower growth in late winter–early spring.

Oversowing of tropical grass pastures with an acid-tolerant oat variety like Saia during autumn for winter grazing, which has proved successful in a similar climatic region in subtropical Australia (Colman 1966), is also a feasible option for north Guangdong Province.

Setaria-based pastures

The balance of the 562 t feed requirement of a 100-cow breeding unit must be provided by setaria-based pastures. Setaria can produce 3-6 t/ha DM, depending on the fertiliser inputs (Michalk and Huang 1994b), and assuming utilisation of 65%, an area of 104-209 ha of setaria-based pasture would be needed.

Moderate grazing pressure is required to maintain vegetative growth and palatability of setaria-based pastures. Slow establishment of setaria allows good legume establishment in the initial years of these pastures, but after several years, setaria becomes more aggressive and management becomes increasingly important in maintaining adequate legume content (Bogdan 1977).

Management required to maintain lotononis as the companion legume in a mixed sward is not well understood at present, although Compton *et al.* (1989) report that lotononis was successful under relatively heavy continuous grazing when grown with bunch grasses (*e.g.* plicatulum and setaria). As with *Trifolium repens* and *T. semipilosum*, heavy late summer- autumn grazing may favour regeneration of lotononis (Fujita and Humphreys 1992).

Ratio of pasture types

Based on the above pasture budgeting analysis, a ratio of 1:4:8.5 of forage oats, white clover, and setaria should be the goal in the development plans for Lechang Farm. However, while this pasture budget gives a broad indication of how well the selected combination of pastures will meet the requirements of the breeding-and-fattening beef enterprise, actual pasture production will vary between years, dependent on factors

such as rainfall. Forage production can be modified by implementing short-term management options such as strategic selling (Table 4), supplementing with urea-molasses (Table 4), or application of nitrogen and/or deferred grazing to extend the growing season of tropical pastures (Table 3), especially those sown with Narok setaria (Ostrowski and Mulder 1980). The value of the pasture budget lies in the initial planning stage when deciding the area to allocate to each type of pasture (Murtagh and Moore 1987).

While the ratio will remain similar, the area of each pasture type will increase significantly to provide the dry matter required if fertiliser inputs are not maintained (Table 2). At present, the ratio of winter to summer pastures is about 3:7. Greater emphasis needs to be given to the production of forage oats to provide green forage in late winter-early spring.

Estimated carrying capacity of Lechang Farm

Lechang Farm has an area of about 170 ha available for pasture development. This type and size of farm is common for state farms formed in the 1950s and 1960s, and it is anticipated that it should be able to support the 100-cow breeding herd in the Stage 2 phase of soil improvement. Herd size can be increased only as soil fertility improves to support better quality pasture types (*e.g.* kikuyu).

Pasture and cattle management plans

Pasture and livestock management are very complex so the broad guidelines presented in the following pasture and livestock plans should be modified as more experience becomes available.

Pasture management plan

The Pasture management plan given in Table 3 provides guidelines for the timing of cultural operations necessary for the establishment, management and timing of grazing of pastures and forage crops in north Guangdong Province. This plan should assist Chinese farm managers to plan operations, order and prepare fertiliser, and cultivate land well in advance of requirements so that pastures and forage crops are sown and/or fertilised at the correct time.

Herd management plan

The Herd management plan provides a check-list of all operations to be undertaken at specific times throughout the year. The format given in Table 4 details the management programs for specific classes of cattle presently recommended for Lechang Farm.

When combined, the Pasture and Herd plans form the operational basis for breeding and fattening cattle in north Guangdong using the integrated pasture "feed year" outlined in Figure 1 and Table 2.

However, while these guidelines have proven to be successful at Lechang Farm, plant and animal behaviour vary from farm to farm, and producers in north Guangdong Province must constantly observe the reactions of their pastures and the performance of their cattle, and adjust the programs accordingly to secure efficient pasture use within a stable ecosystem.

Discussion

The central objective of Lechang Model Cattle Farm was to develop legume-based pastures to improve cattle production, especially through the winter–spring period. However, slow establishment (*e.g.* bargoo vetch (*Aeschynomene falcata*), lotononis) and low palatability (*e.g.* round-leafed cassia) of summer legumes coupled with the high inputs required by temperate pastures and forages meant that supplementary feeding strategies are also needed to carry livestock through the winter period on low-quality carry-over setaria residue.

Since hay and silage production from tropical grasses are unreliable due to poor forage quality, compaction difficulties and low density (Whiteman 1980), the feeding of urea-molasses supplements is common commercial practice in the tropics. These supplements improve intake and utilisation of low-quality base pasture and allow growing cattle to maintain liveweight in the dry or winter period (Foster and Blight 1984; Preston and Leng 1987).

Urea-molasses feeding was used successfully at Lechang Farm to ensure survival of cattle over the winter (Michalk and Ryan 1989), and until more suitable companion legumes for setaria are found, supplementation will remain an important component of cattle management. However, given the high risk of animal death associated

Table 3. Pasture and forage crop plan for Lechang Farm.

Month	Cultural operations		Cattle grazing activity
	Operations for sowing pastures and forage crops	Management operations for established pastures	
January	Apply lime and disc plough areas selected for sowing summer pasture.	Watch for army worms and spray if necessary.	Graze standing dry setaria with supplement (urea-molasses).
February		Watch for army worms and spray if necessary.	Start grazing winter forage crop areas when roots are well developed and the crop has sufficient available dry matter.
March	Scarify area for summer pasture sowing. Remember to reduce the depth of cultivation. Seedbed should be ready for sowing.	Commence fertiliser program on grass-dominant pasture (Narok setaria) with nitrogen and maintenance phosphorus and potassium fertiliser. Watch for army worms and spray if necessary.	Commence grazing winter (temperate) pasture. Development of temperate pasture and forage crops depends on rainfall in Nov-Dec and soil fertility. Favourable conditions should give earlier grazing.
April	Sow summer pasture into fine weed-free seedbed in late April following rain.	Apply maintenance fertiliser to all summer pasture paddocks. Remember to add lime when fertilising paddocks that have received the 4.5 t/ha lime treatment at sowing.	Commence grazing established summer pastures.
May		Finish applying fertiliser to summer pasture areas.	Graze summer pastures. Stop grazing winter pastures to allow seed set.
June			Graze summer pastures.
July	Apply lime and disc plough winter pasture and forage crop areas.		Graze newly sown summer pastures taking care not to overgraze these areas. Continue to graze established summer pastures.
August	Remove weeds from April-sown pastures.	Remove weeds from all pastures.	Graze summer pastures.
September	Close April-sown paddocks to allow seed set. Scarify, at shallower depth, areas already ploughed for winter sowing.	Slash, then apply nitrogen fertiliser to grass-dominant summer pasture following rain. Select and close up other summer pasture areas for: (1) pastures to build up dry matter for standing dry feed supply over winter; (2) seed production.	Graze summer pastures.
October	Sow winter pasture and forage crops into fine, moist weed-free seedbed.		Graze summer pastures.
November		Fertilise winter pasture areas with maintenance fertiliser (including lime) to stimulate growth.	Graze summer pastures previously treated with nitrogen to extend growth season. Graze summer pastures with urea-molasses supplement if required.
December	Following rain apply nitrogen to forage crops to stimulate dry matter production and improve quality of feed.		Graze summer pastures with nitrogen applied. Continue feeding urea-molasses supplement on dry summer pastures if required.

Table 4. Cattle herd plan for Lechang Farm.

Month	Cow herd (selected for low tick)	Replacement heifers (>18 months)	Replacement heifers (12-18 months)	Weaners (<12 months)	Steers and cull heifers (12-18 months)	Bulls
January	Feed supplement.	Feed supplement.		Graze best pasture. Feed supplement. Dip.		Feed supplement.
February	End supplementation.	Feed supplement.		Graze best pasture. Feed supplement. Dip.		Feed supplement.
March	Graze cows-heifers on oats or white clover. Joined heifers start calving. Drench for worms.	End urea-molasses feeding.		Dip. Drench. Weigh. Segregate into: cull heifers; replacement heifers; steers.		End urea-molasses feeding. Drench.
April	Cows start calving. Tag calves at birth and record data.	Graze good pasture.	Grow out on good pasture.		Fatten-sell steers and cull heifers. Dip	
May	Calving continues.		Grow out on good pasture.		Fatten-sell. Dip.	Select small bulls for heifer joining.
June	Calving ends. Cull-sell cows without calves.	Weigh. Cull-sell heifers (high tick; small). Dip. Fluke drench. Join heifers.	Grow out on good pasture.		Fatten-sell. Dip.	Select bulls for cow joining. Fluke drench all bulls.
July	Start joining. Castrate male calves (leave best entire). Drench for fluke.	Joining continues.	Grow out on good pasture. Fluke drench.		Fatten-sell. Dip. Fluke drench.	Check bulls in heifer group. Replace if not physically sound and sexually active.
August	Joining continues.	End joining. Dip.	Grow out on good pasture.		Fatten-sell. Dip.	Check bulls in cow group. Action as above.
September	Early wean in poor seasons. End joining.	Graze joined replacement heifers with cow herd.	Grow out on good pasture.	Early weaning. Drench. Dip. Graze best pasture.	Fatten-sell. Dip.	Cull-sell damaged, aged or non-working bulls.
October			Grow out on good pasture. Drench for worms.	Graze best pasture if early weaned. Dip.	Sell last of steers and cull heifers.	
November	Wean calves. Start feeding supplement. Worm drench. Pregnancy test. Cull-sell cows not pregnant, not rearing calf, in poor condition, or with high tick numbers.		Cull-sell heifers for: high tick; conformation defects; small size. Start urea-molasses supplement. Selected animals moved to heifers >18 month group.	Normal weaning. Graze best pasture. Dip. Drench. Segregate replacement bulls.		Buy replacement bulls. Drench. Start feeding urea-molasses supplement. Move bred replacement bulls from Weaner group.
December	Feed supplement.	Grow out selected heifers for joining next June.		Graze best pasture. Dip.		Feed supplement.

with poorly implemented urea-molasses feeding programs, the value of alternative strategies for maintaining livestock condition over the winter period should be examined, including:

(1) Spraying urea-molasses mixture directly on to setaria pastures and then using high intensity, short duration (1 day) grazing to ensure uniform N intake for more efficient rumen fermentation;

(2) Feeding protein meal (Preston and Leng 1987);

(3) Applying N strategically to extend growth season and improve quality of autumn-saved setaria pastures (Ostrowski and Mulder 1980);

(4) Feeding sugar cane tops, which are readily available in south China, with urea supplementation (Preston and Leng 1987); and

(5) Growing sorghum and maize specifically for silage production (Zhang 1989).

The economics of such practices will depend on the cost and availability of ingredients and essential machinery, the price of beef, and the level of risk involved. However, where survival of cattle becomes the issue, any of these strategies may be warranted irrespective of the risk.

Conclusion

Prior to the commencement of the Lechang Model Cattle Farm project, little was known about the limitations to cattle production or the management options available to achieve the national objective of increasing red meat production from degraded grasslands (Zhao 1982). The 3-year R & D program in north Guangdong Province has provided a great deal of information about the adaptation of species to the infertile acid soils, their fertiliser requirements and management options.

As well as documenting this data, this 4-part series has identified areas where further research is needed to provide adequate nutrition for free-grazing cattle throughout the year. Only when these research needs are addressed will the full impact of the other aspects of grassland improvement, such as animal health, parasite control and genetic improvement, become evident. Refinement and extension of this technology remains a major challenge for agronomists and livestock specialists in Guangdong Province.

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