Australian Government

Australian Centre for International Agricultural Research

Project final report

project	**Increasing milk production from cattle in Tibet**
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Contents

1 Acknowledgments

The initial concept and project development was due to the vision of Dr John Skerritt and Dr Bill Winter in collaboration with Dr Nyima Tashi and the hard work in developing the proposal and commencing implementation by our initial project leader Dr Alan Kaiser, who sadly passed away during the term of the project. Alan's tireless inputs to get the project up and running are gratefully acknowledged by all project staff in both the Australian and Tibetan research teams. The outstanding inputs to initial planning and the ongoing support and management of Dr Nyima Tashi (TAAAS) have also been vital to the execution of the project. His involvement here is just one example of Dr Tashi's extensive and well known commitment to the improvement of Tibetan agriculture.

Acknowledgments would be incomplete without sincere thanks to Mr Wang Guanglin (ACIAR, Beijing) – he ensured critically important liaison by his excellent interpreting and facilitation skills, which was a major factor in the success of visits to the project site. He was tireless in handling the many interactions required for this project between Australian, Chinese and Tibetan project staff, other research and field personnel, as well as outside organisations. We are also most appreciative of the management support provided from the ACIAR Beijing office by Chris Brittendon and Catriona Murray. We gratefully acknowledge the willing assistance with administrative and other matters at the Australian ACIAR level given by Catherine Hanley and Bill Winter.

We gratefully acknowledge the inputs of the staff at the Tibet Livestock Research Institute (TLRI), listed in the text, and the many field staff from various organisations who assisted in the collection of farm production data. We also acknowledge our colleagues from the ACIAR agronomy project, Dr Nick Paltridge, Ass. Prof. Jin Tao and Prof. David Coventry for their assistance and reference to some of their findings. A very useful adjunct to the project was the study done by Ms Amanda Mather, NSW DPI Agronomist, during her mission in Lhasa supported by the Australian Youth Ambassador for Development program, which provided a comprehensive description of the administrative, research and extension infrastructure relevant to the dairy/cropping industry.

Lastly we thank the Tibetan farmers and their families who participated in the study and who have hopefully gained some useful knowledge for their efforts that will improve their livelihoods - we look forward to future involvement with the Tibetan farming community.

2 Executive summary

The aim of this project was to increase milk production and thereby household income of the farmers in the livestock/cropping zone of the Tibet Autonomous Region (TAR) of China. To achieve this aim, the constraints to production had first to be identified to develop feeding (and management) strategies that would be practical and economic to implement. In addition to improving farm family livelihoods, increasing production of dairy products is a high priority for this agricultural region to satisfy rising demand in the community.

To identify constraints, a benchmark study was undertaken as the major activity of the project in which the feed resources were characterised (type and availability), and data were collected to describe milk production and key parameters of reproduction. The most consistent and relevant finding of the benchmark study was the high reliance on cereal straws as the basis of most diets, and this was rarely supplemented sufficiently to provide adequate feed quality in total dietary intake. Associated with the generally poor nutritional status, was depressed performance in all production parameters – low milk production (average ~ 5-6 kg/cow/day), low fertility (average 69% calving rate), low birthweights of

calves (average 20-25 kg) associated with poor survival rates (average 64%) and followed by low growth rates (average 0.2-0.3 kg/day).

Although inadequate nutrition had been implicated as a major problem prior to this project, we now have a firm basis on which strategies for improvement (feed budgeting, forage production, diet composition, etc) can be developed, due to the benchmarking of current diet content and quality, and of milk and production parameters provided by the study.

Apart from providing the benchmark data, the project has had significant immediate impact in promoting awareness of the nutritional scenario restricting current production and the principles to be applied in designing remedial strategies. In this regard, an unexpected outcome of great importance was the potential to influence local policy makers and funding agencies in deciding the best way(s) to improve production and alleviate farm family poverty. It appeared that previous and current decisions were often based on little or inappropriate advice on aspects of animal nutrition and production, and therefore unlikely to be biologically or economically effective. The feedback suggests that this project has already had considerable impact in this direction within a short time frame, a significant benefit from the ACIAR investment.

The project has built on the local capacity to improve agricultural production by improving the skills of the scientists and field staff and provision of infrastructure. The upgrading of capacity for feed quality evaluation (including staff training and expansion of techniques) is vital for future research, as animal nutrition is without doubt the most important immediate area to be addressed in removing constraints to production. The animal house built at TLRI with ACIAR and local funds is the first and only facility of its kind in Tibet and of a global standard for conducting nutrition experiments. This will be pivotal to the key research required to evaluate feed quality, animal responses to varying feed regimes, examining responses of different genotypes and many other components required in the process of developing efficient and sustainable feeding and production systems. The facility will be available for use in many other projects and thus is a major asset for Tibetan animal research into the future.

Following the external review of the project, it was recommended that ACIAR extend their support to improve production and household income in TAR by funding a further project to build on the outcomes here, as well as those of the contemporary ACIAR agronomy project (CIM/2002/093), in a systems approach to improving livestock and agronomic production. The follow-on project (LPS/2006/119 - *Integrated crop and dairy systems in Tibet Autonomous Region, PR China*) was approved and commenced in April 2008.

3 Background

In October 2003 Dr Nyima Tashi hosted a visit by Dr Winter and Dr Alan Kaiser (NSW Agriculture) to Tibet to develop a livestock project - as a ‘sister’ project to an agronomy project entitled “Intensifying production of grain and fodder in central Tibet farming systems (LWR2/2002/093)”. During this visit, milk production from cattle on mixed crop/livestock farms in the river valleys of central Tibet, was identified as the livestock industry with an expanding market demand and most potential for growth. Thus the project now reported (LPS/2002/104) was developed largely by Dr Alan Kaiser who led the project team in the initial on-the-ground planning and commencement. It was a great blow to all when Alan suffered an unfortunate protracted illness before passing away during the early stage of the project.

(Many of the details in the background information to follow has been drawn from Palltridge *et al.* (2008) and data of the Tibet Bureau of Statistics (2006), unless specifically referenced otherwise.)

TAR occupies 1.2 million square kilometres, approximately one fifth of the area of China. It is best known for its towering mountains and high-altitude plateau where human inhabitants are few and nomad pastoralism is the only land use possible. Less well-known is that in southern and central Tibet there are about 230,000 hectares of fertile valley floors and lower hill slopes where intensive agriculture is practiced. Approximately half of Tibet's 2.7 million people live in and around these valleys, at altitudes between 3,500 and 3,950 masl (Tashi *et al*. 2002). While the winters in these regions are cold and dry, summer and autumn provide ideal conditions for crop and other plant growth with plentiful sunlight and warmth, reliable rainfall, and the potential to irrigate much of the land.

The agro-climatic environment for the mixed crop/livestock production in the valleys of central Tibet is unique as it encompasses high altitude cropping at relatively low latitude, with a summer dominant (monsoonal) rainfall pattern. This central crop/livestock zone (Figure 3.1, Tashi *et al.* 2002) includes 18 counties (with 50% of the country's population), and is located in the river valleys of the middle reaches of the Yarlong Tsangpo River and its two tributaries, Lhasa River and Nyachu River. Although 80% of the area is used for spring and winter wheat and barley (all naked), farmers grow a broad range of other crops including rapeseed, faba beans, maize, vegetables, potatoes, and fodder crops (Tashi *et al*. 2002). The typical farm family in this zone has 5-7 people and only 14 mu (15 mu = 1 ha) of arable land, this being the major limitation to production. Livestock are dependent, more or less, on crop residues (straw), weeds and regrowth in the field, and crop by-products, with only very limited periods of grazing following cereal harvest. In other parts of Tibet, there are agro-pastoral areas where livestock are much more dependent on grazing close to the village, but rely on crop by-products and straw during the winter period. These zones have been identified by the TAR government as key areas for improvement of both crop and livestock production. Almost all households in these zones raise livestock, especially cattle and sheep. Improving the productivity of the livestock component will both diversify and increase household income, and the development of better feeding systems will reduce the grazing pressure on nearby rangelands where this is practiced, reducing land degradation.

Nearly all farms in the livestock/cropping zones keep cattle, typically two to six head. In fact about 95% of the cattle in Tibet are found in these areas, with few in the rangelands where the dominant animals are yak, sheep and goats. The cattle are mostly *Bos taurus* stock of the type bred by Tibetan farmers for centuries, known as 'local' cattle. In addition, about 30% of Tibetan cattle are of the type described as 'improved' – the result of crosses, promoted by government, between local cattle and western breeds (mostly Holstein-Friesian or Simmental and some Jersey). Local cattle are, by western standards, very small (only 250-300 kg adult live-weight), and it is unclear whether this is mainly genetic or a consequence of inadequate nutrition. About 10% of the cattle herd are yaks and yak/cow hybrids, commonly called "zho" (the males, which are sterile, are known as *dzo*, and the females, which are fertile, are called *dzomo*), which are kept primarily as draught animals.

Most of the large ruminant research in Tibet has focused on yak production and cattle breeding. Considerable research has been conducted on milk and meat production from yak and this has been reviewed by Qiumei Ji (2002). Research on the genetic improvement of dairy cattle commenced 20 years ago. The focus has been on the introduction of new breeds into Tibet, using artificial insemination, and crosses of Holstein (= black/white cattle) and other breeds with local cattle which is considered successful (Wei Xuecheng (1991). It is estimated there are now more than 200,000 cross-bred cattle in Tibet. As a result, the average size (liveweight) of dairy cows has increased considerably. However it has become evident that the consequent increases in nutrients required for maintenance (energy as the first constraint) are not being met in many cases, and an already poor nutritional status may in fact be exacerbated. Thus, the increased genetic potential for milk production is rarely approached. This highlighted a need to adequately define the nutritional status (quality of the diet) and milk production of typical Tibetan dairy systems so that sound management guidelines can be formulated.

Although there are great challenges ahead, the animal production system with greatest potential in the livestock/cropping zones is milk production. The consumption of butter and milk is part of Tibetan culture, and there are ready markets for dairy products. Demand for milk is growing at 20% per annum and local production cannot meet the current demand (eg. 60% of the butter currently consumed during the winter period needs to be imported). If this current trend continues, a deficit of up to 400,000 tonnes could exist by 2020, as opposed to the situation of relative sufficiency for most other food types (Figure 3.2). Total milk production (cattle and yak) in Tibet in 2003 was about 250,000 t, with 35% being produced in the mixed crop/livestock zone. Thus, with a market price of about 3 yuan/kg milk in Lhasa, the value of milk production in Tibet was then about 750 million yuan annually. Milk production per cow is very low. It is was thought to be, for example in Naidong County, about 3 kg/cow/day from an improved crossbred cow, but could be as high as 12 kg/cow/day where high levels of brewers grain are fed. In addition to this low milk production, there also seemed to be long intervals between calving, a reflection of the poor nutritional status of most milking cows in Tibet. Usually only about half the cows are lactating at any point in time.

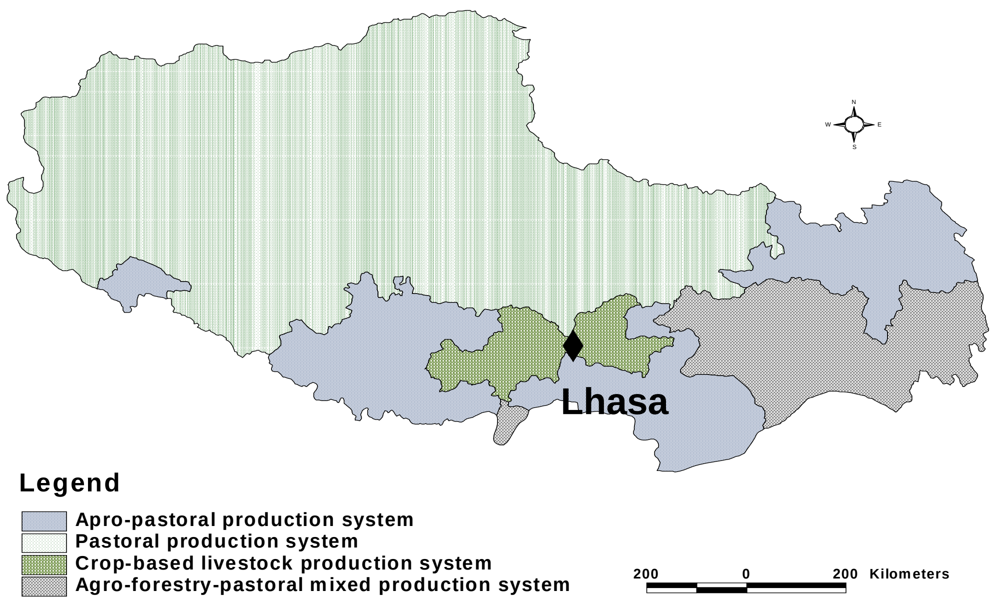

Figure 3.1. The four broad land use zones for livestock production in Tibet. Although the land area has been allocated to four broad categories, there is considerable diversity in production systems within each zone (from Tashi et al. 2002).

If the demand for dairy products is to be met and a viable milk production system developed, the nutritional constraints on production (and reproduction) need to be overcome.

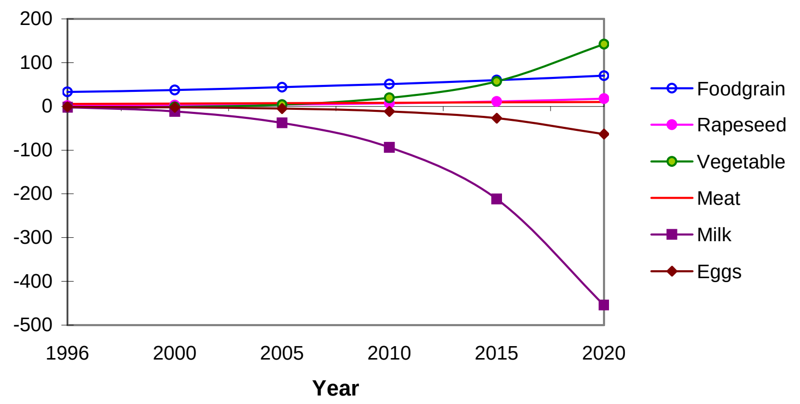

Figure 3.2. Production data for the major food items in Tibet ('000 t), showing predicted surplus / deficit for the future (Nyima Tashi 2006, pers. comm.).

It was evident during the development of the project that there were severe limitations in the research capacity of the Tibetan livestock scientists in both capabilities and facilities. Few had postgraduate training and there was limited scope for laboratory or controlled animal experimentation. These areas obviously needed to be addressed within the project. It was also recognised that most research would be conducted on-farm and thus the participation of the farmers would foster ownership, facilitate the two-way flow of information between scientists and farmers and enhance eventual adoption of recommendations arising from project results and production principles.

Apart from benefiting farmers in Tibet, the project was also designed to benefit Australian farmers (dairy and beef producers) by providing new information on the management of cereal and cereal/legume crops for silage production, and the use of these silages in cattle diets. Silage is becoming an important component of cattle diets, particularly on dairy farms, beef feedlots, and beef grazing enterprises (especially in southern Australia), as evidenced by the development of a national silage extension program – 'TopFodder Silage' – by Dairy Australia and NSW DPI. When developing the comprehensive silage reference manual 'Successful Silage' for this program, it became evident that there was very little information on the production of whole crop cereal silages in Australia. There were major gaps in information on the best cereals to use, optimum stage of growth at harvest (yield × quality tradeoff), the benefits of a companion legumes, and cattle production on cereal silage based diets.

Conserved forages are options for improving the nutrition of dairy cattle in Tibet, and thus the production of hays or silages from cereal crops or cereal/legume mixtures is relevant to both Tibet and Australia. The experiments in Australia provided an opportunity to train visiting Tibetan scientists in forage and animal house experimentation.

While there were several interacting aims for this project, the key technical issue can be put simply as identifying the constraints to dairy production so that strategies could be developed to manage (feed) the cow to be an efficient and economic producer. This will therefore increase the productivity and income of the targeted households.

4 Objectives

As stated in the proposal, the project aimed to increase milk production from cattle, and hence household income, through improved nutrition on mixed crop/livestock farms in the valleys of Tibet. There are ready markets for milk and milk products as local production cannot meet the current demand for these products.

Specific objectives of the project were to:-

1. Develop feeding strategies using crop residues, forages and by-products for Tibetan farmers by:
   - Characterising the feed resources available and in use
   - Establishing milk production responses to better nutrition
2. Identify conservation (silage) management strategies that optimise animal production from cereal and cereal/legume forage crops
3. Strengthen the capacity of Tibetan scientists and institutions
4. Encourage the adoption of better nutritional management of dairy cattle by farmers through training of extension workers and demonstrations for farmers. Identify any future support needed for dairy extension in Tibet.

5 Methodology

The research program comprised both conventional feed evaluation and nutrition research on research institutions in Tibet and Australia, and also a significant component of on-farm research in Tibet. The latter (benchmarking) work monitored milk production on farms through annual production cycles, as well as describing seasonal feed availability and quality in relation to milk production. The participatory approach for the field research was aimed at fostering ownership and facilitating two-way flow of information between farmers and scientists, thus benefiting both parties and enhancing eventual adoption of project results and improved technologies.

Locations for research work

Field sites in Tibet – benchmark study

The major work in Tibet, applied field research, was the collection of data from participating farmer households to establish benchmarks for feed types and availability, animal intake, milk production, reproductive performance and animal growth rates. The farms were chosen as a representative cross section of family farm production in the livestock/cropping zone.

The farms (total 36) were situated in 4 villages in different districts (Figure 5.1), one on the outskirts of Lhasa city and 3 others, 100 - 300 km distant:

Bailang county – Luobuqiong village	– 8 farms	(site1)
Shigatse county – Tama village	– 5 farms	(site2)
Lhasa county – Nadjin village	– 10 farms	(site3)
Naidong county – Chang Zhu village	– 13 farms	(site4)

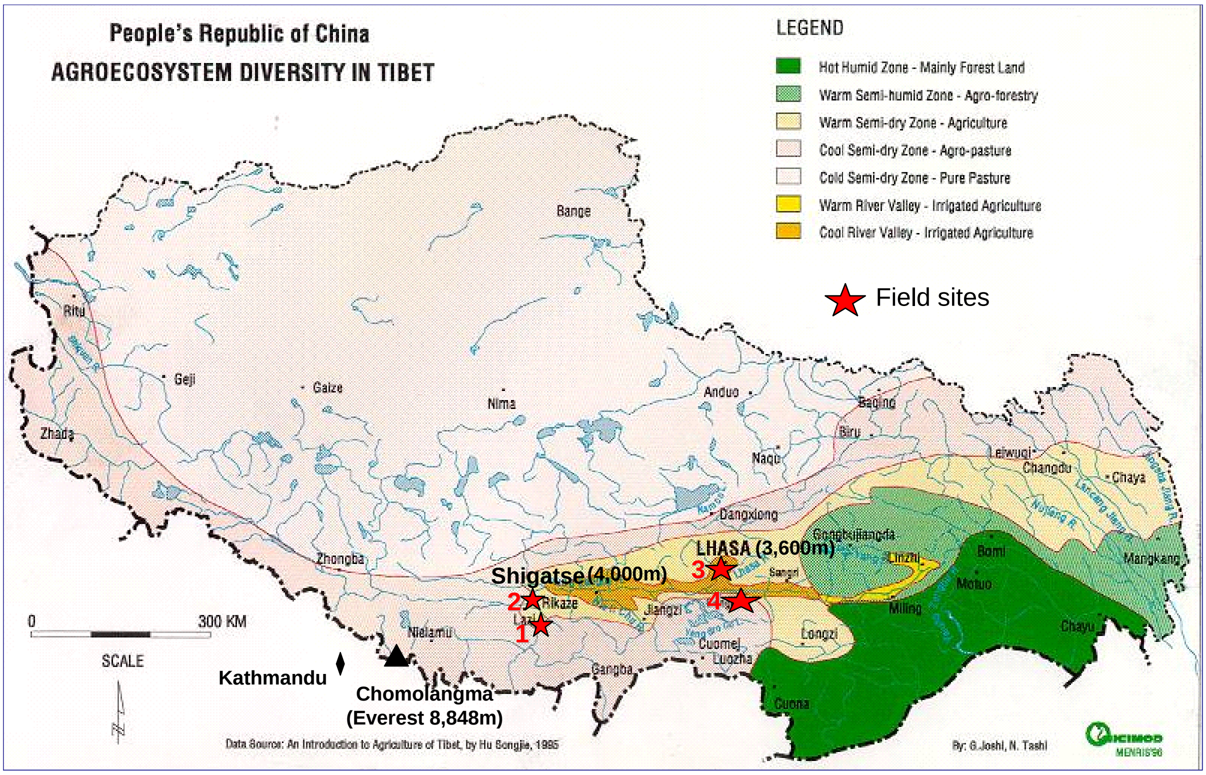

Figure 5.1. Location of field sites for the benchmark study in the livestock/cropping zone.

Laboratory based research was done in both partner countries:

- At the Tibet Livestock Research Institute, Lhasa - in the animal house and chemical laboratory
- At the NSW DPI Agricultural Institute, Wagga Wagga - in the field, animal house and chemical laboratory.

Research methods and designs

Field sites in Tibet – benchmarking study

The production data for the benchmarking study were collected from the various participating farms using a standard set of forms (shown below as Figures 5.2 – 5.4), that were designed at the start of the project with the combined inputs of the Australian and Tibetan staff. These were designed to capture information on feed, milk production and reproduction. The data collection process was co-ordinated by the TLRI staff and assisted by various people in the field (Animal Husbandry Bureau personnel, local village leaders and others) to get the information from the Tibetan farming households. The forms were translated from English to both Chinese and Tibetan to facilitate the process since there is a low rate of literacy among the farmers. There were problems in the rigour of data collection (on farm) as well as in the chain of transfer of data from information on field sheets, through various translations, to eventual entry to electronic spreadsheet files. This caused considerable delays at least, limiting the time available for collection, and in some cases resulted in the adjustment or exclusion of data from analyses.

Background basic farm details were collected in the survey and included farm size, total family size, number of workers, total numbers of cattle – further broken down by sex - females/males, age - >2yo/<2yo, breed - local/HoslsteinX/SimmentalX. Many farms also had varying numbers of “zoh” (yak X cattle crossbreed), which were kept primarily as draught animals.

In collecting the production data, farmers were asked to provide information on the type and quantity of feed given to their cows individually on 2 sampling days each month (approximately 10th and 20th days of the month). For those days, they were also asked to also record the individual milk production. There was also a third sampling day at the end of the month but only for individual milk production. The total production for all cows milking was also recorded/estimated daily. The reproductive performance of the cows under observation was monitored by the recording of calving dates and details, along with information about AI and natural matings.

Samples of the different feed types offered at these sites were also taken on a seasonal basis for laboratory analyses of feed quality parameters – see below.

Data collection forms

Feeding to Milkers and dry cows

Information to be recorded on the 10th and 20th day of each month (same day as milk production records)

Farmer ID: 102 **Month:** **Mar-06**

	Feed	**Cow ID:301**		**Cow ID:302**		**Cow ID:303**		**Cow ID:304**	
All weights in jin	**Type**	10th of Mon	20th of Mon	10th of Mon	20th of Mon	10th of Mon	20th of Mon	10th of Mon	20th of Mont
Wheat grain	G								
Wheat straw	LQR								
Barley grain	G								
Barley straw	LQR								
Oats grain	G								
Oats straw	LQR								
Treated straw	LQR								
Corn stover or hay	LQR								
Green Fodder - alfalfa	GF								
Green Fodder - vetch	GF								
Green Fodder - turnips	GF								
Green Fodder -	GF								
Hay - alfalfa	GF								
Hay - oats	LQR								
Hay - vetch mix	LQR								
Silage - corn	LQR								
Other crops -									
By-products - vege waste	GF								
By-products - brewer's grain	BG								
By-products - canola (meal)	ByP								
By-products -	ByP								
Concentrates -									
Salt									

Feed Types		
	G	Grain
	LQR	Low quality roughage
	GF	Green feed
	BG	Brewers grain
	ByP	By products

Figure 5.2. Data collection form for feed offered, recorded twice per month for individual cows. The various feeds were aggregated into the 5 major types shown for summary analyses of seasonal patterns in availability.

Milk Production

Total milk (jin) for all cows recorded every day (including milk for calves), and on every 10th day also production from each cow

Farmer ID: **Month:**

Day	Daily Milk Total (jin)				Cow ID:			Cow ID:			Cow ID:			Cow ID:		
		1st Milk	2nd Milk	3rd Milk	1st Milk	2nd Milk	3rd Milk	1st Milk	2nd Milk	3rd Milk	1st Milk	2nd Milk	3rd Milk	1st Milk	2nd Milk	3rd Milk
(All cows) 1																
2																
3																
4																
5																
6																
7																
8																
9																
Each cow 10																
(All cows) 11																
12																
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19																
Each cow 20																
(All cows) 21																
22																
23																
24																
25																
26																
27																
28																
29																
Each cow 30																
(All cows) 31																

Figure 5.3. Data collection form for milk production, recorded daily for farm totals and 3 times per month for individual cows.

Reproduction Data

Farmer ID:101

Month:

	Cow ID	Cow ID	Cow ID	Cow ID	Cow ID
Previous calving date					
Current calving date (or abortion)					
Calf ID					
Birth difficulty (nil, assistance L_M_H)					
Calf alive at birth - Y/N					
Survival past 1 week -Y/N					
Birth weight (jin)					
Colour					
Sex					
1st Mating date					
AI or Local bull					
Breed of Bull					
2nd Mating date					
AI or Local bull					
Breed of Bull					
3rd Mating date					
AI or Local bull					
Breed of Bull					

Figure 5.4. Data collection form for reproductive performance.

Laboratory research in Tibet

Analyses of feed samples

Feed quality evaluation is critical in setting nutritional targets and formulating diets that drive animal production. Current information on the chemical composition of feeds in Tibet

is sparse. Thus an evaluation the nutritional composition of feedstuffs used in the Tibetan dairy industry was conducted in conjunction with the benchmark study.
A total of 236 feed samples were collected from the various co-operating farms over different seasons. These were analysed in the laboratories at TAAAS and TLRI using standard procedures. Samples were oven-dried at 60°C for 24h and ground through a 1mm sieve prior to analyses which included :- dry matter (DM%), crude protein (CP%), neutral detergent fibre (NDF%), acid detergent fibre (ADF%), acid detergent lignin (ADL%), ash and dry matter digestibility (DMD%). Digestibility was estimated using the pepsin/cellulase *in vitro* method.

Samples included the typical major feed types - straws (wheat, barley), grains (barley, wheat), brewer's grain, canola meal, vegetable waste, as well as a variety of others like peas, corn, hays, bran, vetch etc. The less commonly used feed types had few samples represented.

Animal house study on improving digestibility of straw

Straws (predominately wheat and barley) are conserved on all farms in this region following cereal harvest, and they form the major base component of the diets of the dairy cattle. However they have poor nutritive value due to low digestibility, energy and protein content, and therefore severely limit production if not adequately supplemented. As well as using nutrient rich supplements, diet quality may be increased by improving the utilisation of the straw component. The length of the straw stalks in the diet may affect digestibility and intake and therefore animal production. Thus an experiment was conducted in the animal house at TLRI to examine the effect of chop length of straw on these parameters. This experiment was the first to be conducted in the animal house, and also served as a test for the newly commissioned facilities and operational procedures.

The experiment used 12 crossbred yearling bulls,134kg (mean liveweight at start), allocated among 3 treatment groups (= 4 reps/treatment). Treatments were 2 levels of chop length of wheat straw - Fine: 3-4 cm (F group) or Medium: 7-8 cm (M group), compared with Long: unchopped: > 30 cm (L group, control). All diets consisted of 60% straw (chopped or control) : 40% concentrate, which consisted of wheat and corn grain, wheat bran, soybean, cottonseed and canola meals and a mineral/vitamin premix. The quality of the diet was estimated as 13 MJ/kg DM and 18% CP. All animals were offered the same diet but differing only in the treatment of the straw component. Animals were fed over a period of 60 days, including a 7 day period to determine intake, liveweight gain and *in vivo* digestibility, following a period of diet introduction.

Research in Australia

This component was conducted at the NSW DPI Wagga Wagga Agricultural Institute in southern NSW. Wagga Wagga is a major cereal growing area, and also has frequent need for supplementation of livestock to overcome periods of low quality feed. Cereal crops are increasingly being grown for livestock forage both for grazing and conservation as silage. The issues of supplementation of low quality feed and alternatives for forage production and conservation are highly relevant to both Australian and Tibetan animal production, despite the vastly different structure and scale of the livestock industries in these countries.

Forage production study – time of harvest of cereal and legume mixed crops for silage – field and laboratory experiment comparing various cereals and cereal/vetch combination

This experiment compared 7 cereals (3 wheat, 2 barley, 2 oats) sown either alone or in combination with purple vetch (7 X 2 factorial design for main plots). Due to the dry seasonal condition the crops were not sown until June 2005. Each plot was approximately 8m x 2m wide. There were three reps/blocks for each crop treatment. Each crop was harvested at four stages of growth (sub-plots) in spring – boot, full ear emergence, milk and dough stage of grain development. Yield, quality, botanical composition and wet chemistry data were all collected.

Animal production from cereal crops cut at various stages of growth

Replicated barley and oat crops were grown for the production of silages and harvested at three stages of growth in spring – ear emergence, milk stage and dough stage of grain development. The six silages were fed to steers in the animal house at the Wagga Wagga Agricultural Institute, during an experiment in April-June 2006. Data were collected to determine intake, digestibility, liveweight gain and feed conversion efficiency.

Staff involved

The following tables show the staff of the Tibetan and Australian project teams.

Tibetan staff – TAAS and TLRI

Name	Position/ speciality
Dr Nyima Tashi	Vice-President,TAAAS, Production Specialist (Tibetan Project Leader)
Prof. (Mdme) Se Zhu	Deputy Director, TLRI, Livestock Specialist (Tibetan research team Project Leader)
Dr Tsamyu (Can Mu You)	Research Leader, Nutrition, Nutrition and Dairy Specialist
Dr Ji Qiumei	Research Leader, Yak production, Livestock Specialist
Mr Osman (Ao Si Man)	Group Leader, Cattle Breeding Specialist
Mr Luosang Qiangbai	Cattle Breeder, Extension, Shigatze
Mr Pingcuo Zhandui	Cattle Breeder, Extension, Shigatze
Mr Pubu Ciren	Livestock Scientist, Breeding
Mr Basang Druptra	Livestock Scientist, Breeding
Ms Wang Li	Livestock Scientist, Breeding
Mr Han Jiancheng*	Livestock Scientist, Nutrition
Ms Xiangbazhuoga*	Livestock Scientist, Nutrition
Mr Dunzhu Jiangcan*	Livestock Scientist, Nutrition
Mr Qu Guangpeng*	Livestock Scientist, Nutrition
Ms Bao Yuhong*	Livestock Scientist, Nutrition

** Note: The junior scientists listed had varying periods of input to the project*

Australian staff – NSW DPI

Name**	Position/specialty
Dr Alan Kaiser	Special Livestock Research Officer, Animal nutrition (initial Australian team Project Leader)
Dr John Wilkins	Senior Livestock Research Officer, Animal production and reproduction (subsequent Australian team Project Leader)
Mr Colin Griffiths	Senior Livestock Extension Officer, Dairy nutrition and management, Extension specialist
Dr Brad Granzin	Livestock Research Officer, Dairy nutrition
Mr John Piltz	Livestock Research Officer, Animal nutrition and forage production
Mrs Kristy Bailes	Technical Officer, Animal nutrition
Mr Adam Green	Technical Officer, Animal nutrition

*** Notes: The initial Australian Project Leader, Dr Alan Kaiser, sadly passed away early in the project and his role was taken on by Dr John Wilkins. Dr Brad Granzin (Livestock Research Officer, Nutrition) was initially part of the Australian project staff but resigned from NSW DPI in June 2005, and his role was replaced by John Piltz.*

6 Achievements against activities and outputs/milestones

There were large delays in building the animal house. Thus on completion there was little time left to conduct experiments and this meant that only one feeding trial was able to be carried out, which occurred during the final year of the project.

Several other milestones were not fully achieved under the original descriptions. This was a result of delays in starting the field work and many logistical problems with data collection and handling. These problems were well recognised and accepted by the committee at the external review meeting in May 2007. In fact that review returned a very favourable report to ACIAR on the achievements of this project, with the recommendation that further funding be provided for an expanded follow-on project which was subsequently approved for commencement in April 2008 (LPS/2006/119).

Objective 1: Develop feeding strategies using crop residues, forages and by-products (Tibet)

no.	activity	outputs/ milestones	completion date	Comments
1.1	Review (paper in English) of existing information and statistics on milk production systems	Review paper (in English) completed and distributed to project team	The first draft of this paper was completed in June 2005, final draft May 2007, submitted for publication Nov 2007	There were many redrafts and modifications to the review paper. The reasons for long delays between drafts were because of problems in translation and checking of data sources of some of the material quoted to clarify its credibility and significance to the review. It was also difficult to find a suitable Chinese journal for publication. The authors were still awaiting confirmation of acceptance at the time of writing of this report.

1.2.1	Conduct benchmark survey of current practices and the annual feed budget on mixed crop/dairy farms in the valleys of central Tibet.	Field studies completed and summary table of key input and production data (mean and range) completed	Completed May 2007	There was a delay in starting the benchmark study which commenced in March 2005, with 38 farms, subsequently reduced to 36. During the March 2006 visit, a large amount of time was spent in assessing the state of the data collection and identifying issues that needed attention. There were problems with the Tibetan field recording sheets in capturing some of the critical milk production, feeding and reproductive data. Thus it was necessary to simplify the field recording sheets and make further modifications to make them more "field staff and farmer friendly". A local Tibetan interpreter with word processing skills was commissioned to assist with the preparation of modified field data collection forms with the guidance of the research team. The Australian team joined with the local Tibetan staff in an intensive exercise to get all data onto computer files, since this was well behind what was expected, the reason proposed as being a logistic problem of long delays in the translation from Tibetan to Chinese to English. It was also recognised and agreed that the period of data collection would need to be extended to establish the benchmarking required. Thus the period of data collection was extended to May 2007 for the bulk of the records with limited further observations to Nov 2007 during an approved period of extension of the project. The proposed annual feed budgets were not able to be completed within the time and are carried over as an activity for the follow-on project (LPS/2006/119) approved by ACIAR
1.2.2	Relationships developed between feed inputs and milk production from benchmark survey data	Report prepared (in English) on survey results, presenting all data and relationships, and assessing profitability of different systems	May 2007	Relationships of feed inputs to milk production in the benchmark study were examined in May 2007 and it was decided that the data were not sufficiently robust to derive confident predictions. This area is also proposed to be pursued within LPS/2006/119.
1.2.3	Continue benchmark survey (1.2.1 & 1.2.2) for an additional 12 months to collect reproduction data	Report prepared (in English) on survey results, presenting reproduction data and relationships	Completed November 2007	These data were collated and used for the final reporting here.
1.3.1	Construct animal house facilities	Animal facilities completed	August 2006	There were considerable delays in starting the construction of the animal house. It was finally completed in August 2006. Additional local funding form the Dept of Science and Technology (DOST) was required for the construction of this facility which is a first for Tibet and a major asset for future animal research.

1.3.2	Conduct experiments with dairy cattle	Summary of experimental results available, quantifying response to improved nutrition	May 2007	Due to the delay in construction and other local constraints, only one experiment was able to be conducted in the animal house by the time of the completion of the project. The results of this experiment (effect of chop length on digestibility of straw) were reported at the external review meeting in May 2007.

PC = partner country, A = Australia

Objective 2: Optimise animal production from conserved cereal and cereal/legume forage crops (Australia)

no.	activity	outputs/ milestones	completion date	comments
2.1	Field experiment to measure forage yield quality from cereal-based crops cut at various stages of growth for silage.	Field experiment and laboratory analyses completed. Yield and quality results available for various crop management options	August 2006	Due to drought the experimental plots were sown later than optimal (June) and following a brief period of reasonable conditions the area again subsided into drought in September. As a result the plots were severely moisture stressed. The crops were harvested, laboratory analyses conducted and data analysed as planned
2.2	Animal house experiment to determine cattle production from cereal-based silages cut at various stages of growth.	Crops grown, silages made and fed to cattle in animal house experiment. Results available on animal production for various crop management options	June 2007	Animal house experiment to determine intake, growth rate and in vivo digestibility proceeded as planned. As above, the results were affected by the severe drought conditions that prevailed during the making of the silages. Thus it is proposed that this work be repeated along with other experiments within project LPS/2006/119 to obtain more confident results and recommendations.

PC = partner country, A = Australia

Objective 3: Strengthen the capacity of Tibetan scientists and institutions (Tibet/Australia)

no.	activity	outputs/ milestones	completion date	comments
3.1	Study tour by Tibetan scientists to Australia – nutrition, silage and dairy production research	Three scientists complete study tour to Australia	June 2005	Three of the Tibetan scientists (Dr Tsamyu, Mr Aosiman, and Mr Basang) visited Australia in September/October 2005 for 2 weeks, to study dairy production systems, forage production, silage production, animal house design, laboratory methods for feed evaluation, ultrasound scanning for monitoring reproductive status and methods for determining digestibility of feeds in sheep and cattle.
3.2	Training of Tibetan scientist in nutrition research and animal house experimentatio n methods	One scientist completes 2 month training in nutrition research methods in Australia	June 2006	During April-June 2006, Dr Tsamyu (nutrition specialist) returned to Australia for 9 weeks at NSW DPI Agricultural Institute at Wagga Wagga. The purpose of this mission was to further her experience in nutrition research, and in particular the design, management, operation and analysis of animal house experimentation, as well as the associated laboratory procedures for assessment of feed quality. The visit was timed for Dr Tsamyu to participate in the experiment to evaluate silages in the Australian research component (described below). These skills will be vital to the ongoing research within this project and beyond, which will be possible with the provision of an animal house facility at TLRI, Lhasa, as part of the project.

PC = partner country, A = Australia

Objective 4: Encourage adoption of technology by farmers (Tibet)

no.	activity	outputs/ milestones	completion date	comments
4.1	Extension officers trained in basic cattle nutrition	Training courses conducted for local extension staff. Three extension staff trained for each field station, and 5 farmers trained at each field station.	November 2007 and on-going	Training of local personnel was a continuing aim by exposure of the scientists and extension staff to nutritional principles by discussion of the field data, presentations of results and involvement in report preparation. This continued till the end of the extended period of the project. Specific training courses will be part of LPS/2006/119 which has the adoption of technology as a major objective.
4.2	Demonstrations for farmers on benefits of better cow nutrition	Demonstrations conducted – two demonstration households established at each of the four sites/ field stations. Aim is to have 20 dairy households at each site adopting the results.	November 2007	This was not able to be achieved in terms of the original aims, under the difficult circumstances of the project. This was accepted by the external review committee and recommended to ACIAR that it be incorporated into project LPS/2006/119 as part of the general strategy – in fact the demonstration sites are an integral part of the methodology of the new project.

PC = partner country, A = Australia

7 Key results and discussion

Inadequate nutrition as the major constraint to dairy production had been previously proposed, and was in fact one of the basic premises of this project. However the data available on milk production and feeding practices for typical household production scenarios were very limited. Thus the general levels of production and factors affecting productivity of the dairy sector in the livestock/cropping areas were not well described or understood. The project was therefore aimed firstly at the systematic description of types and seasonal availability of feed and associated milk production and reproductive performance in annual production cycles. These benchmark data were aimed at providing the basis for strategies to improve dairy cow nutrition and production, and therefore household income.

7.1 Results from field research in Tibet - benchmark study

Summary of household and farm statistics

Table 7.1.1 shows the basic household statistics and dairy cattle inventory of the farms participating in the benchmark study. At the time of collecting this information, there was only one “local” cow recorded – this is the genotype that has evolved in this part of Tibet and has a small mature size, averaging of the order of 250 – 300 kg. Thus all others were of the “improved” crossbred genotypes (Holstein or Simmental X local). The breakdown of cattle types (by sex, age and genotype) was at the time of data collection, and is therefore a snapshot of those distributions. At other times there were small numbers of the local genotype and other crossbred cattle (eg Jersey X) seen on these farms but do not appear in these data.

Some pictures of the different types of cattle typically kept on farms in the livestock/cropping area are shown in Appendix 11.4.

Table 7.1.1. Farm, family and dairy cattle inventory statistics (means and ranges) for the households participating in the benchmark study.

Site	**1 Bailang**	**2 Shigatse**	**3 Lhasa**	**4 Naidong**	**OVERALL**
No of farms	8	5	10	13	36
Total cattle	50	49	54	60	213
MEANS/FARM					
Farm size (mu)	25.5	26.6	6.5	10.8	15.1
(range)	*(4-46)*	*(13-38)*	*(0.5-12)*	*(6-19)*	
Family size	8.1	8.8	3.8	5.2	5.9
	(4-13)	*(6-12)*	*(3-5)*	*(4-10)*	
Workforce	3.4	5.2	1.9	2.5	2.9
CATTLE					
Total head/farm	6.25	9.8	5.4	4.6	5.9
	(4-8)	*(7-13)*	*(3-8)*	*(1-7)*	
Milking cows					
Holstein X	4	3.2	1.7	1.2	2.25
	(3-6)	*(1-5)*	*(0-3)*	*(0-3)*	
Simmental X	0.5	3.6	1.1	1.1	1.3
	(0-2)	*(2-5)*	*(0-2)*	*(0-4)*	
Young females					
Holstein X	0.75		0.7	0.7	0.6
	(0-1)		*(0-3)*	*(0-3)*	
Simmental X	0.5	1	0.8	0.8	0.75
	(0-3)	*(0-3)*	*(0-2)*	*(0-3)*	
Males > 2yo					
Holstein X	0.25	0.4	0.1	0.1	0.2
	(0-1)	*(0-1)*	*(0-1)*	*(0-1)*	
Simmental X		0.6		0.2	0.1
		(0-3)		*(0-2)*	
Males < 2yo					
Holstein X	0.25	0.4	0.7	0.1	0.3
	(0-1)	*(0-1)*	*(0-4)*	*(0-1)*	
Simmental X		0.6	0.2	0.5	0.3
		(0-1)	*(0-1)*	*(0-3)*	

The data in Table 7.1.1 describing the basic statistics of the family households involved in the benchmark study here agree well with an independent survey of different samples of households in these areas conducted by Dr Nick Paltridge in association with the ACIAR agronomy project (CIM/2002/093).

Feeds offered to dairy cows

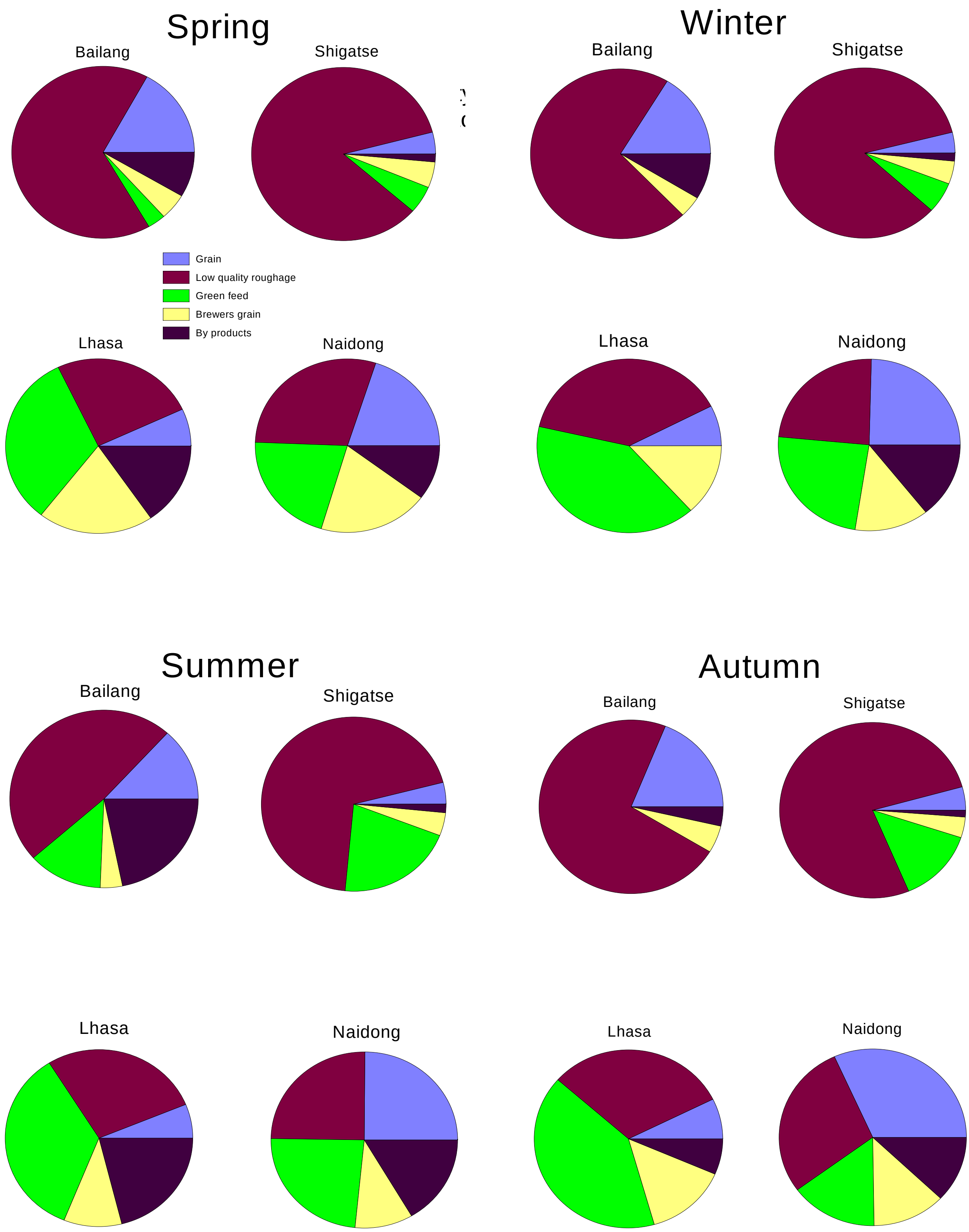


Figure 7.1.1. Proportions of the various feed types (shown in the legend) in the diets of dairy cows in Tibetan benchmark study according to season and district.

The data collected on feed offered to dairy cows are summarised in Figure 7.1.1 to show the proportions of the diet represented by the 5 most commonly fed major components – low quality roughage (LQR- predominantly wheat or barley straw), cereal grains (G), brewer's waste/grain (BG), green feed (GF), and by-products (ByP- predominantly canola meal). These distributions are presented on a seasonal basis, averaging farms within the 4 districts examined.

- The most obvious and consistent feature of the data is the high proportions of LQR in most districts in most seasons.
- The Bailang and Shigatse sites had the highest proportions of LQR (straw) in their diets in all seasons.
- This heavy reliance on cereal straw as a major component of the feed offered is the most significant factor affecting the overall (low) nutritive value of cow diets.
- Proportions of grain in the diet were quite constant within sites over seasons – but there was considerable variation between sites.
- The Naidong site had the highest proportions of grain in all seasons.
- Lhasa site had opportunistic access to green feed (mainly as vegetable waste) in all seasons, thus having the highest proportions overall.

Other general observations on the diets include:

- Cereal grains were generally over-milled compared to Australian practices for feeding to animals – this is probably a result of using the same milling process as used for the grain for human consumption.
- High fibre diets were generally not balanced for protein and energy and also likely to be deficient in Ca, P, Na, Cu, Mg, Mn, Se and Zn.

7.1.1 Production data – milk, reproduction, survival and growth

Milk production

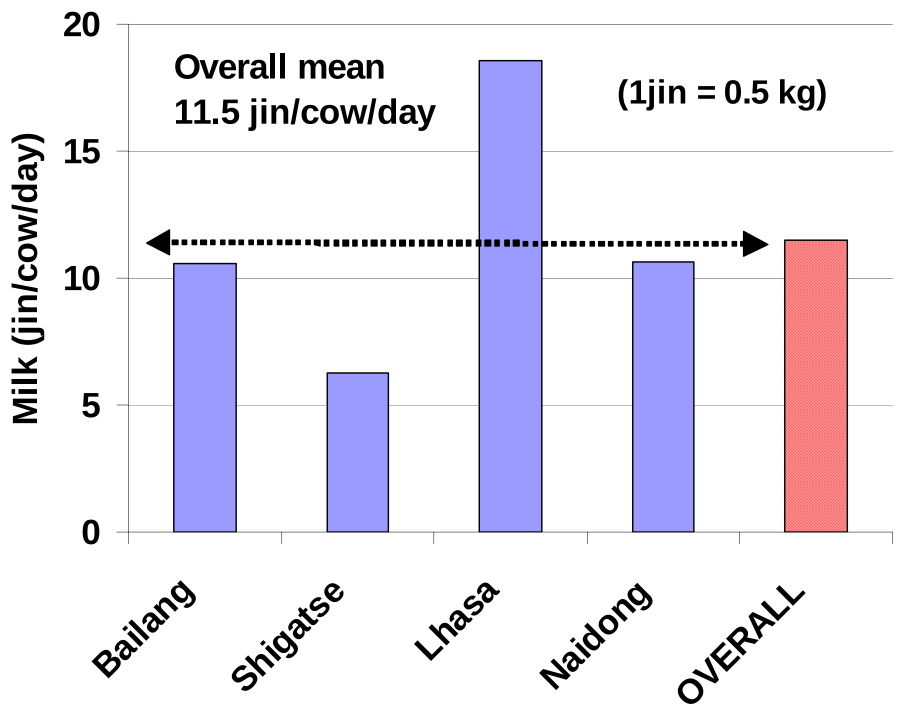


Figure 7.1.2. Mean daily milk production (jin/cow/day) for the 4 districts (and overall) in the benchmark study.

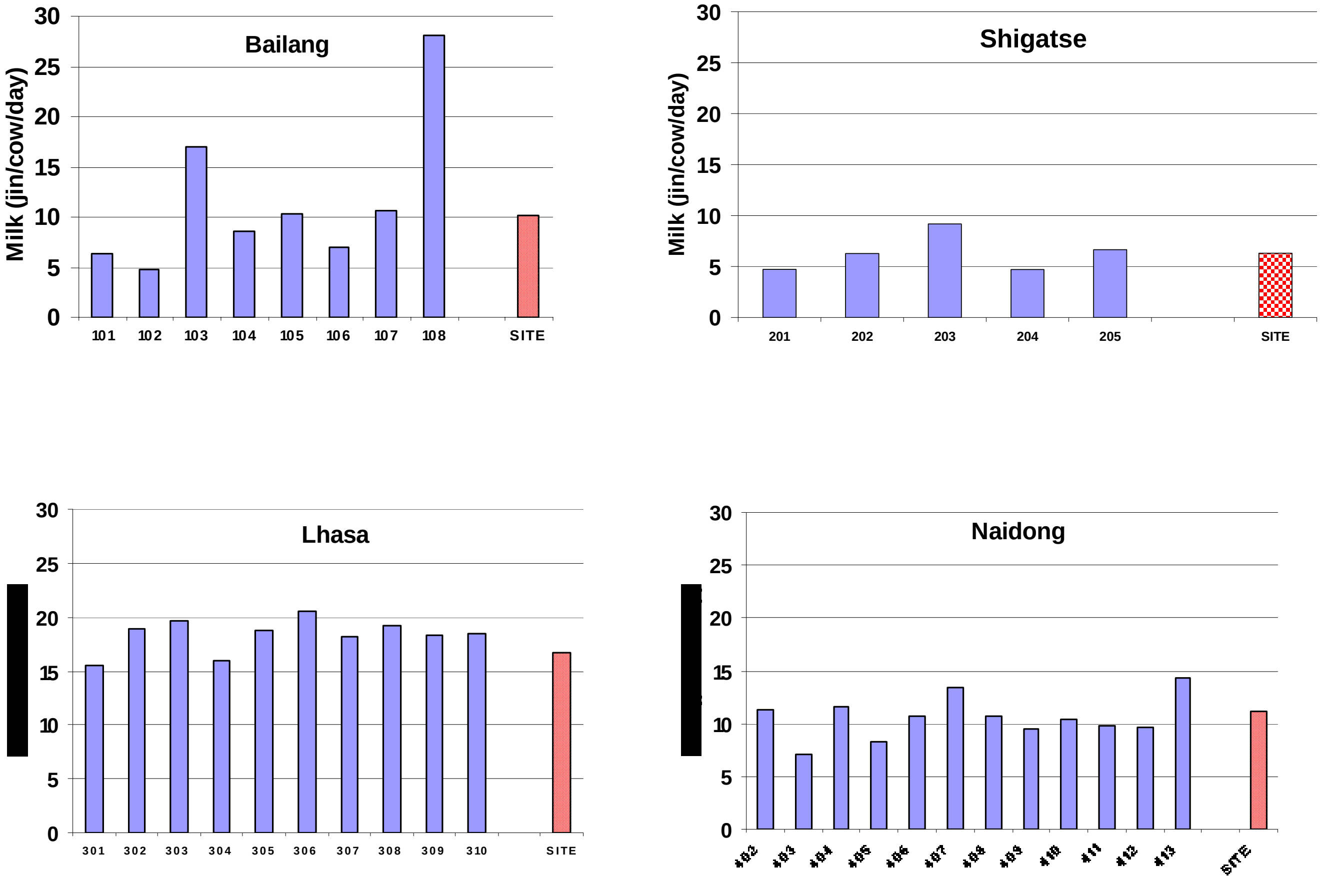


Figure 7.1.3. Mean daily milk production (jin/cow/day) for each farm in each of the 4 districts, showing the variation between individual farms, and average for each site.

The overall mean milk production of 11.5 jin/cow/day (= 5.8 kg) shown in Figure 7.1.2 is low compared to production in more developed countries (average 15-17 kg/cow/day in Australia). The variation between sites was significant ($P<0.05$), with Shigatse lower than the rest and Lhasa higher than the rest. Differences between farms within sites were also significant at all sites ($p<0.05$), with the greatest variation at the Bailang site (Figure 7.1.3). All farms at the Lhasa site averaged between 15 and 20 jin/cow/day but few at other sites reached these levels. However the “standout” best producing farm overall was in fact at the Bailang site (Farm 108), with mean production of 28 jin/cow/day almost 3 times the site (and overall sites) average. This farmer was particularly aware of the importance of feed quality as well as quantity, basic principles that were unfortunately not generally appreciated by most other farmers in the study. The highest site mean and fairly consistent performance across farms for the Lhasa site was attributed to the higher proportions of green feed available to these cows in all seasons (Figure 7.1.1), due to opportunistic access to vegetable waste, which would considerably improve the nutritive value of the diets. It is also noteworthy that the Bailang and Shigatse sites had the highest proportions of LQR (straw) in their diets in all seasons (Figure 7.1.1), and this was associated with the lowest means for milk production, particularly if the 2 highest producing farms at the Bailang site (108 and 103) were considered atypical.

Reproduction

Calving percentages

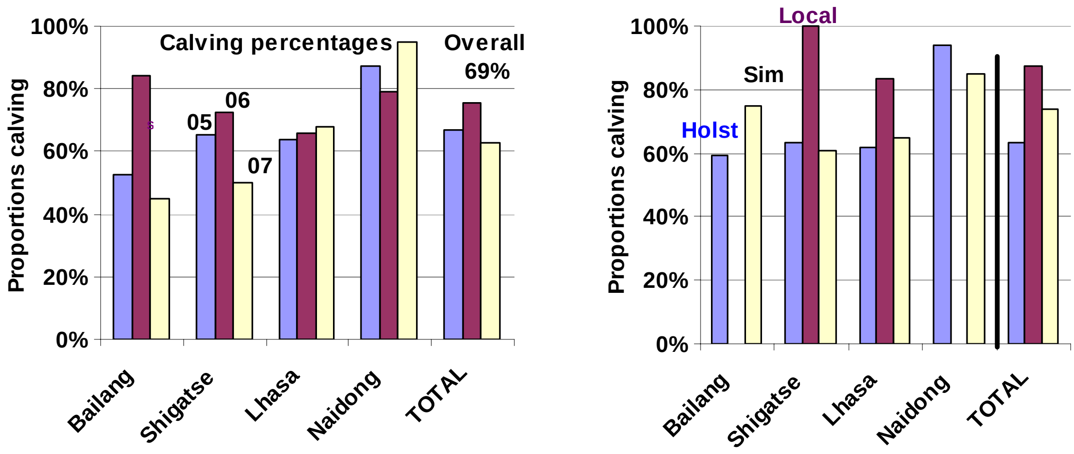


Figure 7.1.4. Calving percentages showing the variation between years and across districts and the variation between the Holstein X, Simmental X and "local" genotypes.

Calving percentages (Figure 7.1.4) were variable between years and significantly different between districts ($P<0.05$). The levels observed again reflect the general poor nutritional situation, which would impact on time to post calving re-conception, and result in long inter-calving intervals and fewer lifetime calving events. We were unable to get accurate data on these aspects. However our best estimates indicated inter-calving intervals of 15-18 months. Poor fertility and long inter-calving intervals are an excessive burden on the production system since dry cows are expensive to maintain when they are producing neither milk nor calves.

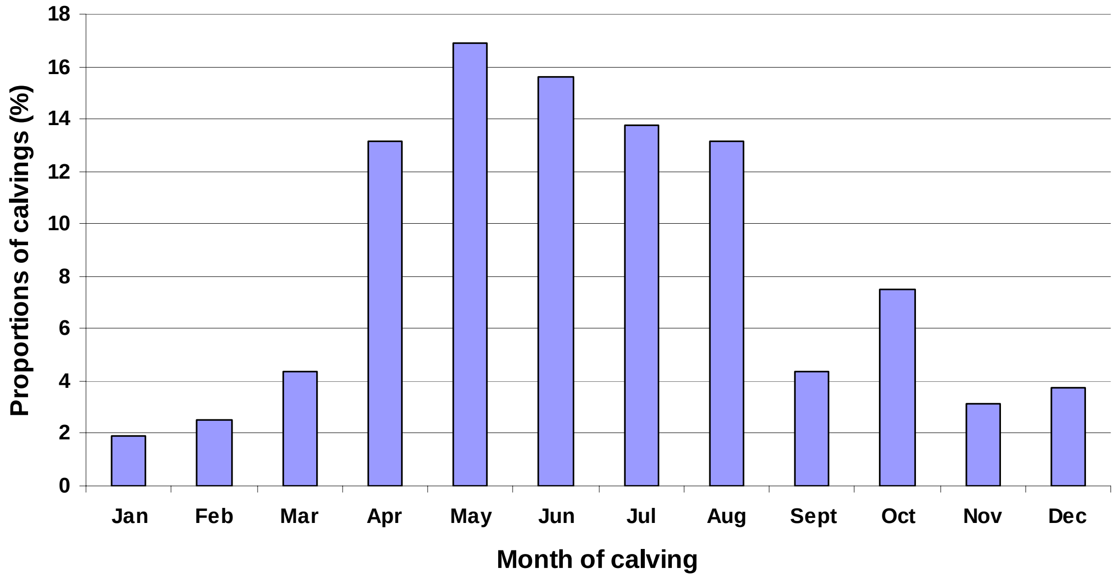
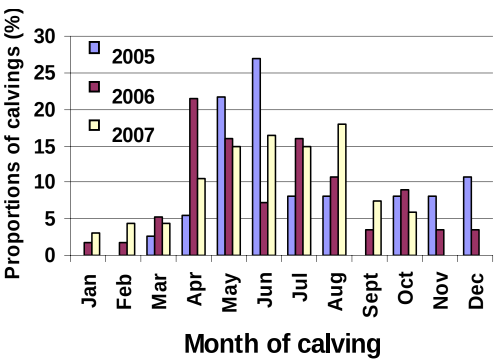


Figure 7.1.5. Spread in time of calving showing proportions of cows calving in each month, combining data for all calvings recorded 2005 - 2007.

Performance was similar between the genotypes (Figure 7.1.4, P - n.s.). Although there were few “local” cows contributing to these estimates, there was a suggestion that their fertility was at least equivalent, and possibly even better than the (perceived) “improved” crossbred cows.



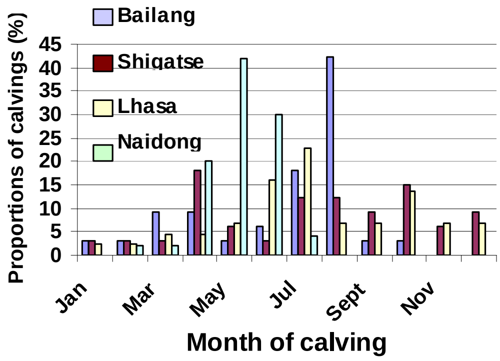


Figure 7.1.6. Spread in time of calving showing variation between years and districts, combining data for all calvings recorded 2005 - 2007.

Timing of calving

Figure 7.1.5 shows the distribution of time of calving, where the month of calving was recorded in the data, over all reproduction records collected 2005 – 2007. This shows the concentration of calving time to occur during the months of April - August, which covers the spring/summer seasons in Tibet.

The timing of calving was most compressed at the Naidong site (Figure 7.1.6), and this site also had the highest calving percentages.

Cow death rates

Cow health and survival is an important issue for these dairy farmers. It seems widely accepted that considerable numbers of adult cattle will succumb to the harsh conditions of winter. We estimated a loss of around 15% of cows over 2 years within this study. Cattle are a very large part of the farm family assets in these livestock/cropping communities, and thus any losses not only reduce production potential but severely affect the total household economy.

Birthweights and survival of calves

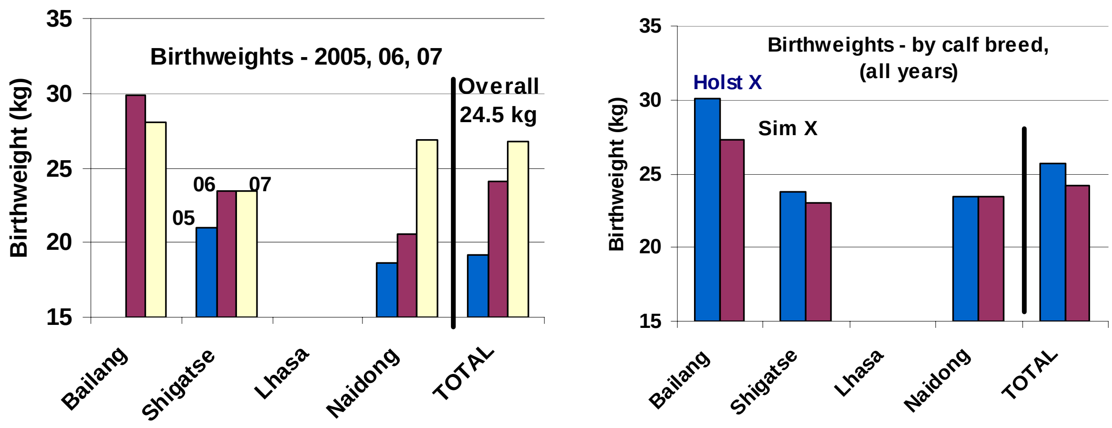


Figure 7.1.7. Mean birthweights of calves showing variation between years and the differences due to breed type (no birthweight data were collected for the "local" genotype).

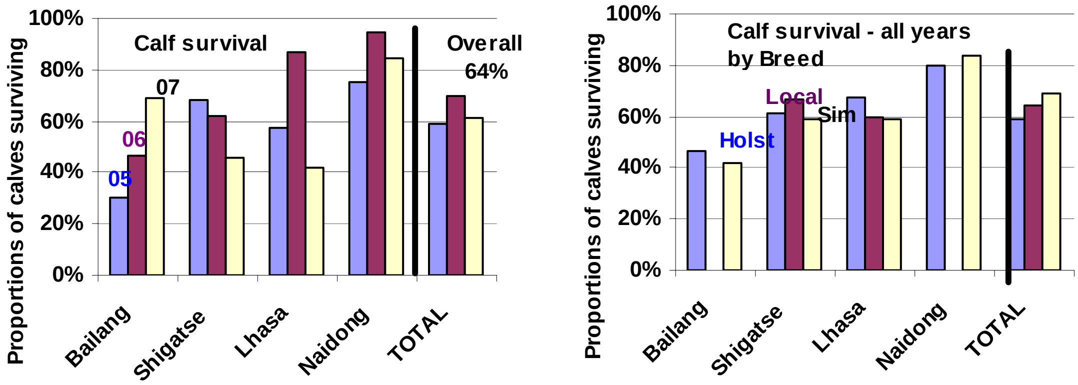


Figure 7.1.8. Survival rates of calves showing variation between years and the differences due to breed type (a small sample of the "local" genotype was available for survival data).

The birthweights of the calves were low (Figure 7.1.7) for crossbred calves of these genotypes (Holstein and Simmental) by standards in Australia and other countries. The overall mean of 24.5 kg is of the order of 15-30% below that expected, when compared to situations in other countries having better nutrition. There differences in birthweight due to genotype (dam or calf) were small and not significant, but considerable differences between years and sites (P<0.05). Birthweights improved over the period of the study, which suggests farmers may have improved the cows' nutrition, but this is speculative. A similar story was evident in the survival rates (Figure 7.1.8) showing only small (and non significant) differences between genotypes but considerable variation between years (n.s.) and significant differences between sites (P<0.05). The overall mean of 64% survival is very low compared to well managed situations, and is a major cause of loss for the farmers in this production system. Low birthweights are a primary predisposing cause of poor survival rates in calves. Although no post mortems were conducted, we believe there is a large component of perinatal infection involved, causing calf deaths soon after birth and in the first weeks of life. A further compromising factor that emerged in discussions is the practice of taking at least some of the colostrum from freshly calved cows for other uses, depriving the calf of the maximum benefit of nature's kick-start in nutrition and immunity.

Growth rates of calves

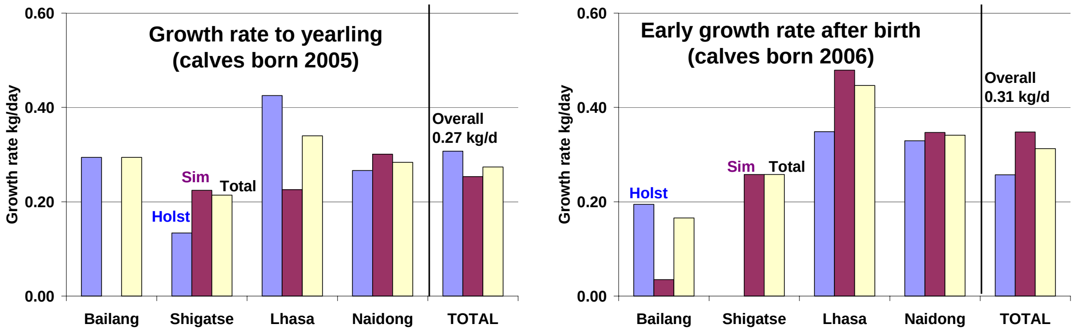


Figure 7.1.9. Growth rates to yearling age for the calves born in 2005 and early after birth for those born in 2006.

The growth rates of the calves (0.2-0.3 kg/day) shown in Figures 7.1.9 and 7.1.10 were again very low compared to Australian standards, where 0.7 to 1 kg/day is expected under usual conditions. Winter growth is obviously affected by the relatively harsh environment and lack of sufficient feed, which also applies to older cattle. These low growth rates prevent the females from reaching puberty at a reasonable age and probably have long lasting carryover effects into adult life. Thus delayed first calving and lower lifetime reproduction and milk production are predictable consequences of such poor early growth.

There were significant differences ($P<0.05$) between districts for winter growth rates for both 2005 and 2006 born calves, and for the early growth rates of the 2006 born calves, but differences due to sex and breed were not significant (Figures 7.1.9 and 7.1.10). There were no significant differences due to site or breed in the growth to yearling for the 2005 born calves. All other growth rates were higher at the Lhasa site, in association with the highest milk production at that site.

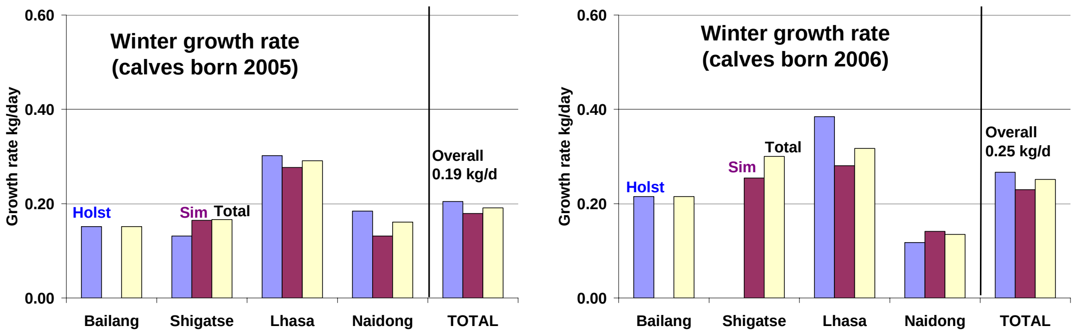


Figure 7.1.10. Winter growth rates of calves born in 2005 and 2006.

Summary of benchmark data

The most important issues to emerge from the benchmarking study are summarised as follows:

- Feed offered. The high reliance on straw as the major component of typical diets severely restricts their nutritive value for milk or other animal production. The low digestibility of the straw restricts intake, thereby limiting total energy and other nutrients.

- Milk production. Low milk production (average 5.75 kg/cow/day) was a consistent finding across sites and farms. However the variation observed also shows that production may be easily increased when the quality of the diet is improved. Cows are producing well below their genetic potential under current nutritional regimes.
- Calving – percentages and timing. Low calving rates (average 69%) were common throughout the study, again a consequence of poor nutrition. Poor fertility and long inter-calving intervals are an excessive burden on the production system since dry cows are expensive to maintain when they are producing neither milk nor calves. There is also considerable scope to tighten the patterns of calving.
- Calf birthweights and survival. Poor survival of calves (average 64%), associated with low birthweights (average 24.5 kg), is a major problem for these farms. The situation requires improvements in both pre and post calving nutrition of the cow, as well as perinatal care of the calf.
- Growth rates. Growth rates estimated here were very low (average 0.2-0.3 kg/day) by standards of good nutrition and management. Replacement females will suffer from decreased milk production and reproduction as discussed below.

General conclusions from benchmark study

Previous data on dairy production in TAR were very limited, but the results here have confirmed the estimates proposed in earlier reports.

The results of this benchmark study leave little doubt that low milk production, poor reproductive performance, in cow fertility, calf birthweight and survival, and low calf growth rates are all associated with nutritionally deficient diets (severe in some cases). This highlights nutrition as the major constraint to reasonable levels of production, and clearly indicates that most cows would fall far short of their genetic production potential.

The examination and demonstration of the levels of improvement made possible by correcting inadequate nutrition are major issues to be addressed in the project to follow (LPS/2006/119). There is a huge potential for improvement when considering the consequences of under-nutrition that are currently operating, including:-

- Effects on the calf due to nutritional restrictions in utero during pregnancy include – birth weight/calf survival, early growth, age at puberty, age at first conception, lifetime reproductive performance, age at first lactation/lifetime milk production.
- Effects on the cow due to restrictions during pregnancy include – metabolic disease risks, calving ease/cow survival, colostrum production, post-partum anestrus, calving to conception/intercalving interval, initiation and maintenance of lactation.
- Effects on the cow due to restrictions during lactation include – milk quantity and quality, length of lactation, metabolic disease risks, post-partum anestrus and consequences as above.

7.2 Results from Tibetan laboratory research

Analyses of feed samples

A summary of the overall means for important quality traits of the major feed types collected in association with the benchmark study is shown in Table 7.2.1.

Table 7.2.1. Mean values for dry matter (DM%), crude protein (CP%), neutral detergent fibre (NDF%) and dry matter digestibility (DMD%) over all samples for the major feed types collected in association with the benchmark study.

Feed type	Samples	DM%	CP%	NDF%	DMD%
Barley grain	28	91.04	11.58	24.93	79.74
Barley straw	6	93.9	4.06	86.11	35.7
Brewer's grain	38	22.62	24.72	42.54	70.23
Canola (meal)	27	88.17	34.68	30.8	67.35
Lucerne hay*	3	89.36	14.84	47.53	55.24
Vegetable waste	4	22.35		24.21	58.19
Vetch	4	87.97	19.96	53.73	62.56
Wheat grain	17	90.82	12.15	16.69	78.32
Wheat straw	31	92.76	3.61	78.7	42.04

** The quality of product called hay by the local farmers is extremely variable and often much poorer than commonly experienced elsewhere.*

The major components of diets used across all sites were straws (wheat or barley), grains (wheat or barley), brewer’s grain and canola meal. The values for CP% and DMD% for these components were examined for variation among sites and these results are shown in Tables 7.2.2 to 7.2.4.

Table 7.2.2. Means for dry matter digestibility (DMD%) and crude protein (CP%) for the major grain components of the diets showing the variation across sites.

Grains	Wheat		Barley		Brewer's grain	
Site	DMD%	CP%	DMD%	CP%	DMD%	CP%
1	82	12.7	81	11.6	71	23.3
2	78	13.9	83	12.6	66	25.2
3	89	11.0			65	20.0
4	85	11.3	80	10.5	60	23.0

Table 7.2.3. Means for dry matter digestibility (DMD%) and crude protein (CP%) for the straw components of the diets sampled, showing the variation for wheat samples across sites.

Straws	Wheat		Barley*		Oats*	
Site	DMD%	CP%	DMD%	CP%	DMD%	CP%
1	47	3.4				
2	41	3.7	27	2.8		
3	37	4.6				
4	42	3.7			51	5.8

** Note: Only one oat straw and only 2 barley straw samples.*

Table 7.2.4. Means for dry matter digestibility (DMD%) and crude protein (CP%) for the canola meal samples collected, showing the variation across sites.

Site	DMD%	CP%
1	77	32.9
2	69	32.4
3*	79	26.7
4*	60	29.6

** Note: Only one or 2 samples for these sites.*

The quality of the major components of typical diets varied considerably, significantly affecting animal production. This needs a systematic approach to determine the likely contributing factors.

As seen from the feed sample analyses, the quality traits of Tibetan feedstuffs commonly used in dairy cattle diets are generally similar (in mean values) to those reported elsewhere. This was expected, but the variation observed needs to be further examined to avoid exacerbating problems where possible, or to take advantage of better quality feedstuffs if due to local climate, management or plant genotype.
A more robust set of samples is also required to strengthen the quality database and enable more accurate estimates of digestibility and quality to be obtained. Thus continued additions to the database commenced here are well warranted and will provide a valuable reference resource for nutrition research and extension into the future.

Animal house study on improving digestibility of straw

The results of the animal house study showed a significant effect of chop length on dry matter digestibility of the wheat straw ($P < 0.002$), with the fine chop considerably better than both the medium chop and control (long) – Figure 7.2.1.

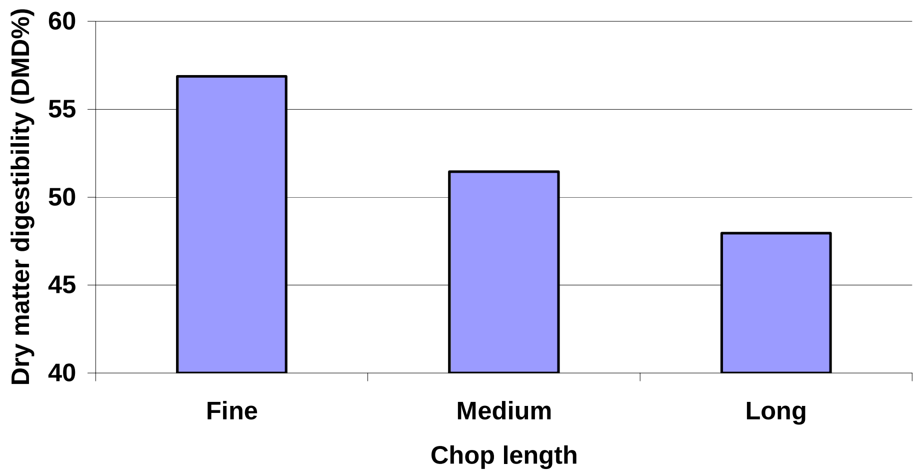


Figure 7.2.1. Effect of chop length of wheat straw on dry matter digestibility (DMD%) when fed to yearling crossbred bulls.

The trend in favour of shorter chop length was the same as the above for both dry matter intake (DMI - Figure 7.2.2) and liveweight gain (Figure 7.2.3), although these did not reach significance.

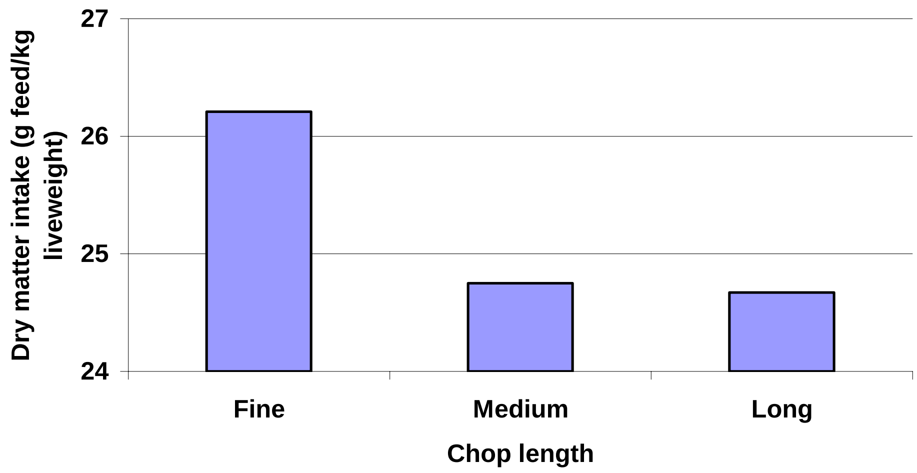


Figure 7.2.2. Effect of chop length of wheat straw on dry matter intake when fed to yearling crossbred bulls.

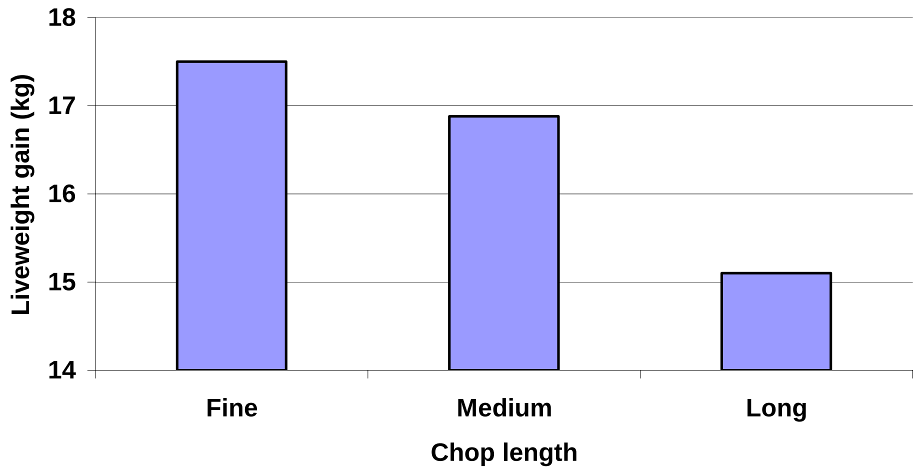


Figure 7.2.3. Effect of chop length of wheat straw on liveweight gain when fed to yearling crossbred bulls.

It was concluded from this experiment that chopping of straw is likely to considerably improve the utilisation of diets typically fed to Tibetan cattle, since they are heavily dependent on straws as the major component. The trend of improved intake and weight gain was consistent with improved digestibility of the diets and thus an animal production response is most likely to occur as a result, although the effect was not significant in this experiment.

Chopping of straw is a management practice that can be recommended with confidence as it improves nutrient utilisation and is very low cost to implement.

7.3 Results from Australian research

Severe drought conditions were experienced in the Wagga Wagga region (as indeed for most of eastern Australian cropping areas), for the duration of the experimental period. This caused the sowing of crops in 2005 to be delayed until June. Yield potential was reduced by this late sowing and poor follow-up rainfall. Despite the adverse season, the crops were harvested and silage made.

Plot trial data:

As expected the results from the plot trail were highly variable, in particular the digestibility data. Figure 7.3.1 presents the yield data from the plot trial. As there was no significant difference between the plots with or without vetch, straight treatment means are presented. Varietal differences were highly significant (<0.001), although there was no significant yield differences between harvests. Overall yields were 50-60% less than would be expected in a normal year.

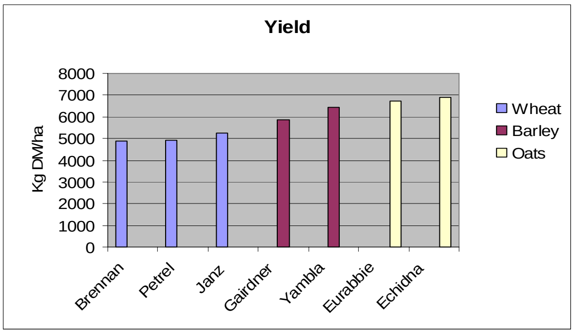


Figure 7.3.1. Yield data from plot trial.

Vetch content of the plots varied from 19-46% (P<0.001). The decreased vetch content in the oaten plots (Figure 7.3.2) highlighting the vigorous growth habit of oats compared to barley or wheat.

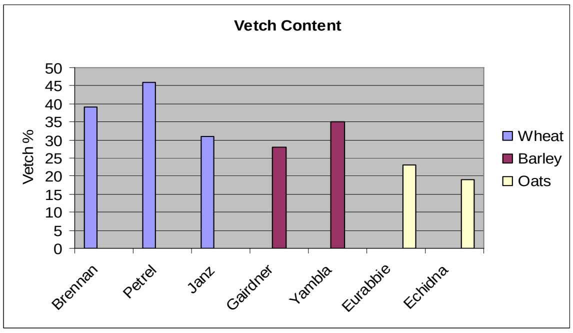


Figure 7.3.2. Vetch content of the various plots.

Due to the drought conditions, protein levels for all crops were also lower than expected. While the differences between treatments were not significant (P>0.276), the addition of vetch to the cereal plots increased protein levels by 4% on average. The wheat plots which contained the highest percentage of vetch showing the greatest difference and highest protein content (Figure 7.3.3).

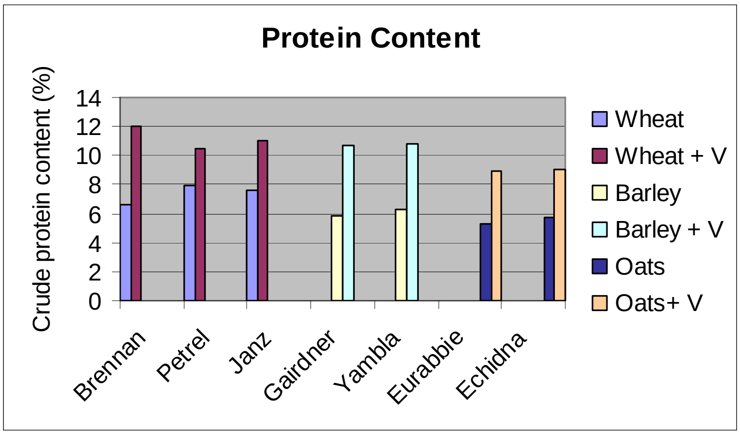


Figure 7.3.3. Protein content of the various plots.

In vitro digestibilities were determined for all of the samples from the plot trial. No significant differences between plots was found, although there were strong trends in species (P>0.013) and variety (P>0.029) differences (see Figure 7.3.4).

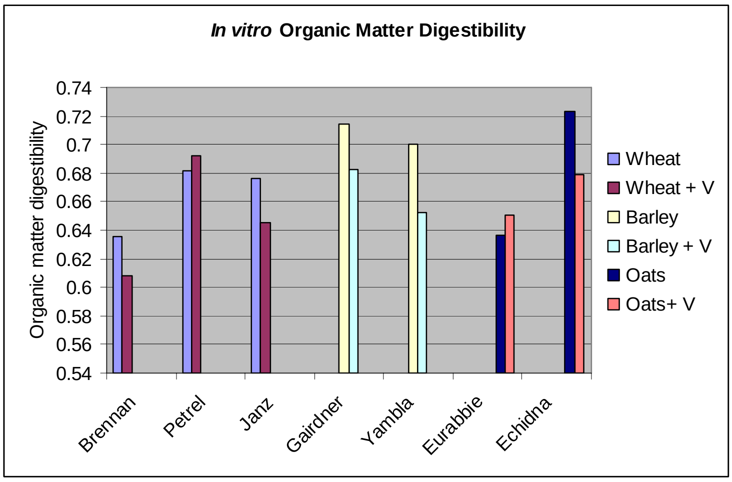


Figure 7.3.4. In vitro Organic matter digestibility of plot samples.

Animal House Experiment:

The barley and oat crops grown to make silage for the large animal house experiment suffered from the same drought conditions as the plot trial, and as a result, quality and yield were both compromised. Crops were mown at 3 stages of growth - boot, milk and soft dough stages, and made into silage which was stored in bunkers at the animal house at the WWAI for a minimum of five months. Crops had initially grown well, however as drought condition worsened the crops became very moisture stressed and had, particularly before the last cut, started to die with very little grain development. As a result, dry matter content of the later cuts was higher than normal (see Figure 7.3.5) and water had to be added during ensiling to aid compaction. This decline was also noted in the quality data with organic matter digestibility falling quite significantly between the first and second cuts (Figure 7.6).

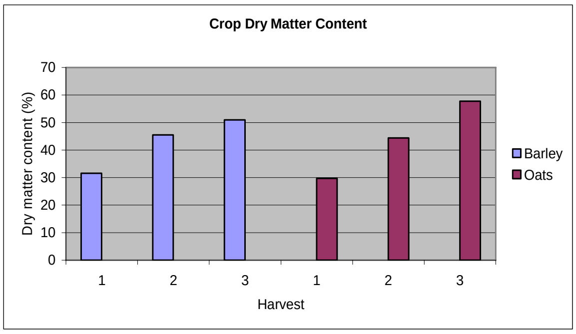


Figure 7.3.5. Dry matter content of the parent forage.

After the ensiling period silages were fed to steers and intake, liveweight gain and silage digestibility measured.

Both total dry matter intake (TDMI) and dry matter intake on a liveweight basis were both highly significant (<0.001) for the first cut of barley and oats with differences becoming less notable in later cuts (as seen in Figure 7.3.7).

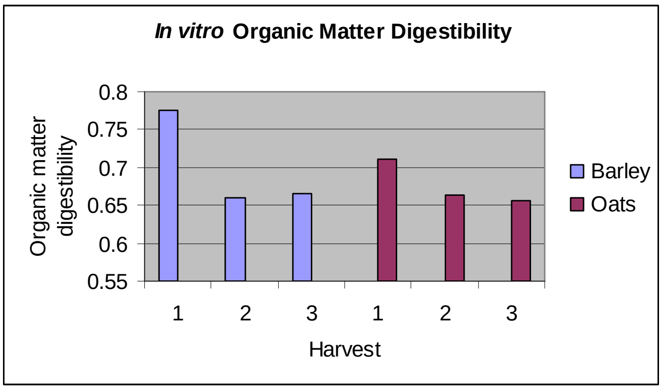


Figure 7.3.6. In vitro organic matter digestibility of parent forage.

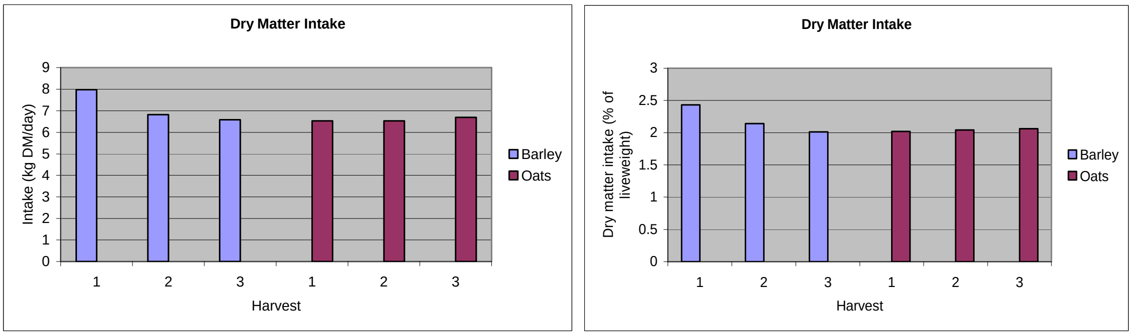


Figure 7.3.7. Total dry matter intake and dry matter intake on a liveweight basis.

Digestibility results were also highly significant for dry matter digestibility (DMD) (P<0.001), organic matter digestibility (OMD) (P<0.001) and digestible organic matter in the dry matter (DOMD) (P<0.011). The decline in quality between harvests can be easily seen in Figure 7.3.8, with a marked drop in digestibility between the first and second and particularly second and third harvests for the barley crop.

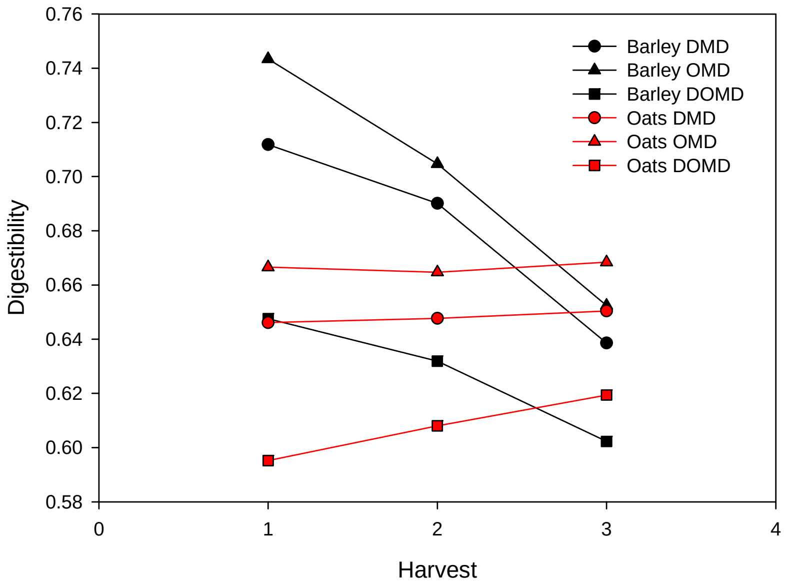


Figure 7.3.8. Digestibility results for the six silages fed in the animal house study.

The differences between harvests would also be magnified by the drought conditions and the rapid deterioration of the standing crops for the later two harvests. The lower digestibility of the first cut oats (harvest 1) is abnormal and below what would normally be expected. These anomalies in the ensiled forage cannot be explained but are mirrored in the *in vitro* digestibilities carried out on the samples of the same silage offered to the cattle during the course of the experiment (Figure 7.3.9). These digestibility results are substantially lower than the results obtained from the *in vitro* studies on the parent and forage chopped material before ensiling. The results from these *in vitro* studies are more in line with what you would expect from a first cut oaten crop (average DMD 0.697, OMD 0.714 and DOMD 0.645). This would indicate that something has happened during the ensiling process that has dramatically altered the quality of the silage, and in turn, has had a significant impact on silage digestibility. This cause is unknown.

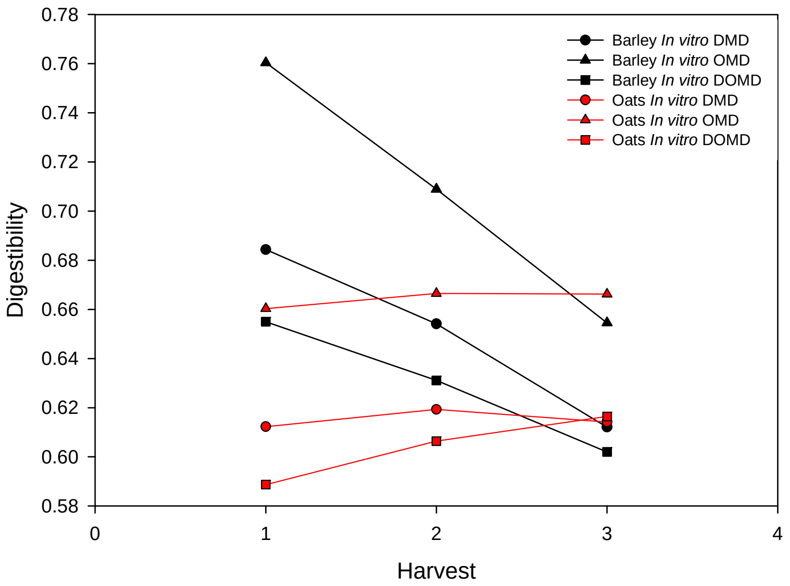


Figure 7.3.9. In vitro digestibility of the ensiled material offered during the experiment.

Metabolisable energy (ME) content was estimated for the six silages and these are shown in Figure 7.3.10. Results were not significant (P>0.065), with an average ME content of 10.04 and 9.67 for the barley and oaten crop respectively.

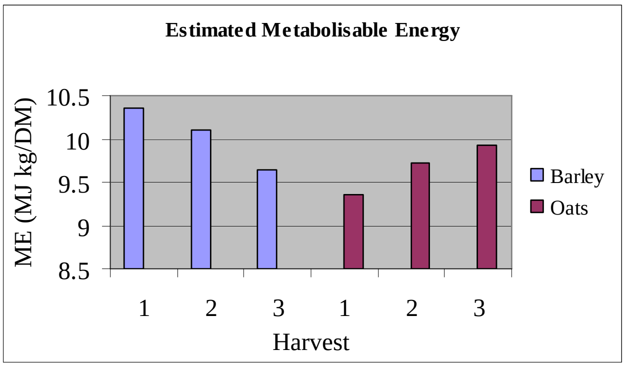


Figure 7.3.10. Metabolisable energy content of the six silages.

Differences in daily liveweight gain were highly significant (P<0.001), with a marked drop (0.31kg/day) in gain between the first and last harvest of the barley (Figure 7.3.11). This mirrors what would normally be expected, with results again magnified by the drought conditions and the rapid deterioration of crops toward the end of the growing season. The oat data however, shows an unusual trend with daily gains highest at the final harvest. This would not normally be expected and cannot be explained.

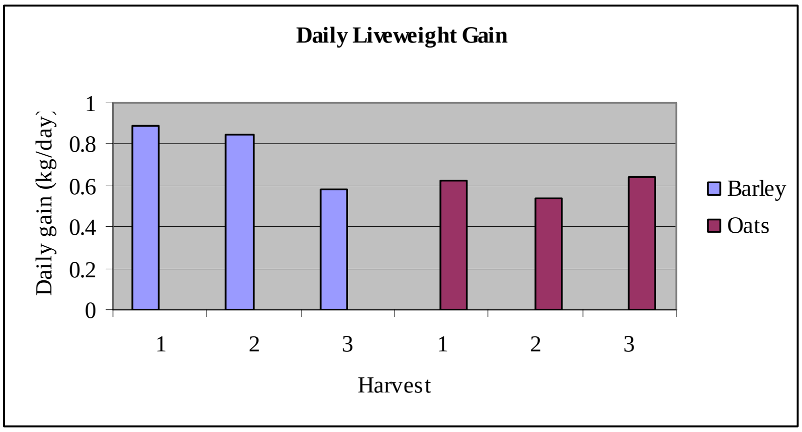


Figure 7.3.11. Liveweight gain of steers fed the six silage diets

Feed conversion efficiency (FCE) was analysed and was found to be not significantly different between treatments (P>0.133) with an overall average 10.35.

Conclusion:

It can be seen that the severe drought conditions had large effects on the experiment – this resulted in overall reductions in yield and quality, which would be expected, but also some unexpected anomalies. Digestibility, animal intake and performance data showed variable agreement with expectations. Thus, while there were some useful results, they did not provide sufficient confidence to make recommendations or to formulate specific strategies. It is therefore concluded that the work needs repeating, as proposed to be done in the project to follow this one (LPS/2006/119), which was approved for ACIAR support for commencement in April 2008.

(Additional data from this experiment for digestibility, intake and wet chemistry analyses are provided as appendices.)

8 Impacts

Outcomes from the project were expected to assist the development of a specialised dairy sector in Tibet, and conservatively increase production by at least 20%, enhancing the standard of living for individual farmers with flow-on benefits to the local economy. Direct benefits to the local community through improved human nutrition were also proposed, as well as economically empowering women in the community, since they play a key role in milk production as the main livestock managers in the family farm activities. Positive environmental benefits were envisaged as flowing from the better integration of cropping and animal production on the mixed crop/livestock farms, and better management of grazing lands where this is part of the dairy production system. The project was consistent with the TAR government policy of reducing overgrazing of the rangeland areas through a combination of concentrating cattle production to the mixed farming areas in the valleys, and a restriction of grazing access to environmentally sensitive areas.

The project has achieved significant impacts already as detailed below – However an unexpected outcome of great importance was the impact on the thinking of local policy decision makers and thus the potential to influence future directions that will have wide ranging implications for Tibetan agriculture and household livelihood. This constitutes a demonstrable benefit of ACIAR projects to the partner country on a broad economic and social scale. These immediate impacts of the project were highlighted in the comments of the external review committee, led by Dr Peter Doyle (DPI Victoria) and supported by Mr Wang Jian (Office of Integrated Agricultural Development of Tibet Autonomous Region), in the Review report to ACIAR. (Discussed further in Community impacts, below.)

8.1 Scientific impacts

The scientific impacts were only just starting to emerge at the end of the project. These involve establishing the bases for formulating feed budgets and rations for dairy production as well as identifying the areas requiring specific research. The impacts will be more evident as the new project gets under way and will continue in their effect well into the future (5 years and beyond). The nature of the science here and in the new project is such that it logically extends into all future RD&E, and therefore has no real time limit on its impact. This goes hand-in-hand with the capacity impacts, as the science can only be progressed and extended by providing the necessary human and hardware inputs.

The project has provided the necessary benchmarks of cattle and milk production systems to plan future RD&E. Thus, it provides specific direction for researchable issues that will in due course be incorporated into extension information to benefit the farmers of TAR. It was not possible within the life of the project to proactively extend the findings or to pose solutions to deficits in energy and protein supply to livestock. However it has provided some immediate guidelines for extension activities to educate those providing advice to farmers, and farmers themselves, on the severity of nutritional constraints to livestock production in current systems. In this sense the information has provided a much clearer understanding of the challenges.

A local feed quality database has been started by Dr Tsamyu and her nutrition team at TLRI. This, along with the expanding capacity for laboratory analyses, will be a valuable ongoing asset for underpinning future nutrition research and for evaluation of pasture, forage and grain quality. Data on feeds and animal production will be added to in the new project and thus will be having downstream effects in the next 5-10 years time frame, and well beyond.

8.2 Capacity impacts

There are capacity impacts in infrastructure and in many areas of human resource development which can be summarised as follows:

- Provision of the animal house research facility (shown in Appendix 11.4)
- Specific training of Tibetan staff of TLRI
- Expansion of feed evaluation techniques and skills
- Use of feed quality analysis skills in other locally supported projects (e.g. Dr Tsamyu's sheep nutrition projects, yak research by Dr Ji Qiumei's group)
- Promotion of closer collaboration of research and extension staff in formulating strategies
- Identification of the potential for greater collaboration with other extension efforts – especially with the development of the Farmer Training Centre at TAAAS
- Tibetan scientists have been exposed to a number of technologies through this project, for example whole crop silage and the application of feed budgeting.

Some of these areas have had immediate impacts within the term of the project, like upgrading of skills, but all will have ongoing benefits within the next 5 years, within the new project and other associated research and activities, and extending far beyond.

The ACIAR and TAR investment in infrastructure and equipment has provided the facilities needed for sound controlled nutrition experiments and field studies. The animal house was built with project funds, supplemented locally by the Department of Science and Technology (DOST) – we were advised that the total cost of the building and fitting out was 330,000 RMB, approaching double the ACIAR allocation. This is the first facility of this kind in Tibet, and is on par with current global standards. This will be pivotal to the key research required to evaluate feed quality and animal responses to varying feed regimes, examining responses of different genotypes and many other components required to develop efficient and sustainable feeding systems. Only one experiment was able to be conducted in the animal house before the completion of this project, but future experiments conducted by this facility will have major benefits – within 5 years, in the term of the new project and importantly extending well into the future to improve Tibetan agriculture. It is envisaged that the animal house will be used for many other locally funded projects (yak, sheep and goat research), and would also be available if required for intensive experiments within the recently commenced ACIAR Minerals project (LPS/2005/129). It is reported by Prof. Mdme. Se Zhu (Deputy Director, TLRI) that many government officials and visiting scientists have inspected the facility, and all have been impressed with its utility and potential for future research. The animal house is clearly a major asset for future animal science (and related agriculture) in Tibet.

Scientists from TLRI visited Australia on two occasions for short study tours and for specific intensive training in experimentation and analytical procedures. A group comprising Mr Osman, Mr Basang and Dr Tsamyu visited Australia (based at DPI Wagga Wagga) in September 2005, and were exposed to a wide variety of technology, research and extension areas relevant to animal and forage production. Subsequently Dr Tsamyu had another visit staying for 2 months over April/May 2006, when she was totally involved in the ACIAR feeding trial conducted at the Nutrition Research Unit at NSW DPI Wagga Wagga. This enabled her to further her skills in animal house experimentation and in the associated laboratory analyses of samples, which will strengthen her capacity in the leadership of the Nutrition Research group at TLRI.

Two scientists from the project staff at TLRI were awarded John Allwright Fellowships to undertake MSc. studies in Australia. They will commence their research programs in September 2008 at Charles Sturt University, Wagga Wagga, to be jointly supervised by CSU and NSW DPI staff. Research within their studies will equip them with valuable skills in animal and forage production, laboratory analyses related to feed quality and in animal house experimentation. This will further strengthen the capacity for animal production and nutrition research at TLRI on their return to Tibet.

The assignment in Tibet of Ms Amanda Mather (NSW DPI Agronomist), sponsored by the Australian Youth Ambassador for Development program, was an extremely valuable adjunct to the project, since this provided a detailed study of the infrastructure of local government administration, research and extension. TLRI staff benefited from their involvement in this study as well as having the results and recommendations as resource material for the future.

Some comments from the review committee report to ACIAR on capacity impacts are worth noting:

> "The TLRI research team has benefited significantly in expertise and science process. Further improvements in understanding the importance of research or survey protocols, attention to detail in methodology and timely examination and analysis of data are needed, and these areas will be addressed within the new project. However, given the starting base and language difficulties, the gains made should not be undervalued. When an animal breeder of 17 years experience acknowledges that nutrition is the primary constraint to increased cattle and milk production rather than genetics, the basis to go forward is clearly in place. The Tibetan team are motivated to find new ways to improve income for Tibetan farmers, but there remains a need to improve knowledge, scientific and English skills to capitalise on this commitment."

8.3 Community impacts

The current local policy for the valleys of Tibet is to increase cattle numbers and genetic potential. This strategy is in direct conflict with the significant deficits in amounts and quality of feed. The presentation of the benchmarking study results during the external review, and associated workshops, has already influenced senior decision makers of the need to rethink this policy. To quote from the reviewers' report :-

> "The impacts should extend to examination of current livestock policies in TAR, improvements in the Tibet economy and to maintenance of natural resources in this zone."

In her report to the review meeting, Prof. Mdme. Se Zhu commented that many farmers neighbouring those participating in the benchmark study had shown great interest in the progress and results, and were keen to discuss how they might implement improved practices on their own farms.

This project (and the approved following one) was directly aligned with the ACIAR Partner Country Priorities for China, viz "Technologies for crop-livestock systems in favourable areas of TAR", and is consistent with the current goal of TAR authorities to boost grain and dairy production (most recently stated in the proceedings of the 8th People's Congress Anon., 2006).

8.3.1 Economic impacts

The economic impacts of the project will be realised by its effects within the new ACIAR project in adoption of new technologies to increase profitability and by its effect on influencing agricultural policy. Thus the time frame for such effects will be certainly within the next 5 years. However, on a broader perspective, adoption of new technology and/or any changes in agricultural policy influenced by this or following projects, will have ongoing longer term effects on farm productivity and profit and thus on profitability at an industry level.

Some specific examples economic benefits, as measured by gross increases in product value, expected to arise from the new project include :- An increase in product value of ¥240 million across the industry (or about ¥1,000/annum per household) resulting from a 15% increase in grain production (at current values of ¥1.8-2.0/kg at the farm gate) and an increase in total dairy product value of ¥180M across the industry resulting from only a 25% increase in production (at current value of 3¥/kg milk at the farm gate). The increases in production to achieve these benefits are considered conservative. However it should be noted that those estimates of increased value of production are based on many individual component inputs. The increased cost of inputs to achieve these gains has not been estimated in the above – in some cases it will require only minimal extra inputs with most benefit coming from management changes. These and other issues affecting adoption will be fully addressed within the new project, which will focus on whole production system outcomes. Thus the economic impacts have to be vigorously tested and validated by accounting for the interactions of various farm activities, costs of production and trading opportunities, as well as the social and economic factors that will affect adoption.

Most farming households sell only a small fraction of the crop and livestock products they produce, and are thus regarded as subsistence farmers (Goldstein *et al.* 2003). The average per capita income of rural Tibetans is around than 2000 yuan per year (TSY 2006), or less than US$1 per adult per day, putting these farmers amongst the world's poorest. Thus the potential to raise farm family income suggested by the economic estimates is large.

8.3.2 Social impacts

As was the case with economic impacts, the social impacts of the project will not be realised until the effects of adoption of improved technology come into play within the new project and beyond.

Tibetan farmers are relatively poor, both in terms of income and the proportion of income expended on daily living, estimated as 64% (Lu Qi *et al*. 2005). It is also understood that most grain produced by Tibetan farmers is consumed on farm (N. Paltridge, unpublished data), and that Tibet produces about the same amount of food as it consumes (Nyima Tashi 2006). In the new project, increasing levels of grain and dairy production will lead to both increased farm incomes and increased levels of food security, with each of these having great social benefit. For this reason there is a strong emphasis on social and economic benefits (improved family well-being) resulting from proposed practice change.

Survey work will be conducted in the follow-on project (LPS/2006/119) to gain a greater understanding of farmer attitudes, constraints and opportunities and household finances, together with interactions with farmers during the on-farm evaluation of crop/forage/dairy production options. This will provide greater insight into the actual and potential social effects of changed farm practices. This information will be used to guide future on-farm and on-station initiatives and help strengthen extension messages in future. Various organisations in TAR have expressed strong interest in project outputs, which applies to current and future projects. Good liaisons with the funding and government bodies (like the Poverty Alleviation Office and the Department of Science and Technology) have been established during to term of this project. This bodes well for the success of future technology transfer strategies and thus the improvement of agricultural production and household incomes in TAR.

Food supplies are inadequate on many farms in Tibet - around one third of farmers do not produce enough grain to meet their yearly household needs (Goldstein *et al*. 2003), let alone having a surplus to sell, barter or feed to animals for increased production.. Low income levels and food security are therefore major social/economic issues in rural Tibet that will be addressed in future work. It is also reasonable to expect improvements in the health status of communities where the availability and security of food is improved, which will be a major positive outcome.

8.3.3 Environmental impacts

The impacts on the environment as a result of this project will start to be realised in 3-10 years time, within and beyond the term of the new project (LPS/2006/119). The expected positive environmental impacts include improving the efficiency of resource use by increasing livestock, crop and fodder production in sustainable systems. Through the project's demonstration sites, an understanding of environmentally responsible practices will be promoted as well as the use of resource-conserving technologies such as zero-till, appropriate fertiliser use and irrigation management.

Positive environmental benefits will flow from the better integration of cropping and animal production on the mixed crop-livestock farms, and through the shift of milk production from the rangelands to the valley floors. This is consistent with the TAR government policy of reducing overgrazing of the rangeland areas through a combination of shifting cattle production to the mixed farming areas in the valleys, and a restriction of grazing access to environmentally sensitive areas.

8.4 Communication and dissemination activities

Awareness/extension activities

Although no specific extension recommendations were made from the results of the study, there was a need to expose the project to scientific and extension staff as well as the farm community, particularly to those directly involved in the project. Thus a series of presentations was given to farmers and to field and research staff (many of whom were assisting in field data collection) to give an overview of the aims of the project, the methodology and expected outcomes. Presentations were given at each of the field site locations - Shigatse, Bailang, Naidong and Lhasa. Within these presentations, some general principles of animal production were discussed in very simple terms.

The presentations were given in PowerPoint format and a specifically designed approach was taken for the discussion of animal production principles. This was to deliver simple messages in cartoon form so that the meaning was quite obvious without reliance on an explanation in text, although both Chinese and Tibetan interpretations were in fact provided for the audience. This approach was very well received and we had numerous requests for copies of the slides from the research and extension staff. A sample of the cartoon style slides is provided as an appendix.

Dairy Industry Workshop

A Dairy Industry Workshop was convened by TAAAS and TLRI, held at Tibet International Grand Hotel, Lhasa, 15 June 2005. This was attended by 60-70 scientists, field and administration staff and other invited guests. Australian and Tibetan project staff (John Wilkins, Colin Griffiths and Tsamyu) gave presentations to describe the aims and design of the project and the progress to date, although in initial stages only at that time. The project was very well received by the local scientists and government officials.

Review meeting

A meeting was held at Lhasa in May 2007 for external review of the project. The review team was led by Dr Peter Doyle (Dept Primary Industries, Victoria, Australia) supported by Mr Wang Jian (Office of Integrated Agricultural Development of Tibet Autonomous Region, Lhasa, PRC, incorporating the Poverty Alleviation Office, PAO). The meeting was combined with a workshop for the ACIAR Minerals project LPS/2005/129 which has recently started, enabling a wide range of scientists from that project and other TAAAS staff to take part in discussions. Senior officials from other organisations were also invited, including Ms Drolma, Deputy Division Chief, Dept Science and Technology.

The Australian and Tibetan team members of the project gave presentations providing information and results to date of the benchmark field study, as well as the results of the Australian and Tibetan experimental components. These provided the basis for assessment of progress to date by the review team, as well as the justification for ACIAR support of further work. Scientists from the Australian and Tibetan teams of the Agronomy project CIM/2002/094 also gave presentations as these were relevant to discussions and planning for the new project to integrate livestock, crop and forage production.

The review process produced very positive outcomes with good reports on work and results to date and on capacity building, management of the project and the commitment of the project teams to improving Tibetan dairy production. The reviewers gave very useful recommendations, but most significantly, firm support for further ACIAR funding of a follow-on project. They highlighted the current and potential impacts of the project, which they believed could extend widely to examination of current livestock policies in TAR, improvements in the Tibet economy and to maintenance of natural resources in this zone – outcomes not often achieved in a short time by new projects.

Thus the major conclusion of the review was the recommendation that ACIAR fund a project to follow which would incorporate both livestock, cropping and forage issues into an integrated farming systems approach. This would have an underlying charter of addressing the economic and sociological issues required to achieve the adoption of improved technology. This has been supported by ACIAR and the new project commenced in April 2008 - *Integrated crop and dairy systems in Tibet Autonomous Region, PR China* (LPS/2006/119).

Project conclusion workshop

On the final project visit to Tibet, a one day workshop was convened by TAAAS, held at TLRI in November 2007, to present the results, conclusions and recommendations of the project to a meeting of key senior officials of Dept of Science and Technology (DOST) and the Poverty Alleviation Office (PAO). The proposals for the project to follow were also presented, with the message of recommendation to ACIAR by the external review report. A presentation was given by Prof. Mdme Se Zhu to give the Tibetan perspective of the importance of the study to local agriculture and the future directions of research at TLRI. A specific aim of this meeting was to consider future funding support for TLRI in the context of joint research projects, such as the proposal with ACIAR at the time, as well as other initiatives of the institute. These would be building on the achievements of this project and capitalising on the increased capacity in research skills and infrastructure.

Following presentations by both the Australian and Tibetan scientists, the committee of these funding agencies indicated ongoing support for future RD&E by the research units under the TAAAS umbrella. This augers well for the return to investment in current and future programs for ACIAR, NSW DPI and the local funding agencies, by ensuring efficient improvement in production and increased smallholder income. This was another occasion where policy decision makers were influenced by the ACIAR project. By demonstration of the underlying principles of nutrition driving animal production in relation to the study, they were convinced that problems will not be solved by "silver bullet" strategies (like genetic improvement programs), that do not consider the overriding basic constraints to animal production due to inadequate dietary quality and quantity.

Animal production guidelines

At the request of Mr Wang Jian (PAO), a document was prepared to discuss the principles involved in calculating nutrient requirements for animal production, for dairy cows in particular. This provided the means to choose appropriate cow genotypes, based on maintenance requirements and potential production, in relation to nutrients available according to the composition of the diet. The calculations of requirements were made by providing a relatively simple spreadsheet procedure to determine total energy costs throughout a yearly cycle, accounting for maintenance, lactation and pregnancy for various cow liveweights and milk production levels. This discussion document and requirements calculator proved a valuable aid to all staff in relating animal requirements to feed on offer. Importantly it provided Mr Wang Jian with the logic involved in making decisions affecting the choice of appropriate animals for varied production and feed scenarios. He was concerned that he and other policy makers/fund providers previously had little technically sound advice to assist such decisions.

The document (*Guidelines for Animal production in Tibet, John Wilkins and John Piltz*) is included as an appendix.

Presentations

PowerPoint presentations describing the project aims, methodology and results at various stages have been given on numerous occasions and at many venues in both Australia and Tibet. Audiences have included research and extension staff, visiting scientists and producer groups, local organisation management (including NSW DPI Board of Management), funding body representatives etc.

J.F. Wilkins, C.N. Griffiths and J.W. Piltz. Overview and progress reports of ACIAR project LPS/2002/104 -*"Increasing Milk Production from Cattle in Tibet".*

Reports

Project visit reports were provided to ACIAR and NSW DPI following each visit to the project site in Lhasa. These occurred in October 2004, June 2005, March 2006, September 2006, May 2007 and November 2007.

Miscellaneous

Reference to the project and benchmark data has been used in extension activities by TLRI and TAAAS staff, Ag Bureau and other field officers, although no specific material had been prepared for this purpose to date. However TLRI staff were encouraged to start the process of organising suitable extension material and this will be part of aims of the project to follow.

9 Conclusions and recommendations

The major conclusion from the benchmark data was that milk production, reproduction and growth rates are all considerably limited by the generally poor levels of nutrition. This was highlighted by the demonstration of the large dependence on cereal straw as the basis of dairy cow diets, which will continue to limit production until cost effective supplement strategies to improve the nutritive value of the total diet are devised. Results from the agronomy project suggest that forage crops grown in conjunction with cereals may provide high quality feed with minimal reduction in grain yields. However it may be more efficient on a farm or district basis to have dedicated forage systems separate to cereal production. Upgrading of cattle by the introduction of (perceived) “improved” genetics will be ineffective without improved nutrition, and may not deliver the most efficient production under current management systems in any case.

It was noted by the project review team that, in retrospect, the original objectives were too ambitious – a situation appreciated by ACIAR as not uncommon to projects involving such remote agricultural areas and subsistence level households. Hence the failure to complete some of the stated goals did not detract from the achievements of Tibetan and Australian staff. The shortfall here, mainly in the progression of devising feed budgets and diet formulation strategies, will be more than adequately addressed in the follow-on project.

9.1 Conclusions

It was apparent that the principles driving animal production are poorly understood across the complete spectrum of farmers, field staff, scientists and administrators. This has implications for future directions of research and extension as well as agricultural policy and funding. The project has made a start at rectifying this situation but there is much ground to cover yet within the new project, and it has been identified as a high priority area.

The results of the benchmark study on diet composition, milk production and reproduction parameters now provide valuable information, previously unknown, on which to base future directions of research and extension:

- Current feeding systems were heavily reliant on cereal straw(s) in all districts and in most seasons
- The high proportion of straw commonly seen in the diets would restrict intake and digestibility, limiting total energy available for maintenance and production – other nutrients are also likely to be inadequate
- Restricted nutrient intake means animals are unable to express their genetic potential
- Sources of high quality green feed need to be investigated before an annual feed budget can be formulated
- Sources of protein supplements (eg NPN) need to be evaluated.

Production levels were all low as a result of poor nutrition:

- Low milk production (average ~ 5-6 kg/cow/day)
- Decreased fertility (average 69% calving rate)
- Low calf birthweights (average 20-25 kg)
- Poor calf survival rates (average 64%)
- Low growth rates in young cattle (average 0.2-0.3 kg/day)
- Associated problems of long intercalving intervals, late maturity of females and low lifetime performance were also evident.

There was little time available for research in Tibet in the newly constructed animal house in Tibet. There was however the opportunity for the local nutrition research group to commence their experimental program with one small experiment, and they were able to produce useful results to show the improvement in utilisation of straw by a simple treatment of chop length.

The research done in Australia on forage production and quality within this project was useful to some extent, but results were severely affected by drought conditions, and this needs repeating and expanding within the new project.

9.2 Recommendations

The major recommendation from this project, as a consequence of the review report, is to continue ACIAR support with a follow-on project having a total production system approach to capitalise on the work to date (in both this project and CIM/2002/093). This has in fact already happened – LPS/2006/119 (*Integrated crop and dairy systems in Tibet Autonomous Region, PR China*) was approved and started in April 2008.

The principles of matching animal requirements to nutrient availability need to be applied when devising feeding strategies and diet composition for defined production situations within the new project. This may reveal conflict between requirement and cost or availability of feed resources. In such cases, the best option may be to feed fewer animals while meeting all of their nutritional requirements, thus avoiding the inefficiency of poor production from underfeeding larger numbers animals.

The issue of choosing suitable cattle genotypes needs to be carefully considered in the future by considering the interaction with nutrient requirements. Crossbreeding using genotypes of large mature size is a poor strategy if the quality of the diet (energy content in particular) cannot support the extra maintenance cost of larger animals. Thus the principles of matching animal nutrient requirements to that available in the diet must be applied to the particular production scenario when selecting the type of cattle to best suit that situation. The quality of feed on offer will determine the potential limit of production, and quantity fed will be largely determined by the cost of the ration in relation to value of production.

Recommendations for future areas of research at TLRI have been discussed with local scientists and three basic areas of importance to the new project and to dairy cattle production in Tibet were identified, viz:

- Limitations to production due to feed quality – including responses to improved diets
- Limitations to lifetime production due restricted growth in early life
- Limitations to production due to genotype.

The capacity building in staff skills during the project was a good start but it must be continually expanded in the future to ensure the progress of research and extension at TLRI and other sections under TAAAS. Strengthening the capacity in written and spoken English is vital to widening liaison and collaboration outside Tibet and China in general. The dependence on just a few people proficient in English and with postgraduate training is an undesirable situation which was noted by the project review team in their report to ACIAR. This will be improved by the training of the 2 John Allwright Fellows from the TLRI group and one from the TARI group, starting their postgraduate programs in Australia in the second half of 2008, and needs to be continued within the new project.

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10.2 List of publications produced by project

Kaiser, Alan (2006). *Increasing Milk Production from Cattle in Tibet* (ACIAR project – LPS/2002/104). Update 2006, Wagga Wagga Agricultural Institute, NSW Dept Primary Industries, Wagga Wagga.

Qiumei Ji, Tsam You, Zhang Qiang. Milk Production in Tibet. (Review paper submitted for publication)

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Tsamyu, Dunzhu Jiangcan, Qu Guangpeng, Bao Yuhong and Xiu Hua. Study on nutritive evaluation of dairy cattle feeds in Tibet (*in preparation*).

Se Zhu (2007). Final Report – ACIAR/TLRI project *Increasing Milk Production from Cattle in Tibet*. Final Report to Dept of Science and Technology, TLRI, Lhasa, November 2007.

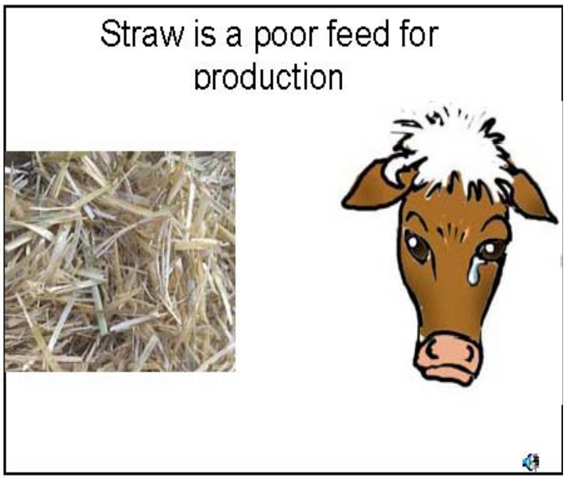
Wilkins, John (2008). *Integrated crop and dairy systems in Tibet* (ACIAR project – LPS/2006/119). Update 2008, Wagga Wagga Agricultural Institute, NSW Dept Primary Industries, Wagga Wagga.

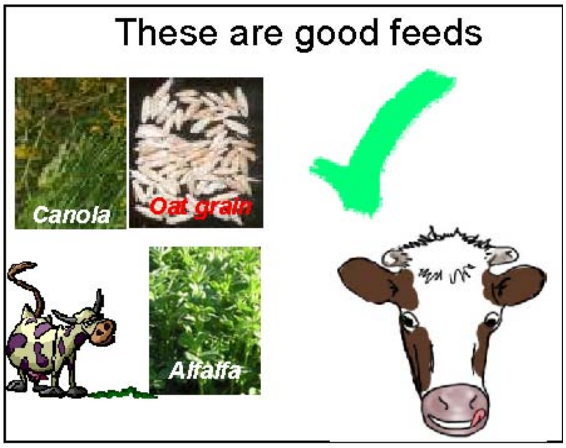
Associated publication
Amanda Mather (2006). Assignment Report (Description of the agricultural extension structure and operation in TAR). Australian Youth Ambassador for Development (AYAD) Program, September 2006, AusAID, Canberra.

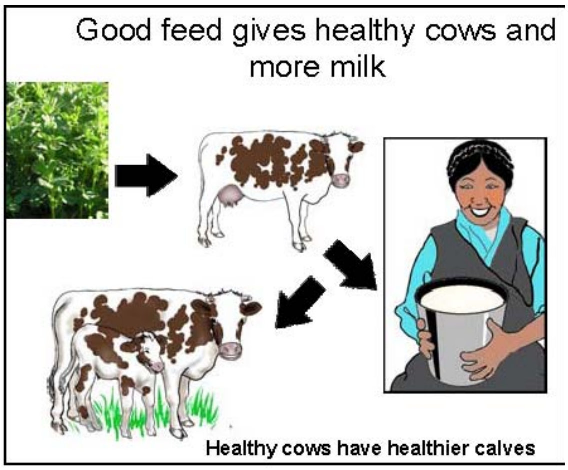
11 Appendices

11.1 Appendix 1 – Sample of cartoon format for extension/awareness presentation

Extension Activity
ACIAR project LPS/2002/104
Increasing Milk Production from Cattle in Tibet







11.2 Appendix 2 – Guidelines for animal production in Tibet

11.2.1 Guidelines for Animal production in Tibet

John Wilkins and John Piltz

NSW Dept Primary Industries, Wagga Wagga NSW, Australia

The following principles are used to calculate the nutrient requirements of livestock. This affects the numbers and types of animals that can be managed with a given feedbase resource (pasture or hand fed).

The capacity of grazing land to support animals is determined by the quality (nutritive value) and quantity of the pasture, and the nutrient requirements of the animals grazing that pasture.

The same principles apply to the situation where animals are not grazed, but are fully or partly fed (like milking cows in Tibet). The nutrient that is most often critical is energy, but protein is also important, particularly for growing animals or for milking cows.

Maintenance requirement of animals – size matters

All animals have a nutrient requirement just for maintenance – this will vary with the type of animal and with the environment, but is firstly dependent on liveweight. The energy required for maintenance is used for keeping body temperature constant and for walking around and for all the body functions apart from growth, and pregnancy and lactation (milk production) in the case of cows. If the environment is cold, the animal will need more energy just to maintain its body temperature. If the animal does not get enough energy for maintenance (by grazing or by being fed), it will loose weight and become very skinny and may even die.

The liveweight of an animal at any time (during growth or at adult stage) has an upper limit that is set by genetics, but is dependent on nutrition, and in fact may not often be reached, even under relatively good conditions. If nutrition is restricted, the animal's liveweight (or growth rate for young animals) will be less than the genetic potential. Animals that have severe restrictions of nutrition early in life may be permanently affected, and never reach their genetic potential, even if they are given good nutrition later on.

Which animals are most suitable for production?

Selection of the type and numbers of animals that are best for any situation will depend on their size (their demand for nutrients) and on the ability of the available feed to supply the nutrients they need (mainly energy). Animals that are very large because of their breed (genetics) will require a lot more feed to keep (maintain) them, and therefore they may not be suitable for situations where the quality and quantity of feed is not good enough. If cows are expected to produce a large amount of milk, it will require a lot more feed, which may not be possible to supply. So if such cows do not get enough feed, they will loose weight and they will produce only a small amount of milk.

Large Holstein cows are often thought to be the best for dairy production because they have the potential to produce large amounts of milk. However they need a lot of feed to produce amounts of milk that get close to their potential, and this is often not available, or it would cost a lot of money to supply the amount of feed they need. If there is a lot of good quality pasture available (which is relatively cheap to produce), like in New Zealand or some parts of Australia, these large cows may be suitable. However, this not generally the case in Tibet, and is not ever likely to be.

Calculating the energy requirements and efficiency of milk production

We can calculate the amount of nutrients required by a cow that is milking, or for an animal that is growing. As mentioned before, the first thing is the liveweight, which will determine how much feed the animal needs just for maintenance. We then have to add the extra nutrients required for the type of production (milk in this case). In these examples we are considering energy only, as this is usually the most limiting, but the total nutrient requirement must also consider protein and minerals to satisfy the type of production. The energy used in these examples is called metabolisable energy (ME) and the units are mega joules (MJ). (In these examples we have not added in the extra "cost" of energy for walking/grazing or for pregnancy.)

So to give some examples for milking cows (the units of energy are MJ – mega joules):-

Cow liveweight (kg)	**200**	**250**	**300**	**400**	**500**
	Energy requirements (MJ/day				
Energy for maintenance	35	40	45	55	65
Energy for producing 5 kg milk *	27	27	27	27	27
Total	62	67	72	82	92

It takes around 5.3 MJ energy to produce 1 kg of milk. And a large cow requires as much energy to produce kg (or jin) of milk as a small cow. So:

To produce 5 kg milk requires 26.5MJ energy. So we can calculate that:

- For a 250 kg cow to produce 5 kg milk – it "costs" 67/5 = 13.4 MJ/kg (or 6.7 MJ/jin)
- For a 500 kg cow to produce 5 kg milk – it "costs" 92/5 = 18.4 MJ/kg (or 9.2 MJ/jin)

To produce 10 kg milk requires 53MJ energy. So we can calculate that:

- For a 250 kg cow to produce 10 kg milk – it "costs" 93/10 = 9.3 MJ/kg (or 4.7 MJ/jin)
- For the 500 kg cow to produce 10 kg milk – it "costs" 118/10 = 11.8 MJ/kg (or 5.9 MJ/jin)

In these examples:

- The most efficient production comes from the 250 kg cow producing 10 kg of milk (9.3 MJ/kg milk).
- The large 500 kg cow producing 10 kg milk is more efficient than the 250 kg cow producing 5 kg milk BUT she is consuming almost twice the amount of nutrients (118 Vs 67 MJ).

We expect larger cows to produce more milk but that will require more energy. We can calculate that to produce 20 kg milk requires 106MJ energy. Therefore:-

- For a 250 kg cow to produce 20 kg milk – it "costs" 146/20 = 7.3 MJ/kg (or 3.7 MJ/jin)
- For the 500 kg cow to produce 20 kg milk – it "costs" 171/20 = 8.6 MJ/kg (or 4.3 MJ/jin)

Smaller cows do not usually produce as much milk as larger cows – 20 kg of milk is probably more than a 250 kg cow can produce – if she could, it would be a very efficient system. So if you want to have more output of milk, you might have to have larger cows, but this will only work if you have sufficient high quality feed to give them.

You should consider that:

- you may have to have fewer cows and feed each of them better, since you may not have enough feed to give all of them the amounts they need to be efficient
- you may have to have smaller cows that need less maintenance because you don't have enough feed to supply them

Based on the quantity and quality of the diets fed to dairy cows a combination of these two strategies seems most appropriate. This may change as systems intensify and/or additional high quality (energy and protein) feeds become available.

How much feed is required to supply the nutrients?

Feeds are composed of dry matter and moisture (water). Dry matter content is calculated by drying a sample of feed in an oven under controlled conditions. It is important to know the dry matter content of the feed because all the energy, protein, minerals and vitamins are contained in the dry matter. Water is essential for animals to live, but it has no nutritional value. A good guide to feed quality is the amount of energy (MJ/kg DM) contained in the dry matter component of the diet. The energy content of the diet is directly related to the digestibility of the feed.

Typical energy and protein contents for the major feeds used in Tibet are in the table below.

Feed type	Energy content (MJ/kg DM)	Protein content (%)
Barley and wheat grain	Very high – 12.5 to 13	10-13
Green lucerne	Good – 9-10.5	14-22
Straw	Very low – 6-7	2-3
Canola meal	Good 9.5-10.5	28-35
Brewer's grain	Good 9-10	22-25

Once we know the composition of the feed and the requirements of the cow we can calculate how much dry matter (kg) the animal needs. We can include the liveweight and milk production of the cow.

Cow liveweight (kg)	Milk production (kg/day)	Straw	50% straw: 50% grain	50% straw: 30% grain: 20% canola meal
250	0	6.15	4.2	4.3
	5	10.3	7.1	7.2
	10	14.3	9.8	10.1
500	0	10	6.8	7
	5	14.2	9.7	9.9
	10	18.2	12.4	12.8
	20	26	18	18.5

Assumes the ME contents of the diets are: Straw 6.5, straw+grain 9.5, straw+grain+canola meal 9.25

A cow cannot eat a diet totally of grain or it will get sick. She must have some "roughage" – hay or straw or other vegetable matter - in the diet as well. In Australia the maximum content of grain in the diet of a dairy cow is about 40% because the quality of the milk declines (lower fat content) when high producing cows consume more grain.

How much can cows eat?

Cows have a limit to how much feed (dry matter) they can eat. They can eat more dry matter if the quality (digestibility) is high. For high quality green feeds like lucerne, cows may eat about 3% of their liveweight. Cows in early lactation may even consume more. But if the feed is poor quality, like straw, the amount needed to supply the energy is more than the animal is able to eat, if this was the only feed in the diet. Australian cows can eat is about 1.5% of the cow's liveweight per day for feeds like wheat and barley straw. Cows in Tibet may be able to eat a higher percentage of straw than that, because of their reduced size, but not much more. Even if they could eat a higher %, that still would not supply sufficient energy. Therefore diets with a lot of straw must have some very good quality feed added to supply enough energy in the total diet.

This means that when cows are fed low quality diets then the impact is doubly bad – the low quality feed restricts how much they can eat, and even when they eat the maximum possible, it does not have enough energy to fill their needs.

Is it economic to give cows more feed ?

When considering if it is economic it is necessary to know the response you are likely to get – how many extra kg of milk - if you give extra kgs of feed or higher quality feed,

In some cases we can predict the response so we can do the mathematics to see if the value of the extra milk is greater than the cost of the extra feed. However in other cases we do not know the response, and we may have to do carefully controlled experiments first to measure the response. For example, we need to do the experiments to find out the responsiveness of the "local" Tibetan cow genotype and the various crossbreds ("improved genotypes") if we give them extra feed. The local cow has evolved in the local environment and should be better adapted than any introduced breed. So we should make sure we don't overlook that advantage. But if she has only limited potential to produce milk, even if given plenty of feed, there is need to introduce better genetics.

We don't know what are the best options yet. It is likely that a crossbred situation will be the most efficient if it can combine the advantage in adaptation of the local cow with greater genetic potential for milk production – but she must be fed properly. The local cow is naturally smaller (compared to most introduced breeds), which is an advantage by having lower maintenance cost, but this will not be enough to make her the best choice (without crossbreeding) if she cannot produce enough milk.

Working out feed budgets

Like the calculations above, we can expand that to work out the requirements for different animals over a whole year. This allows us to construct a "feed budget" – to determine the diet (mixture of different feeds) that will supply the nutrients required for the maintenance and production of the animal. An example of the nutrient (energy) requirements for a milking cow over a whole year is shown in Figure 1 below – in this example the extra cost for pregnancy is also added in, so the values are a bit higher than in the table above. From this we can work out the diet that will supply the requirements for each month of the year.

How do you choose the most suitable cows?

Firstly - "bigger" is not always "better". We have seen above that big cows have a large "cost" in maintenance alone, and if they do not produce a lot of milk they will not be very efficient users of the energy fed to them. The "ideal" efficient cow probably has a low to medium liveweight and is able to produce lots of milk.

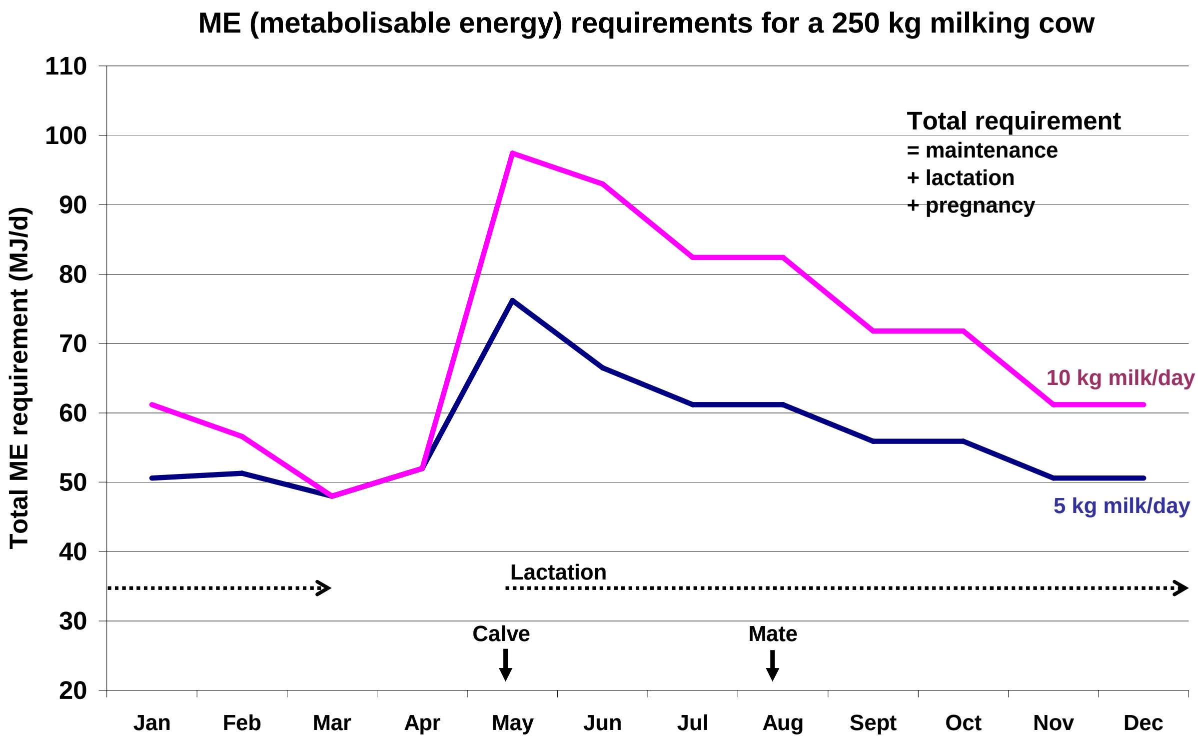
To make the most efficient use of feed, it might be better to give the same amount of feed to fewer cows. But we also need to know how much extra milk we will get by giving extra feed.

There are also other issues to consider like the quality of milk – some genotypes will produce less quantity of milk but with higher fat content and this may be better for some situations.

Another consideration is the effect of the mother's genotype on the size and growth rate of her calves.

So in choosing the most suitable types of cattle there are many considerations – each situation must be examined separately – general recommendations will often not work over a wide range of conditions

However, one thing we can be sure of that applies in general, is that when the feed is very limited (at the level of an individual farm or at the level of districts or counties), having greater numbers and bigger cattle is not good for efficient production.



Appendix Figure 2.1. Total energy requirements for each month over the year for a 250 kg cow that is producing either 5 or 10 kg milk per day at her maximum output (1 month after calving). The energy requirements for pregnancy as well as for milk production are accounted for in this example, and these are added to the requirement for maintenance to get the total requirement.

11.3 Appendix 3 – Additional data from the animal house experiment at Wagga Wagga - laboratory analyses and intake of silages fed

Appendix Table 3.1. Digestibility values for silages in the experiment at Wagga Wagga presented on an oven dry (ODM) and true (TDM) dry matter basis.

Silage #	**Type**	**Cut**	**TDM basis**			**ODM basis**		
			DMD	OMD	DOMD	DMD	OMD	DOMD
1	Barley	1	0.726	0.758	0.665	0.712	0.743	0.648
3	Barley	2	0.712	0.728	0.658	0.690	0.705	0.632
5	Barley	3	0.637	0.651	0.601	0.639	0.652	0.602
2	Oats	1	0.653	0.673	0.603	0.646	0.667	0.595
4	Oats	2	0.651	0.668	0.612	0.648	0.665	0.608
6	Oats	3	0.656	0.675	0.627	0.650	0.668	0.619

Appendix Table 3.2. Intake data for silages in the experiment at Wagga Wagga presented on an oven dry (ODM) and true (TDM) dry matter basis.

Silage #	**Type**	**Cut**	**TDM basis**		**ODM basis**		**TDM basis**		**ODM basis**	
			Total DMI	Total OMI	Total DMI	Total OMI	DMI / LWT	OMI / LWT	DMI / LWT	OMI / LWT
1	Barley	1	7.978	6.88	7.609	6.512	24.29	20.94	23.16	19.81
3	Barley	2	6.824	6.047	6.419	5.641	21.39	18.95	20.1	17.66
5	Barley	3	6.582	5.944	6.698	6.06	20.12	18.18	20.47	18.52
2	Oats	1	6.522	5.759	6.415	5.652	20.2	17.83	19.88	17.51
4	Oats	2	6.54	5.872	6.432	5.764	20.48	18.39	20.14	18.06
6	Oats	3	6.704	6.11	6.559	5.965	20.62	18.79	20.18	18.35

Appendix Table 2.3. Wet chemistry data for the six silages fed in the animal house experiment at Wagga Wagga.

Silage #	Type	Cut	pH	Fresh N TDM	AMM N%	OM	ODM	TDM	Invitro DMD	Invitro OMD	Invitro DOMD
1	Barley	1	4.633	23.55	12.61	861.4	265.3	279.6	0.684	0.760	0.655
3	Barley	2	4.473	21.77	12.93	890.1	235.5	252.5	0.654	0.709	0.631
5	Barley	3	4.8	17.24	10.17	919.7	402.6	395.2	0.612	0.655	0.602
2	Oats	1	4.75	16.69	12.94	891.5	418	424.9	0.612	0.660	0.589
4	Oats	2	4.583	17.41	10.87	909.9	401	408.3	0.619	0.667	0.606
6	Oats	3	4.808	16.14	10.15	925.3	422	416.5	0.614	0.666	0.616

11.4 Appendix 4 – Pictures of the animal house at TLRI, typical cattle and feed in the benchmark study.

The animal house facility
at TLRI

Typical “local” cow genotype

Simmental and Holstein cross
genotypes at Lhasa site

Best producing cow at
Farm 108 Bialang

Cereal straw – the main diet base
for cattle in Tibet

Brewer’s grain is a supplement
commonly used for cow diets