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Project final report

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2 Executive summary

The sustainable generation of income for small-holder farmers in the central provinces is a major development issue for Vietnam. The Quang Ngai Rural Development Program (RUDEP), through participatory planning and a national workshop determined that cattle rearing and, in particular, finishing were the most desired income generating activity by households. However, farmer and extension staff knowledge of cattle nutrition and production were major constraints. The project was designed to build local research and extension capacity and to generate information to design nutritional strategies for finishing cattle. The overall objective in Vietnam was 'To improve the profitability of finishing cattle by the development of year-round feeding strategies utilising on- and off-farm feed resources'.

The research focus in Australia was on understanding associative effects between grain supplements and grazed forage in dairy cows as a component of improving feed conversion efficiency on dairy farms. Literature reviews and the cow nutrition experiments highlighted the challenges faced in using metabolisable energy systems appropriately when providing advice to dairy farmers.

A project coordinating committee (PCC) comprised of project staff and representatives of Rural Development Program (RUDEP), the Department of Agriculture and Rural Development and the National Institute of Animal Husbandry ensured the scientific integrity and relevance of activities to the needs of stakeholders in Quang Ngai. The PCC enabled the project partners to build strong relationships with these stakeholders, and this provides a platform for future ‘out scaling’ of the technologies that were tested.

The research in Vietnam developed inventories of feeds available in Quang Ngai, a database of their nutritive characteristics, and provided local supplementary feeding response data that are valuable for predicting LW gain to feeding options and for estimating likely profitability. The responses were consistent with known principles of ruminant nutrition, and future research could investigate reducing the amount of protein in formulated concentrates as a means of containing feed costs.

The participatory on-farm research activities confirmed that the concentrate feeding options developed and tested could be applied in rural households, were more profitable than existing feeding systems, and were well received by farmers. The participatory approach provided an effective model for achieving adoption and understanding the complex farmer/service provider interface, which is often a barrier to technology transfer. The approach also enhanced the relationships between cattle producers and service providers in the target commune.

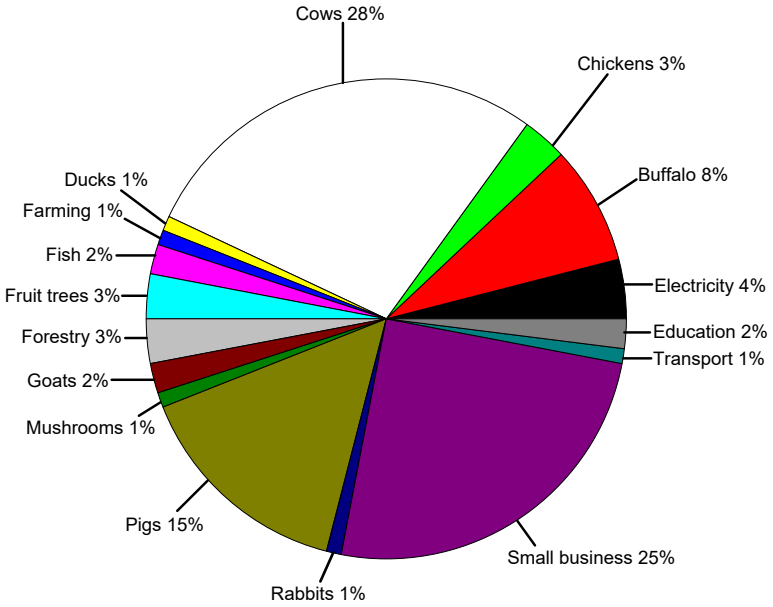
The planned capacity development was achieved through a combination of formal training activities and on-the job learning. A number of scientific journal and conference papers have been produced and the project has contributed to 5 post graduate degrees in Hue University. The infrastructure investment and technical training provide a sound base for future livestock research in central Vietnam.

As this was a category 2 ACIAR project, farm-level impacts have largely been limited to farmer participants in project activities and their immediate neighbours. To capture the benefits of the research achievements requires continuation of the cattle production programs commenced by RUDEP in Quang Ngai, and ‘out scaling’ through new activities in other central provinces. The knowledge and skills of extension staff and farmers remains a major challenge to improved cattle production in this region of Vietnam and there is a need to make generated information more readily and more widely available.

3 Background

The sustainable generation of income for small-holder farmers in Quang Ngai Province and other central provinces is a major development issue for Vietnam. A participatory problem solving census conducted by the Quang Ngai Rural Development Program (RUDEP), which is funded jointly by the Vietnamese and Australian Governments, indicated that cattle rearing and finishing (Fig. 1) was the most desired income generating activity by households and was considered to offer significant market potential and, hence, social stability in both lowland and highland zones in the province. The national workshop 'Livestock income generation for the rural poor' sponsored by RUDEP and ACIAR, held in February 2003, confirmed this analysis.

Figure 1. Requested activities as a percentage of total activities from Problem Solving meetings in a lowland commune (from RUDEP - Phase 1).



This investment opportunity arose from ACIAR's involvement in the RUDEP workshop, the household priority setting analysis conducted in Phase 1 of RUDEP, and it has drawn and built upon the knowledge and capacity developed in project AS2/1997/018 'Profitable beef cattle development in Vietnam'. The strategic linkage to RUDEP and the Quang Ngai Department of Agriculture and Rural Development (DARD) through a project coordinating committee (PCC) has provided a conduit for the flow of information from this project and previous ACIAR investments to farmers, for information to flow back to the research team, and the sustainability of development and extension activities post-project.

In 2000, there were 224,000 cattle in Quang Ngai Province, with the majority of these in lowland Districts. Cattle numbers increased by over 12% between 1996 and 2000, with growth fuelled by strong beef prices in the main cities and increases in consumption of beef throughout Vietnam. In 2006, there were 285,000 cattle in the province, with most kept in small households (Department of Agriculture and Rural Development of Quang Ngai, 2006). The cattle/beef marketing system appears to work well, and cattle fattening is considered highly appropriate in Quang Ngai and neighbouring Provinces. However, the primary constraints to further development identified by RUDEP were access to credit and limited farmer knowledge of cattle nutrition, production and health. This project was designed to build local research and extension capacity and to generate information to overcome the nutrition and production constraints to cattle production. The RUDEP has other programs that address the credit and animal health issues.

Preliminary analysis indicated that cattle fattening in Quang Ngai had attractive returns to labour, but input costs needed careful management to ensure profitability. It was also considered that technologies for cattle finishing were, in the short to medium term, more likely to be implemented in lowland farming systems based on resource availability and market orientation of farmers, which contrasted with sociological and educational constraints in highland areas. Hence, the project target audience was lowland farmers, although it was envisaged relevant information would flow to the upland areas through RUDEP activities.

The project research in Vietnam was designed to develop strategic and tactical feeding options that utilise on-farm resources, such as rice straw, forages and crop by-products, along with on- and off-farm energy and protein supplements. Recommendations on supplement use would take account of market fluctuations in availability and cost of off-farm feeds, and the effects of substitution of supplements for the basal forages.

In Australia, the dairy industry, based on intensive grazing of pastures with increasing use of supplements imported onto farms, was and is under increasing pressure from declining terms of trade at farm level. Feed costs on farms amount to 40 to 65% of total costs, and feed conversion efficiency is a primary determinant of profitability. Hence, the industry depends on optimum conversion of pasture, conserved forage and brought in supplements into milk to remain competitive, and feed remains the largest and most easily manipulated component of the variable costs of production.

Dairy farmers frequently comment that milk production from supplementary feeding strategies is less than predicted by those providing advice. Within pasture-based dairy systems, substitution of supplements for grazed herbage explains part of the reason for this phenomenon. Substitution in these systems is relatively well understood and can be predicted from information on pasture allowance, amount and type of supplement fed and cow production. However, it is not the only reason for lower than expected production responses to supplementary feeding. Negative associative effects between concentrate supplements and grazed herbage are also likely to occur, where the digestibility of the diet is lower than the value calculated from in vitro digestibility and amounts of the individual components comprising the diet. This means that the estimates of metabolisable energy (ME) content of the diet used by nutrition advisers exceeds the ME actually obtained by the animals.

The Australian dairy industry has had increasing concerns that the nutrient requirements of high producing cows cannot be met from grazing systems, as evidenced by poor reproductive performance and increasing incidence of metabolic disorders (see Fulkerson et al. 2000), but it has no quantitative information on the magnitude of associative effects between feeds on the ME available to cows. As an indicator of the economic importance of this issue, a decline of 10% in estimated ME of the forage or concentrate components of the diet would equate to a decline in operating profit of A$23,000/annum in a 240 cow herd (Doyle et al. 2002). If an improved understanding of associative effects led to feeding systems that halved the depression in ME, the value to the Victoria industry is estimated at A$41 million/year.

The research objectives in Vietnam and Australia were similar, namely optimising feed utilisation to improve farm profitability. However, in Vietnam the focus was on improved systems of finishing locally available cattle (mature live weight 250 to 350 kg) in confinement systems based on feeding of low digestibility forages. In contrast, the focus in Australia was on intensive dairy systems (with high producing cows, live weight >500 kg) based on grazing of high digestibility pastures. They represent extremes in cattle production systems, but similar nutrition principles apply.

4 Objectives

The overall objective of the project was:

To improve the profitability of finishing cattle by the development of year-round feeding strategies utilising on- and off-farm feed resources.

There were five Activities in the project with the following objectives:

1. Establish a project coordinating committee that monitored progress of the stated objectives and milestones, and alignment of project activities with the needs of RUDEP and Quang Ngai DARD.
2. Develop an inventory of feeds available in the lowland areas of Quang Ngai, both on- and off-farm, including their nutritive characteristics and design possible year round feed options.
3. Conduct on-station experiments to optimise the use of feed resources for productivity and profitability (Vietnam and Australia). The research in Vietnam was to establish production responses to different feeding strategies, while that in Australia was to quantify associative effects between forages and concentrates.
4. Conduct on-farm trials to evaluate the production/productivity responses, economics and social implications of feeding strategies in collaboration with RUDEP and DARD. The effectiveness of the farmer/extension service provider interface was also studied during this Activity.
5. Develop the knowledge and technical skills of scientists and extension staff in Vietnam and Australia.

5 Methodology

5.1 Activity 1 – Project Coordinating Committee (PCC)

The PCC was established and terms of reference and roles agreed as the first step in implementation of the project. The committee comprised Dr Peter Doyle (DPI; Project Leader, Australia), Prof Le Duc Ngoan (HUAF; Project Leader, Vietnam), Dr Nguyen Xuan Ba (Operational Team Leader, HUAF), Eng. Cao Hoi (Quang Ngai DARD), Trevor Ole (RUDEP) and Dr Vu Chi Cuong (NIAH). Mark Hoey, RUDEP, and Dr Dinh Van Tuyen, NIAH, attended some meetings as proxies. Vu Chi Cuong (or his proxy), NIAH, provided expertise in experimental design and brought to the project a direct link to ACIAR project AS2/1997/018. Ms Clare Leddin (DPI) and Dr Nguyen Huu Van (HUAF) attended meetings as required to present progress reports and Ms Leddin recorded minutes.

The terms of reference for the PCC were to:

- Monitor progress against the stated objectives and milestones
- Monitor alignment of project activities with the needs of RUDEP and DARD
- When appropriate, provide knowledge, experience and direction to the work undertaken in project activities 2 to 5
- Assist in the development and monitoring of a communication strategy for dissemination of project results
- Provide mentoring and guidance to the project team
- When appropriate, comment on reports and outputs to ensure they were compatible with end-user needs

- This approach, and its inherent flexibility, was considered most appropriate for delivery of the project outputs, and to foster the strategic linkages to RUDEP and DARD.

The PCC met 6 times: 22nd April 2004 in Quang Ngai; 3rd September 2004 in Hue; 17th July 2005 in Kyabram; 21st November 2005 in Hue; 31st May 2006 in Quang Binh; and 7th November 2006 in Quang Ngai. Members of the PCC also met with the ACIAR review team in April 2007. Key stakeholders from ACIAR, HUAF, the Ministry of Agriculture and Rural Development, Vietnam and the Ministry of Education and Training, Vietnam were invited to, and participated in, some of the meetings.

The project leaders worked with project staff to develop and document processes for protocols for all work or experiments undertaken, and for peer review of reports and publications. The protocols formed the basis of presentations to the PCC before work commenced and reports on each activity were presented to this group.

The PCC developed communication and evaluation plans for the project to ensure all stakeholders were informed of findings and to monitor progress against the project objectives. At the May 2006 meeting, all project research and communication activities were reviewed and plans for activities in 2006-07 finalised.

In November 2006, progress in Activities 2, 3 and 4 was reviewed and priorities for the remainder of the project until June 2007 agreed. In addition, a facilitated 'pair and share' session was conducted to identify and prioritise opportunities post-project.

5.2 Activity 2 – Develop an inventory of feeds available in Quang Ngai, both on- and off-farm, including their nutritive characteristics and design possible year round feed options

The first component of this Activity, developing an inventory of feeds available for cattle production, was conducted in Quang Ngai. Knowledge of the seasonal availability and nutritive characteristics of feeds is integral to the formulation of strategic (year round) and tactical (shorter term) feeding strategies to finish cattle for market. The objectives of this component were to:

- Compile an inventory of available forages used in lowland cattle production systems in Quang Ngai.
- Develop an inventory of feed resources for cattle production at a provincial scale.

To meet the needs of RUDEP, an inventory was also developed for highland communes in two districts.

Information on availability of feeds at provincial scale was compiled from provincial statistics, information from RUDEP, and other relevant sources. At the commune scale, surveys of 60 households were undertaken in each of four communes, namely Hanh Phuoc and Binh Minh in the Nghia Hanh and Binh Son lowland districts, and Nghia Tho and Son Trung in Tu Nghia and Son Ha highland districts. Information collected on seasonal cropping and feeding practices was compared with cropping calendars developed by RUDEP and used with statistical information on crop production to estimate seasonal availability of feed resources. This provided a qualitative picture of the feeds available on a monthly basis.

Interviews with factory staff and stakeholders were used to estimate the amounts of by-products generated by the sugar, cassava processing and milk factories, the current use of these resources, and constraints to their use in local cattle production in Quang Ngai.

Mark Hoey and Bede Evans, RUDEP provided significant inputs into the design of the surveys, selection of locations and reporting the inventories. Five HUAF staff (Nguyen Xuan Ba, Nguyen Tien Von, Le Van Phuoc, Ho Trung Thong and Nguyen Huu Van) and six Quang Ngai DARD staff (Cao Hoi, Nguyen Huu Nguyen, Ngo Huu Ha, Trinh Luong Thom, Nguyen Van Nam, To Ngoc Tan) conducted the surveys and were involved in the reporting.

The second component involved compilation of information on the nutritive characteristics of feeds. This was a desk-top exercise conducted primarily at HUAF with inputs from the Department of Primary Industries (DPI), Victoria. The objectives were to:

- Compile available data on the nutritive characteristics and feeding value of available forages used in lowland cattle production systems in Quang Ngai.
- Compile available data on the nutritive characteristics of off-farm feed resources available for lowland cattle production systems in Quang Ngai.

There was virtually no information on the nutritive characteristics of feed resources specific to Quang Ngai. Hence, accessible information on the nutritive characteristics of forages in central Vietnam was compiled into spreadsheets. This information was supplemented with published (Chinh *et al.* 2001; Pozy *et al.* 2002) data from Vietnam, and comparisons made with information in the international literature.

Information was compiled into spreadsheets by feed category, feed type within a category, location, time and source of data. The feed categories were:

- forages (native and sown grasses, crop residues and forage from crops)
- tree forages (leaves and edible parts of trees and shrubs)
- on-farm supplements (energy or protein supplements or by-products from processing of crops on-farm)
- off-farm supplements (energy or protein supplements or by-products from processing in factories or mills)

Nutritive characteristics included crude protein and neutral detergent fibre (NDF) concentrations, *in vitro* digestibility and estimated ME, proximate components, and calcium and phosphorus. Metabolisable energy was estimated from total digestible nutrients (Chinh *et al.* 2001) or *in vitro* digestibility (Standing Committee on Agriculture 1990). Where available, the database contains information on location, season and source of data, and any important points on harvesting and storage.

Information from analyses conducted in subsequent activities, and from recent publications, was added to the database throughout the project.

The objective of the third component was to:

Develop a range of feeding options for different times of the year based on the inventory of feeds and the database of nutritive characteristics of feeds.

The initial plan was to modify the approach to examining year round feeding options in China developed by John Nolan and Evan Thompson, University of New England, as part of ACIAR Project AS2/1998/035. The model was developed to estimate the amount of pasture available on a monthly basis, and used data from experiments conducted in China to estimate digestible dry matter requirements for maintenance and growth. The main purpose was to illustrate to scientists and extension staff in China differences in the nutritive value of different feeds and requirements for energy and protein to achieve desired levels of production. The model certainly fulfilled this role, but as it was not a key

output of Project AS2/1998/035, and all relationships in the model were not fully described or documented.

To examine potential to use this spreadsheet model in central Vietnam, Nguyen Xuan Ba visited Bevan Robertson, CSIRO Rockhampton, early in the project to become familiar with the approach and modelling. As the model was not fully documented and the user interface was not friendly, it was hard for him to see the value of the model. Hence, using this approach proved more difficult than originally thought. The work schedule was adjusted for Clare Leddin to visit the University of New England team and to modify the model for use in Vietnam, as there were clear differences in the production systems in China compared with central Vietnam. This was done in consultation with John Nolan.

The LPS/2002/078 PCC strongly endorsed further development and testing of the 'Feed Year' model for central Vietnam. Hence, in September 2006, Peter Doyle and Clare Leddin spent time with John Nolan and Evan Thomson to discuss the modifications that had been made in a Vietnam Version of the model, and to better understand the origins of some of the relationships in the program. However, the challenges encountered meant this work was not completed according to the project schedule.

Tactical feeding options were developed assuming cattle kept in confinement systems would be fed a basal diet of grass and straw with the primary supplements being readily digestible energy feeds available at the farm, namely cassava powder, maize and rice bran. Desk-top analysis was used to define feeding options using information on the nutritive characteristics of feeds and animal requirements. Some options were tested in Activity 3.

5.3 Activity 3 – Conduct controlled experiments to optimise use of feed resources for productivity and profitability

5.3.1 Vietnam

The on-station experiments conducted at HUAF were to establish live weight (LW) gain responses in growing cattle to different feeding strategies developed in Activity 2 and to provide an understanding of the basis of these responses.

Three major experiments were conducted in the animal house constructed at HUAF as part of the project. These experiments were designed based on the feed resources inventory which showed that in the lowlands in Quang Ngai, most cattle graze native grasses during the day and are fed rice straw when tethered or housed for most months throughout the year. However, in confinement feeding systems, cut and carry native grass or sown grass is fed during the day, with rice straw given at night. The most common supplements used by farmers in Quang Ngai are cassava powder, rice bran and maize, but amounts fed are only about 1 kg/day irrespective of the age, LW or condition of animals and they were seldom mixed. The amount fed also varies markedly between days.

Experiment 1

The hypothesis of the first of these experiments was that supplementation with cassava powder (and urea) up to 2% LW/day would linearly increase digestible organic matter intake and LW gain of Laisind cattle. It involved 20 Laisind bulls assigned to the following treatments: a basal diet of elephant grass (Pennisetum purpureum) fed at 1.25% LW (dry matter (DM) basis) during the day and rice straw fed ad libitum at night, or this diet supplemented with cassava powder, containing 2% urea, at about 0.3, 0.7, 1.3 or 2.0% LW (DM basis). The five diets were fed for 88 days.

The Laisind bulls were 164 (+ 19.1) kg LW and about 15 to 18 months of age.

Experiments 2 and 3

The hypothesis tested in the second and third experiments was that supplementation with a formulated concentrate comprised of rice bran (45% fresh basis), maize (49%), fish meal (3%), urea (2%) and salt (1%) up to 2% LW/day would linearly increase digestible organic matter intake and LW gain of Vietnamese yellow cattle. In experiment 2, 20 male yellow cattle were used with treatments lasting 44 days, while in the third experiment 15 yellow cattle were used and treatments were imposed for 49 days. The basal diet (control) was fresh grass (experiment 2 elephant grass; experiment 3 native grass) at 1.25% of LW (DM basis) fed between 0730 and 1800 h, and rice straw at 25 to 50% above the previous days intake from 1830 to 0700 h. Other treatments were the basal diet plus concentrate at about 0.3%, 0.7%, 1.3% or 2.0% of LW (DM basis) of concentrate.

The yellow cattle used in experiment 2 were 116 (+ 12.3) kg LW and about 12 to 15 months of age, while those in experiment 3 were 142 (+ 15.7) kg LW and about 14 to 17 months old.

In all experiments, feed intake was recorded daily, LW measured weekly and digestibility measurements made by quantitatively collecting faeces by hand immediately as or after an animal defaecated over 7 day periods. The faeces collected each day were thoroughly mixed and sub-samples taken for DM determination. Sub-samples of the feeds offered, feed residues, faeces and urine were analysed by standard procedures. Substitution, the reduction in forage intake that occured for each kilogram of supplement DM consumed, was calculated in each experiment.

Experiment 4

Two other feeding experiments were conducted, the first to commission the feeding facility. It involved a study of ensilage and use of industrial cassava bagasse as a supplement in Laisind cattle rations based on rice straw. Cassava bagasse was ensiled in plastic bags for up to 42 days with three additives used, namely rice bran 3% + salt 0.5% (w/w), molasses 3% + salt 0.5%, or salt 0.5%. Changes in the pH and hydrogen cyanide concentration in all silages were monitored over 42 days. It was concluded that cassava bagasse waste from factories could be ensiled and stored for use in feeding cattle on small holder farms in central Vietnam.

A feeding experiment was then conducted to test the hypothesis that growth rates of cattle given cassava bagasse silage in place of cassava powder and rice bran would not be reduced. The Laisind cattle, 12-15 months old with an average LW of 152 kg (± 15.4 kg), were fed rice straw ad libitum, and 1 of 4 supplements, namely: T1, 1 kg DM of a 50:50 cassava powder and rice bran mixture; T2, 0.5 kg DM/day T1 and 0.5 kg DM/day cassava bagasse silage; T3, 0.25 kg DM/day T1 and 0.75 kg DM/day cassava bagasse silage; and T4, 0.9 kg DM/day cassava bagasse silage and 0.1 kg DM/day soybean powder. All bulls were given 50 g urea/day in the concentrate supplement.

Methods used to measure feed intake, digestibility of dietary components and LW were as described above.

Experiment 5

The fifth and final experiment, ‘Fattening Laisind cattle on diets containing cassava bagasse silage’ compared LW gain of Laisind cattle when fed roughage and concentrate diets containing different proportions of cassava bagasse silage. The rations comprised about 33% green forage and 66% concentrates on a DM basis, with rice straw fed ad libitum at night. The concentrate supplement in the 5 dietary treatments (T1 to T5) contained 13% groundnut cake and 2% urea, with the remainder comprising a mixture of

cassava powder (85, 64, 42.5, 21 and 0%, DM basis) and cassava bagasse silage (0, 21, 42.5, 64 and 85%). The green forage in all treatments comprised elephant grass fed at about 0.63% (DM basis) of LW during the day. Feed intake was recorded daily for 45 days, LW measured weekly and digestibility measurements made over 7 days. The effects of different proportions of cassava bagasse silage in the supplement on the intake of the forages, on digestibility, and LW change were examined using the methods described above.

More details of the methodology used in each experiment can be found in the publications listed in Section 10.

5.3.2 Australia

The research in Australia was designed to quantify associative effects between forages and concentrates in lactating Holstein Friesian cows. Associative effects occur when ruminants consume more than one feed and the effects on the rumen environment affect the digestibility of some or all of the dietary ingredients. This means that the digestible energy derived from the diet is rarely equal to that calculated from the amount of each feed consumed and its digestible energy when fed alone. This phenomenon of associative effects is a recognised side-effect of mixing feeds, but it is not often quantified or accounted for when using estimated ME values to assess whether a diet is providing the energy required for a particular level of production. Associative effects are generally negative, whereby depression in digestibility is observed, i.e. the apparent digestibility of the diet is lower than the value calculated from digestibility and amounts of individual components comprising the diet.

Initially, an extensive review of the literature, ‘Associative effects between feeds when concentrate supplements are fed to grazing dairy cows: a review of likely impacts on metabolisable energy supply’, was undertaken. Then, two metabolism experiments with lactating Holstein-Friesian cows were designed based on the review. The focus was to examine the effects of different amounts of crushed wheat on the magnitude of associative effects when cows were consuming different forages (fresh pasture versus conserved forage). Both experiments were approved by a DPI Animal Ethics Committee.

Experiment 1

The first experiment examined associative effects in lactating dairy cows fed perennial ryegrass hay and supplemented with different amounts of crushed wheat. The hypotheses were:

1. The digestibility of NDF in the rumen and whole tract would be depressed in a curvilinear manner as the amount of grain consumed increased.
2. The digestibility of starch from the grain would decline when the amount consumed exceeded 5 kg DM/cow/day (approximately 1% LW).

The experiment had 5 dietary treatments, namely: hay only offered at 3 kg DM/100 kg LW, or this diet supplemented with crushed wheat at 0.5, 0.9, 1.2 or 1.6% LW (DM basis).

There were 3-4 animals on each treatment (total of 16 animals). The cows were adapted to the feeding and management practices and then fed their allocated treatment for an introductory period of 13-days duration. Cows were fed individually throughout with hay fed 4 times each day and grain fed twice daily at milking time. Over the next 10-days, they were housed in individual stalls in a metabolism facility. During this time, total collection of faeces was undertaken to estimate whole tract digestibility, and indices of rumen fermentation and nylon bag degradability measurements were made to quantify associative effects between forage and concentrates. Rumen fluid samples were collected

to monitor diurnal patterns in ruminal volatile fatty acids, ammonia and lactate. The purpose was to examine effects on estimated ME supply to the lactating cow.

Experiment 2

This experiment examined associative effects in lactating dairy cows fed fresh Persian clover and supplemented with different amounts of crushed wheat. The hypotheses were:

1. The digestibility of dietary components (particularly NDF and starch) would become more variable between cows as grain intake increased.
2. The digestibility of NDF in the rumen and whole tract would be depressed in a curvilinear manner as the amount of grain consumed increased.
3. The digestibility of starch from crushed grain would decline when the amount consumed exceeded 3 kg DM/cow/day (approximately 0.8% LW).
4. Rumen pH would be below 6 for more than 12 hours per day for all cows and lowest in cows with the highest total intake and/or highest grain intake.

The experiment had five dietary treatments, with 3-4 animals on each treatment (total of 16 animals). In each treatment, cows were fed a base diet of Persian clover-dominant pasture (at 3.5% LW, DM basis), or this diet supplemented with crushed wheat at 0.25, 0.5, 0.75 or 1% LW (DM basis).

The timetable and procedures followed were similar to those in experiment 1. However, due to the greater nutritional stress cows were under, as evidenced by symptoms of acidosis, the cows were only able to be housed in the metabolism facility for 6 of the planned 10-day period, which meant the digestibility period was reduced to 4-days (instead of 7). After removal from the metabolism facility, the cows continued to be fed their allocated diets and were housed in an outdoor facility. Measurements and samples that could be made/collected in this environment (feed disappearance from nylon bags, feed intake, rumen pool sizes and rumen fluid samples) were completed.

5.4 Activity 4 - Understanding current cattle production systems, opportunities to improve these and testing changes to feeding practices

Within a commune, there will be significant variation between households in knowledge and experience of farmers and in resource (land, feed, cattle, labour, infrastructure, capital) availability. Therefore, opportunities to modify cattle production systems will vary between households. With this in mind, the project team, in consultation with the PCC, used information generated in Activities 2 and 3 in Vietnam, together with RUDEP and DARD experiences in livestock demonstrations, to design an on-farm study.

The first phase of the study was concerned with analysis of current production systems. A survey of cattle production systems was undertaken in Hanh Phuoc commune in Nghia Hanh (lowland district). This survey was also undertaken in Son Ha (an upland district, near a cassava factory) to meet the needs of RUDEP. These communes had previously had RUDEP cattle activity groups. The survey team included five HUAF staff (Nguyen Huu Van, Nguyen Xuan Ba, Le Van Phuoc, Du Thanh Hang and Le Duc Ngoan), an expert from the College of Economics (Dr Hoang Van Liem) and five DARD staff (Cao Hoi, Nguyen Huu Nguyen, Ngo Huu Ha, To Ngoc Tan and Do Kim Cuong). Trevor Ole and Rolfe Ellem, RUDEP, inputted into the selection of locations and interpretation.

Information (quantitative where possible) was collected on current cattle feeding and management practices, the mix of activities in the household, socio-economic aspects of these activities, opportunities the household saw for improving beef production, and the

sources of information to the household. A desk top analysis of RUDEP evaluations of past cattle raising activities was carried out to identify farmer beliefs on constraints or opportunities to improve cattle production. Two RUDEP reports, 'Evaluation of adoption of 2004-2005 demonstrations in RUDEP communes' and 'Evaluation of service provider and demonstration quality – period 04-05' were analysed to inform the design of the on-farm study and to provide information on adoption or non-adoption of technologies in RUDEP demonstrations.

The findings of the survey, previous experiences and the results of Activity 3 were used to plan the on–farm study (Phase 2). These plans involved testing changes to the current feeding systems in hamlet 17, Hanh Phuoc commune (lowlands) and a demonstration on ensiling cassava waste in Son Trung commune (highlands). This report only covers the study in Hanh Phuoc.

During recruitment for the on-farm study, extension materials produced from Activities 2 and 3, such as 'Feed resources for ruminants in small households in central Vietnam' and training manuals on cattle production, were presented in recruitment/training workshops. The material included information on types of feeds, preparation or conservation of feeds, feeding systems, and likely responses in LW gain to different feeding strategies. These training sessions included demonstrations on mixing of the concentrates and appropriate approaches to feeding. This was to explain differences between the recommended feeding approach and existing farmer practices of not mixing available concentrates, not providing protein, and feeding once daily while often varying the amount fed from day to day. Village leaders and the extension workers from the province (Mr Nguyen Huu Nguyen and Mr Do Kim Cuong) and the district (Mr Dao Trong Nga and Mr Vo Ba Tam) responsible for implementing the study participated in the seminars/training workshops. After these sessions, the proposed feeding interventions were modified in the light of farmer suggestions.

The on-farm study implemented changes to the feeding systems in 20 households in hamlet 17, Hanh Phuoc commune, commencing on 20th January 2007. Around this time, sources of advice to farmers were documented. While knowledge on cattle production among HUAF and RUDEP staff was strong, the challenge was to improve skills at the extension level and to understand the farmer/extension interface. This interface was examined in a series of group discussions with the participating farmers and extension workers from the province and district involved in Activity 4. As the extension system is complex, further assessment of the farmer/extension interface was carried out by an institutional analysis using a group meeting involving representatives of the commune peoples' committee, village leaders, farmers' union, womens' union and cattle producers. The perceived value of the advice received from different sources was also assessed.

The RUDEP and DARD suggested the collaborating farmers should to be provided with concentrate to encourage them to participate in the study. However, during the participatory planning with the farmers, they insisted on using their own cassava powder, rice bran, and maize, with the project supporting the purchase of fish meal, urea and salt. The concentrate supplement used in the on-station experiments, which comprised 49% maize, 45% rice bran, 3% fish meal, 2% urea and 1% salt, was modified based on suggestions by the farmers and extension workers to comprise cassava powder (34%), rice bran (30%), maize (30%), fish meal (3%), urea (2%), and salt (1%). Cassava powder was readily available and valued at a lower price than maize and rice bran. The amount of concentrate to be fed was decided by the farmers and varied from 0.5 to 3.0 kg/head/day depending on a household's resources. When the study commenced, there were 15 households (27 beef cattle) feeding the above mentioned concentrate, with 5 other households (9 beef cattle) feeding their usual concentrate as the control. Forages, mainly elephant grass and native grasses during the day and rice straw at night, were provided according to each farmer's practice. The objective was to demonstrate and test the

advantages of the formulated concentrate and to demonstrate the importance of giving the concentrate 2-3 times/day, particularly as the amount of concentrate supplement fed increased.

Information was collected on purchase and sale prices, feeds used by each farmer, and animals were weighed every 2 weeks.

Evaluation meetings were held with the participants after 2 weeks, 2 months and 4 months. Farmers' perceptions of animal responses, issues with technique application, whether they would adopt the new feeding approach and continue to use it were recorded.

During the on-farm study, the effectiveness of the research/extension interface was assessed through independent surveys and group discussions with 22 farmers and 4 commune and village staff.

5.5 Activity 5 - Develop the knowledge and technical skills of scientists and extension staff in Vietnam and Australia.

Capacity-development activities were planned at several levels. From a human resource perspective this included:

- Exchange visits and interaction between the team leaders in Vietnam and Australia to enhance leadership and management skills and broaden knowledge.
- Research processes, activities and travel programs were designed to build research capability in the scientists actively involved in the project.
- Formal and on-the-job training in written and oral communication were planned as the systems approach taken in the project meant a broader range of skills was needed as work went across cultural groups and across the RD&E spectrum.
- Linkages between this project and RUDEP and DARD were designed to build knowledge and linkages between those involved in R,D&E.
- Planned development of skills in support staff in both Vietnam and Australia to enable scientists to dedicate more time to scientific pursuits.
- Involvement of colleagues, post graduate and undergraduate students in project activities.

In addition, the capacity to undertake research at HUAF was to be enhanced through infrastructure development, construction of an animal house and installation of sample processing equipment.

Knowledge and technical skills of extension staff in Quang Ngai were enhanced through RUDEP funded training activities delivered by HUAF staff and through their participation in Activity 4.

6 Achievements against activities and outputs/milestones

Activity 1

no.	activity	outputs/ milestones	completion date	comments
1.1	Establish a project coordinating committee that monitored progress of the stated objectives and milestones, and alignment of project activities with the needs of RUDEP and Quang Ngai DARD.	Documented plans and accepted milestone reports.	December 2007	The PCC was established at the commencement of the project and the terms of reference agreed. This coordinating group also developed project communication and evaluation strategies. The PCC met twice each year and all members participated in the ACIAR review of the project in April 2007. The project leaders and team developed formal processes for documenting protocols for components of work within activities and for reviewing progress. This provided efficiencies in preparation of publications and in reporting on activities. Six monthly and annual progress reports listed as milestones in the project document were all delivered on time and detailed variations to the planned program included in reports. The project was extended for 6 months until December 2007, with the final report submitted.

Activity 2

no.	Activity	outputs/ milestones	completion date	Comments
2.1	Develop an inventory of feeds available in the lowland areas of Quang Ngai both on- and off-farm, including their nutritive characteristics and design possible year round feed options.	Inventory of feeds available on and off farm and documentation of how the resources are used.	November 2005	The planned desk top analysis of feed resources available to small holder lowland farms in Quang Ngai was varied to include surveys of households in two lowland and two highland communes. This was necessary to supplement the existing provincial statistics to provide the information needed for feed planning. This variation to the work plan and greater than expected difficulty in report writing delayed completion of this component. Completion of the literature review on nutritive characteristics of available feeds was delayed by the changes to work schedules. The information was compiled into spreadsheets which have been updated as new information from the project and other sources became available.

2.2		Documentation of year round feed options.	December 2007	The qualitative information from the feed resources inventory has been used to develop both tactical and strategic feeding options. The ability to implement these is dependent on the resources available to individual farmers. The ability of farmers to implement feed plans has been tested in Activity 4. However, while the 'Feed Year' model was modified for use in Vietnam, it has not been extensively tested or adopted. This was due in part to lack of resources and time for testing and the need to develop a user friendly manual and interface for the model which was outside the scope of the project.

Activity 3

no.	Activity	outputs/ milestones	completion date	Comments
3.1	Conduct on-station experiments to optimise use of feed resources for productivity and profitability (Vietnam and Australia).	Response relationships to different feeding strategies.	December 2006	Response relationships to different amounts of supplements have been derived in three experiments at HUAF. The initial plan was to conduct two experiments with results available in June 2006. Delays to Activity 2 and in approvals to use land at the HUAF farm led to a 6 month delay relative to the planned completion of this activity. In addition to these planned experiments, two other studies were conducted on the use of cassava waste, stored by ensiling, as a supplement for cattle.
3.2		Quantification of associative effects between forages and concentrates.	December 2007	An extensive literature review of implications of associative effects between feeds on ME supply to dairy cows was completed early in the project. Two experiments were then conducted at DPI Kyabram to quantify associative effects. Initially, three experiments were planned, but failure to secure dairy industry funding led to a decision to conduct two experiments with intensive monitoring of digestive processes, rather than three experiments limited to measurement of whole tract digestibility.

Activity 4

no.	activity	outputs/ milestones	completion date	Comments
4.1	Conduct on-farm trials to evaluate the production/ productivity responses, economics and social implications of feeding strategies in collaboration with RUDEP and DARD.	Evaluation of the production/ productivity responses, economics and social implications of feeding strategies.	December 2007	Planning for the on-farm study and extension activities in Vietnam occurred between June and December 2006. An in-depth survey of current systems in a lowland commune supplemented the data available from Activities 2 and 3. The field testing of feeding strategies occurred between January and June 2007. Farmers believed that using the formulated concentrate e and feeding more concentrate, increased profit and reduced the time taken to finish cattle.
4.2		Analysis of the farmer/service provider interface.		The farmer/extension interface is complex. Farmers saw banks and RUDEP as more important than information service providers as they provided credit. They also viewed different information providers differently. Confidence in staff employed by RUDEP, who had more technical training, was greater than in the district or commune ('paravet') extension staff.

Activity 5

no.	activity	outputs/ milestones	completion date	Comments
5.1	Develop the knowledge and technical skills of scientists and extension staff in Vietnam and Australia.	Publication of outputs from Activities 2 and 3 in the scientific literature and in forms suitable for extension.		The communication, evaluation and travel plans developed for the project were monitored and adjusted in accordance with progress in the other Activities. Knowledge and research skill development activities for scientists (and students and technical staff) involved both formal courses and learning-by-doing activities.
5.2		Evidence of application of skills gained and of science processes.		Evidence of the success of the knowledge and research skill development activities for scientists is evident in their successful conduct of complex studies and in the project publications. Knowledge and skill development in DARD extension staff occurred through inputs by HUAF into RUDEP training activities, competency analysis conducted by RUDEP and involvement in Activity 4. There was also considerable use of project information by HUAF staff conducting in-service training activities for extension staff in other central provinces and in the intensive training delivered in ACIAR project LPS/2004/073 in Dong Giang.

7 Key results and discussion

7.1 Activity 1 – Project Coordinating Committee (PCC)

The PCC brought a rich mix of experiences, knowledge and perspectives to the project. It was essential to alignment of project activities with the needs of RUDEP and DARD, with all project activity plans and results discussed at meetings. However, alignment was also ensured outside this forum by obtaining inputs into the design and interpretation of the R,D&E in Activities 2, 3 and 4 through face to face discussions with key RUDEP and DARD staff. For example, the survey activities conducted in communes in Quang Ngai in Activities 2 and 4 involved HUAF, DARD and RUDEP staff. In addition, these Activities were conducted in both lowland (the focus of LPS/2002/078) and highland communes to meet the needs of RUDEP, whose major focus was on the very poor. These strategic linkages to both RUDEP and DARD have led to much greater cooperation between HUAF and these groups in Quang Ngai, including outside this project. However, it should be noted that while the PCC was essential in ensuring alignment, the different objectives of the stakeholders involved and the complexity of implementing changes in agricultural systems in Vietnam, at times presented significant challenges for all involved.

A significant benefit to Project LPS/2002/078 was the conduct by RUDEP of a broad range of knowledge and skill development activities with staff in Quang Ngai DARD as well as district extension staff. Project staff and others from HUAF were actively involved in these activities, in particular those concerned with livestock. The outputs of RUDEP activities, for example cropping calendars and evaluations of demonstration activities, were also used in designing LPS/2002/078 activities.

A second strategic linkage has been with ACIAR Project LPS/2004/073, ‘Capacity building in cattle production in Dong Giang District, Quang Nam Province’. This project is a component of the World Vision Vietnam Area Development Program that has been implemented in P’Rao Town and 9 of the 10 communes in Dong Giang. Its focus has been on capacity development to augment the World Vision activities on income generation from cattle production. Nguyen Xuan Ba and other HUAF staff provide training and consultancy inputs into the ACIAR component, the objectives of which are:

- To build the capacity of the project participants in project management skills, especially at the level of commune and village staff.
- To improve the capacity of the rural people and of the extension staff in cattle production.
- Monitor, evaluate, document and report on the effectiveness of capacity development activities.

The resources available and timeframe of LPS/2002/078 has limited the amount of time spent at the adoption end of the R,D&E spectrum and, therefore, on-farm impact. Most impact at farm level to this point in time has occurred with farmers participating in Activity 4 and their immediate neighbours. However, the strategic linkages have enabled extensive inputs into the skill development of extension staff, which provides a basis on which to continue extension of project information post-project.

A key to successful completion of research activities has been the early establishment of documented protocols for each activity/experiment, which delivered efficiencies in preparing publications and reports. The inevitable challenges imposed on the research program by unforeseen events, such as inclement weather, animal health issues, the complexity in gaining necessary approvals for infrastructure development, and in engaging farmers and extension staff, were successfully managed by maintaining records

and updating these protocols. Regular discussion and review were essential to completion of activities, and for publication in the scientific and extension media.

7.2 Activity 2 – Develop an inventory of feeds available in Quang Ngai, both on- and off-farm, including their nutritive characteristics and design possible year round feed options

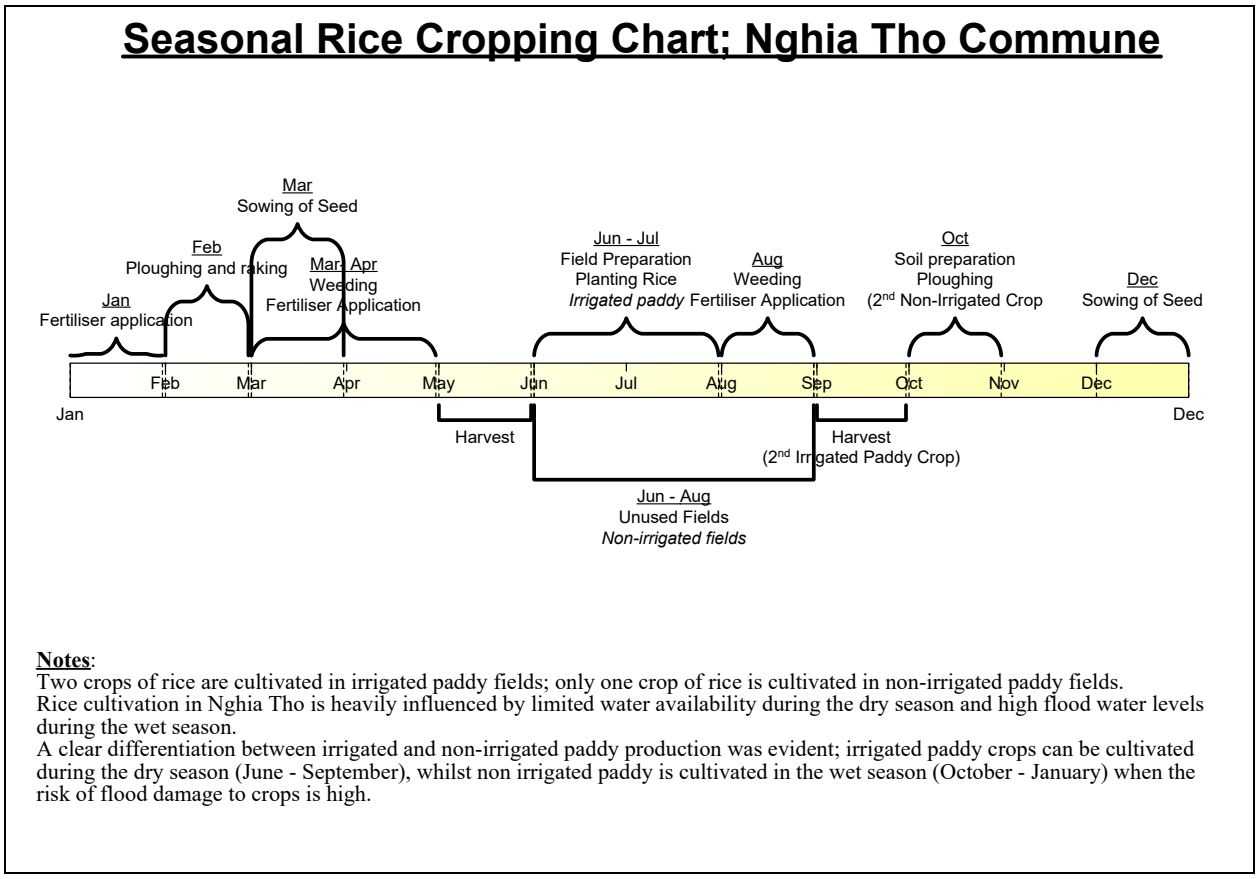
7.2.1 Feed resources inventory

Effective feed planning for strategic or tactical feeding of cattle to improve farm profitability requires knowledge of the seasonal availability of local forages and supplements. This concept is well understood in livestock systems in developed countries, but was less well understood and did not appear to be applied in central Vietnam. Prior to this study, there had been no analysis of the feed resources available to farmers in Quang Ngai to establish the feasibility of different combinations of feeds.

Cropping charts (see Fig. 2 for an example) developed by RUDEP to compile seasonal availability calendars specific to lowland and highland communes were used in conjunction with the surveys conducted in this project to establish possible feeding systems.

Native grass and rice straw were the major feeds in the lowlands (Table 1; Ba et al. 2005a), where cattle were generally allowed to graze native grass areas freely or were ‘controlled’ while grazing along paddy bunds, channels and roads. ‘Cut and carry’ grass was also important, particularly where animals were kept in confinement. More than 60% of interviewed households in Hanh Phuoc indicated their cattle were usually provided with cut-and-carry grass, with sown elephant grass important as a green feed supplement in many households.

Figure 2. Example of a seasonal rice cropping chart for Nghia Tho Commune.



The diversity of forages used by farmers on the lowlands was much greater than in the highlands (Table 1) because of the intensity of agriculture. Crop by-products such as sweet potato vine, corn stover or parts, sugarcane tops and leaf, groundnut vine and banana stalks were also used as feed for cattle. However, they were not as plentiful as native grass and straw, were seasonal in availability, and rarely stored.

Table 1. Calendars of availability of feeds in Hanh Phuoc (plains) and Nghia Tho (highland)

Feed	Jan - Mar		Apr - June		July - Sept		Oct – Dec	
	Plains	High	Plains	High	Plains	High	Plains	High
Grazed native grass	+++	++++	+++	+++	+++	++	++	++
Fed sown grass	++		++		++		++	
Fed native grass	+	+			++		++	+
Rice straw	+++	++	+++	++	++++	+	++++	++
Sweet - potato vine	+							
Maize stover	++	+	++	+	++	++	+	
Groundnut vine	+		++	+	++			
Banana stalk	++		++		++		++	
Sugarcane tops	+++	+++	++	++				
Fodder tree leaf	+		+		+		+	

[1]++++ = high availability; +++ = good availability; ++ = average availability; + = limited availability

In highland areas, extensive grazing of native grasses predominated with little supplementary feeding. Rice straw was not as available and less used in highland areas and sown grass was rare. In both zones, the vegetation cover in native grass areas was very poor because of infertile soils and over-grazing. This meant that grazing ruminants expended considerable energy in walking, particularly in the steep terrain of the highlands, and in grazing.

On an annual basis, it was estimated there would be about 380,000 t DM of rice straw, 36,000 t DM sugarcane tops, 43,000 t DM corn stover and 10,000 t DM ground nut vine available in the province. However, there are constraints to increased use of these resources. For example, with rice straw, constraints included labour availability and weather at harvest, particularly in September/October.

The major supplements available and used in the lowlands were cassava powder, rice bran and maize. However, even in confinement feeding systems, only limited amounts of supplements (usually 1 kg/day or less) produced on farm were fed to cattle. There was no consistency in feeding the supplement, with the amount offered varying from day to day. In addition, the available concentrates were rarely mixed.

Importantly, by-products from factories, such as molasses, cassava waste and brewer's grain, were generally too expensive or not available to farmers because of competing uses, including export to other provinces.

The survey work confirmed that changes to the systems of cattle production are more likely to be implemented in the lowlands, compared with the highlands, of Quang Ngai, due to resource availability and market orientation of farmers in these areas.

7.2.2 Nutritive characteristics of feeds

There was virtually no information available on feeds from Quang Ngai and little information from central Vietnam. As routine analysis at farm level is impractical, a database of nutritive characteristics for crop by-products was developed from published information to illustrate differences between feeds and the variability within a feed type (see Appendix 1). Understanding the variation that exists is important in formulating feeding systems and explaining variation in livestock production to different strategies.

Considerable variation exists in the published values for crude protein and NDF concentrations within forages (Table 2; Ba et al. 2005b). As an example, the nutritive characteristics of rice straws varied considerably, and Khang and Dan (2001) indicated this may be due to differences between locations, seasons and years, between cultivars, and with the timing and method of harvesting. Even greater variation in the nutritive characteristics of rice straw can be found in the international literature (Doyle et al. 1986).

Table 2. Crude protein and neutral detergent fibre concentrations of crop residues in Vietnam.

Feed	Crude protein (%DM)				Neutral Detergent Fibre (%DM)			
	n	Mean	St Dev	Range	n	Mean	St Dev	Range
Rice straw	22	5.1	1.04	3.3 - 7.4	6	70	3.8	63 – 73
Maize stover	17	6.8	2.83	0.9 - 13.0	12	66	4.8	59 - 72
Sugarcane tops	11	3.6	3.15	0.8 - 8.6	5	65	12.0	47 - 77
Cassava leaves	5	26.5	3.71	20.5 - 30.4	-	-	-	-
Groundnut vine	8	16.1	3.51	8.5 - 19.3	-	-	-	-

There was only limited information on total digestible nutrient values and *in vitro* digestibility of forages in Vietnam and, therefore, there were limited estimates of the ME content of these feeds. Doyle *et al.* (1986) have reported a significant range in the digestibility (*in vitro* organic matter digestibilities of 30 to 55%) of rice straws, leading to considerable variation in intake and estimated ME content. Similar variation occurs in the nutritive characteristics of the other forages, which affects responses to supplementary feeding and, consequently, livestock production.

The database includes a considerable amount of published Vietnamese data on forages (native and sown grasses, crop residues and forage from crops), tree forages (leaves and edible parts of trees and shrubs) and supplements (energy or protein supplements or by-products from processing of crops), but it is not complete. Additional data would likely be available from the laboratories of NIAH, Hanoi and the Institute for Agricultural Sciences, Ho Chi Minh. It would be useful to consolidate the information into a national database that is maintained over time.

7.2.3 Designing feeding strategies

From information collected in the inventory and review of information on nutritive characteristics, it was concluded that green forage and rice straw were most likely to form the basal diet in confinement systems of finishing cattle. It was estimated that a basal diet of green grass offered at about 1.25% LW (DM basis) and rice straw fed ad libitum should usually provide maintenance energy requirements and, depending on the digestibility and crude protein concentration of the grass, might support growth rates between 0 and 200 g/day. The reason for restricting grass allocation was the limited areas sown to elephant grass, and labour and availability constraints with harvesting native grass. In consultation with RUDEP and DARD staff, feeding experiments based on the use of cassava powder or rice bran and maize supplements were designed. The treatments used in these experiments were modelled using the Cornell Net Carbohydrate and Protein System model. The purpose was to design supplementation strategies that overcame the constraints inherent in the basal diet, namely low and variable digestibility, high NDF and variable crude protein concentration.

The ‘Feed Year’ model from ACIAR project AS2/1998/035 was adapted for use in Vietnam, but this was undertaken primarily by DPI staff, notably Clare Leddin, in consultation with John Nolan and his colleagues. Some key challenges remain in ensuring the utility of the ‘Feed Year’ model in central Vietnam. These include:

- Creation of a user’s manual that documents the functions in the model and a user-friendly interface that is flexible enough to be applied in a range of situations. These are necessary to give the Vietnamese scientists the confidence to use the model and promote it to extension staff.
- Training Vietnamese scientists and extension service providers in the applications and use of the program to enable them to gain confidence.
- Activity 2 provided qualitative measures of the monthly availability of various feeds in feed calendars, but the resources available to different households vary markedly depending on their cropping activities, land area and crop production practices. The challenge remains for those providing advice to have quantitative estimates of the different feeds available at the level of individual households. This is crucial to decisions on how many animals or groups of animals to finish, in setting target growth rates and in managing risk.
- It would also be useful to re-configure the model to predict cattle growth rates and to compare predictions with experimental and field data, but this would be a significant undertaking.

7.3 Activity 3 – Conduct controlled experiments to optimise use of feed resources for productivity and profitability

7.3.1 Vietnam

Experiments 1, 2 and 3

Feeds

The crude protein concentrations in the elephant grass and native grass (Table 3) were lower than the average value in the nutritive characteristics database, while the NDF concentrations were higher than average values from the Vietnamese literature. The rice straws had similar crude protein concentrations to the average in the database, while the NDF concentrations were at the high end of the range. The basal diet used for cattle in central Vietnam is generally rice straw supplemented with green forage from grazed native grass (Ba et al. 2005a). In cattle finishing systems in the lowlands there is a shift to confinement systems, with sown grasses being used as supplements to rice straw. The effect of adding green forage supplements, like elephant grass, to straw diets is to increase ME intake (Elliott and McMeniman 1987). In these experiments, the amount of grass fed was restricted to 1.25% LW to reflect limited availability of such feeds. The ratio of digestible organic matter to crude protein in the basal diets was 6.3 (experiment 1), 6.8 (experiment 2) and 5.2 (experiment 3). Hogan (1982) concluded that microbial activity in ruminants consuming forage diets was only likely to be limited by ammonia when the digestible organic matter to crude protein ratio was 10:1 or more. Hence, forage intake on the basal diets was reasonable, and they supported growth rates of over 0.1 kg/day. This type of diet is appropriate for maintenance of breeding cattle, but requires supplementation with ME and protein to achieve reasonable growth rates in finishing systems or in growing animals.

Table 3. Crude protein and neutral detergent fibre concentrations in the elephant grass, native grass and rice straws used in experiments 1, 2 and 3.

Experiment	Grass			Rice straw		
	1	2	3	1	2	3
Crude protein (% DM)	10.8	8.1	11.1	5.1	5.2	5.2
Neutral detergent fibre (% DM)	72	82	73	77	84	79

Cassava powder has starch concentrations greater than 80% DM (Vearasilp and Mikled 2001), and the digestibility of starch from cassava tubers is high, about 99% (Tudor and Norton 1982). Thus, at higher intakes, rapid fermentation of this supplement may lead to sub-acute rumen acidosis. The cassava powder used in experiment 1 contained only 1.7% DM crude protein, 8% DM NDF, and 37 mg hydrogen cyanide/kg DM. The crude protein concentration increased to 8.3% DM with the addition of urea. As reported below, there were issues with acceptability of high amounts of this supplement, and digestibility of NDF was impaired. High levels of rapidly degradable starch in cassava powder are more likely to cause intensive production of lactate and rapid reduction in ruminal fluid pH compared with feeds containing slowly degradable, crystalline starches, such as maize (Opatpatanakit 1994). Hence, for experiments 2 and 3, a formulated concentrate based on maize and rice bran was used. It had crude protein and NDF concentrations of 17 and 33% DM, respectively. Within the cereal grains, rates of *in vitro* fermentation rank as wheat > triticale > oats > barley > maize > rice and sorghum (Opatpatanakit *et al.* 1994), and wheat and barley inhibit NDF digestion *in vitro* to a greater extent than maize (Opatpatanakit *et al.* 1995). Hence, the formulated concentrate would be less likely to cause inefficiencies in rumen digestion or dysfunction.

Intake and digestion

The cattle fed cassava powder at about 2.0% LW in experiment 1 did not consume all of the supplement, with their actual intake being similar (2.21 versus 2.16 kg DM/day) to the 1.3% LW treatment. This may have been due to a number of factors, such as palatability, sub-clinical effects of hydrogen cyanide or the effects of the cassava powder on rumen pH and NDF digestibility, which have been discussed by Ba et al. (2007b). There were no issues with intake of the formulated concentrate in experiments 2 and 3.

Increasing cassava powder intake was associated with curvilinear increases in total DM intake and digestible organic matter intake (Fig. 3), while the intake of rice straw declined curvilinearly. Substitution rate of cassava powder for forage was high (between 0.5 and 0.7 kg reduction in forage DM intake/kg DM supplement consumed) (Fig. 4) and was not significantly affected by the amount of the supplement consumed. Most of the substitution was associated with reductions in straw intake, while grass intake was only marginally affected. Substitution occurs when concentrates are fed to ruminants grazing pastures or fed ad libitum on conserved forages, and generally ranges between 0 and 1.0 kg DM/kg DM (Stockdale et al. 1997; Heard et al. 2004). Substitution rates are variable, as was the case in this experiment, and they usually increase with the amount of pasture consumed or with the amount of concentrate supplement consumed (Stockdale 2000; Wales et al. 2006). It has been hypothesised that substitution may be caused by negative associative effects in the rumen where interactions between the digestion of concentrates and pasture reduce the rate of NDF digestion (Dixon and Stockdale 1999). While substitution rate may be influenced partly by negative associative effects, other factors, such as the animal's preference for feeds, are also likely to be involved when cassava powder is fed.

In experiments 2 and 3, increasing intake of formulated concentrate linearly increased total DM and digestible organic matter intakes (Fig. 3), and linearly decreased rice straw intake. The intakes of elephant grass or native grass were not significantly affected by concentrate intake. In these experiments, crude protein intakes and apparent digestibility increased linearly as the amount of concentrate consumed increased.

At the lowest intake of the formulated concentrate, forage intake increased (Fig. 4), while substitution at the next level of supplementation was less than 0.1 kg reduction in forage DM intake/kg DM supplement consumed and increased to 0.3 to 0.5 kg reduction in forage DM intake/kg DM supplement consumed at the highest supplement intake. The apparent increase in forage intake at the lowest amount of supplement consumed was most likely to be due to the supply of nutrients that were limiting digestion in the rumen or tissue metabolism (see Doyle 1987).

Figure 3. Digestible organic matter (OM) intake as affected by concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ○) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fish meal and urea (experiment 2, ■; experiment 3, Δ).

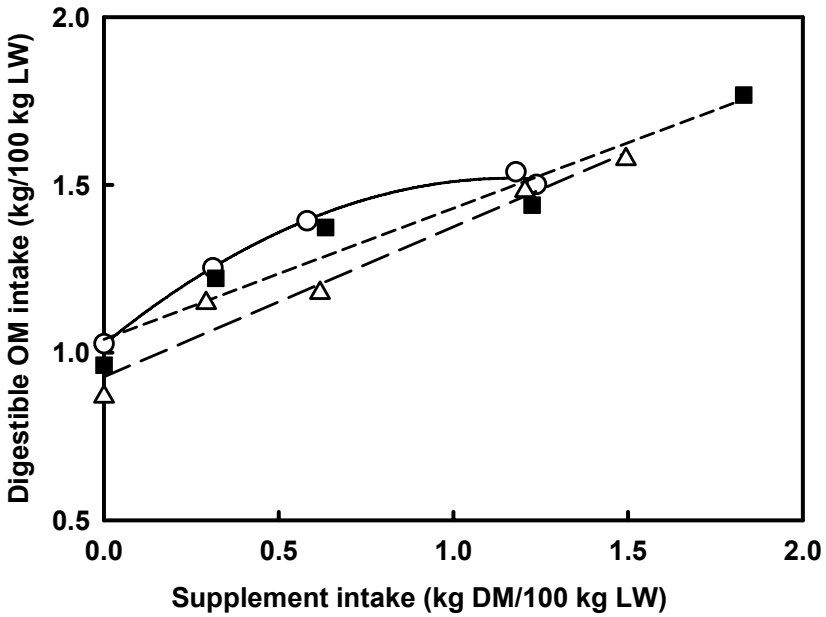
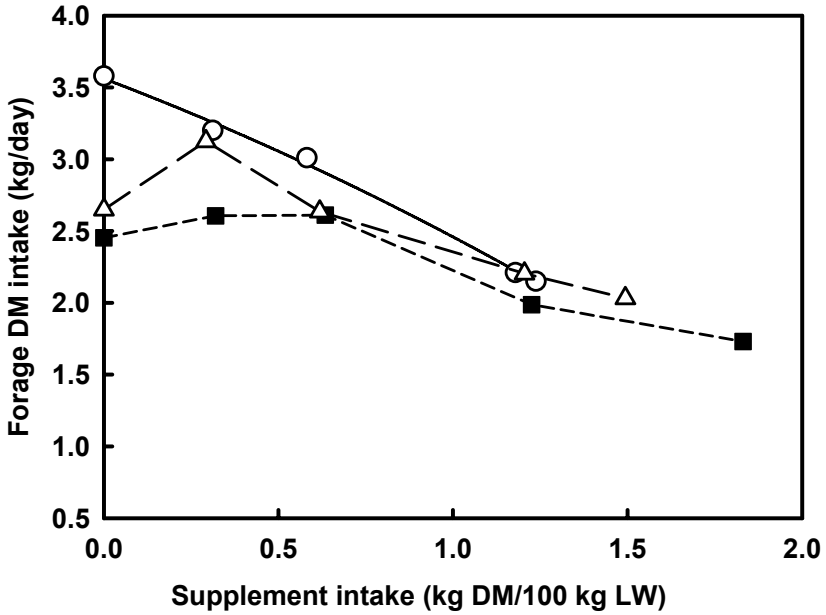


Figure 4. Forage intake as affected by concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ○) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fish meal and urea (experiment 2, ■; experiment 3, Δ).



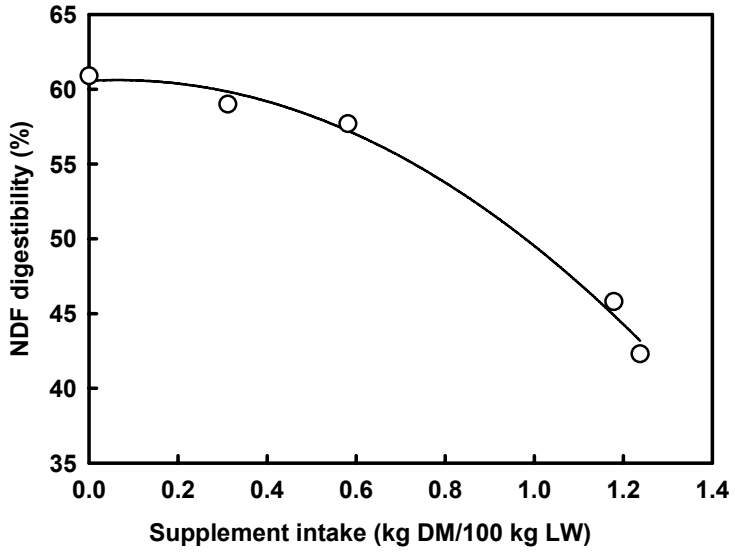
Previously, Crabtree and Williams (1971) reported that forage characteristics had little effect on substitution rates, particularly at high amounts of supplementation. In contrast, Gulbranson (1974) and Leibholz and Kellaway (1984) provided evidence that the reduction in intake was greater with high, compared with low, quality forages. This contrasts with the substitution effects in the current experiments, where most of the effect was a reduction in straw intake. As pointed out by Doyle (1987), substitution effects are mediated by many complex factors operating in the rumen and within the tissues. The restricted feeding of grass would have contributed to this result, but increasing the amount

of formulated concentrate fed also removed energy and possibly other nutrient limitations to production.

The concentrate supplement was formulated to provide readily digestible energy from locally available concentrates, but also protein and non-protein nitrogen. In ruminants fed low quality forages, providing protein or non-protein nitrogen to the rumen organisms (Leibholz and Kellaway 1984) or additional amino acids at the tissue level (Kempton et al. 1979) can increase forage intake, and possibly also moderates substitution effects. Crude protein intake and digestibility both increased linearly as the amount of concentrate consumed increased, but the ratios of digestible organic matter to crude protein in the supplemented diets were between 4.2 and 6.2 and, hence, ammonia supply in the rumen was unlikely to be limiting microbial activity (Hogan 1982). This indicates that the supplement may have alleviated limitations imposed by amino acid supply to the tissues. Consequently, it may be possible to use less protein, and particularly urea, in the formulated supplement, thus reducing its cost.

The depression in NDF digestibility by cassava powder (Fig. 5; from 62 to 41%) was significantly greater than when the formulated concentrate was fed (depressions from 56 to 46% in experiment 2, and from 58 to 51% in experiment 3) or when growing Friesian cattle were fed late-cut perennial ryegrass silage supplemented with rolled barley at 280 or 560 g/kg total DM intake (NDF digestibility reduced from 65 to 56%; Beever et al. 1988 and Thomas et al. 1988). These reductions in NDF digestibility occurred even though straw intake and the intake of less readily digestible NDF declined. There is evidence that the digestibility of NDF in mature forages may be depressed more than that in fresh herbages when the rumen environment is altered by feeding concentrates (Mould et al. 1983b; Huhtanen 1991). This influence of starch-containing supplements is mediated through reductions in rumen pH and cellulolytic activity (Terry et al. 1969; Osbourn et al. 1970), the critical rumen pH below which digestion of structural carbohydrates is reduced being between 6.2 (Grant and Mertens 1992) and 6.0 (Mould et al. 1983a). The consequence of these effects is that estimated ME contents of forage over-estimate the amount of ME actually derived by the animal (see Doyle et al. 2005).

Figure 5. Neutral detergent fibre (NDF) digestibility in Laisind bulls fed a basal diet of elephant grass and rice straw supplemented with different amounts of cassava powder.



Animal performance and economics

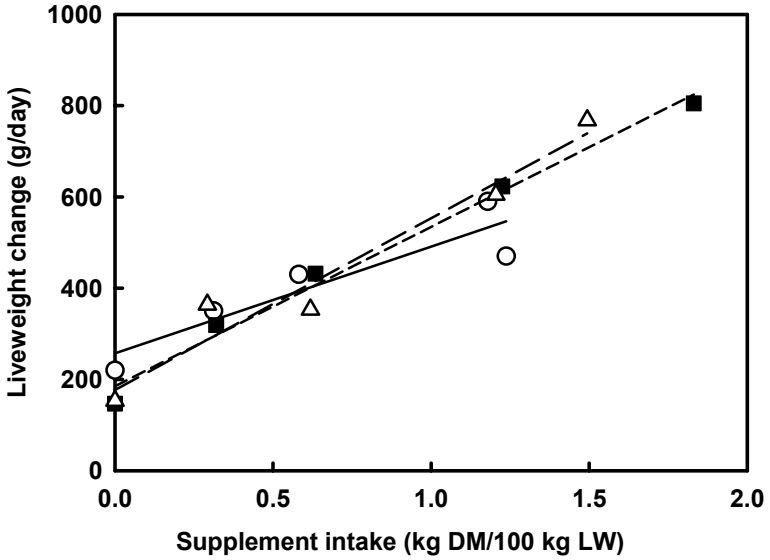
Live weight gain increased linearly with amount of supplement consumed in the three experiments (Fig. 6), but the rate of increase was greater in experiments 2 and 3. In these experiments, the hypothesis that digestible organic matter intake and LW gain would

increase linearly as the amount of a formulated concentrate based on rice bran and maize consumed increased up to 2% LW was supported by the results. There was a significant linear relationship between digestible organic matter intake (DOMI) and LW gain across the two experiments, namely:

LW gain = 0.53 DOMI – 0.50 (R^2 = 0.92)

This result is consistent with previously published reports where supplements have been fed to provide energy and/or protein to cattle consuming low quality forages (Hennessy and Murrison 1982; Lee *et al.* 1987; Hennessy *et al.* 1995).

Figure 6. Live weight gain in relation to concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ○) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fish meal and urea (experiment 2, ■; experiment 3, Δ).



An economic analysis, including sensitivity to cost variations, was performed using data from experiments 2 and 3, with an example of the findings given in Table 4. Using the formulated concentrate compared with the current feeding system, a basal diet of forage with little concentrate, markedly increased profit. The effects were due to reduced time to finish cattle and a greater proportion of the nutrients consumed used for LW gain (i.e. dilution of maintenance energy requirements). Profit was sensitive to labour costs (use of primary versus secondary labour) and whether the farmer needed to purchase concentrate. The cost of the concentrate could potentially be reduced by substituting cassava powder (value at farm level VND 2,000/kg fresh) for maize and/or rice bran (value at farm level VND 2,400/kg fresh).

Table 4. Analysis of the profitability of feeding formulated concentrate at 2% LW per day compared with the current feeding practice, based on finishing 1 bull (growth from 120 to 170 kg LW). Values are VND x 10^6.

System	Current	Formulated concentrate	
Labour source	Secondary	Secondary	Primary
Cattle purchase	2.40	2.40	2.40
Labour	0.56	0.10	0.26
Feed	0.53	0.52	0.52
Cattle sale	3.00	3.00	3.00
Profit	-0.09	0.37	0.22

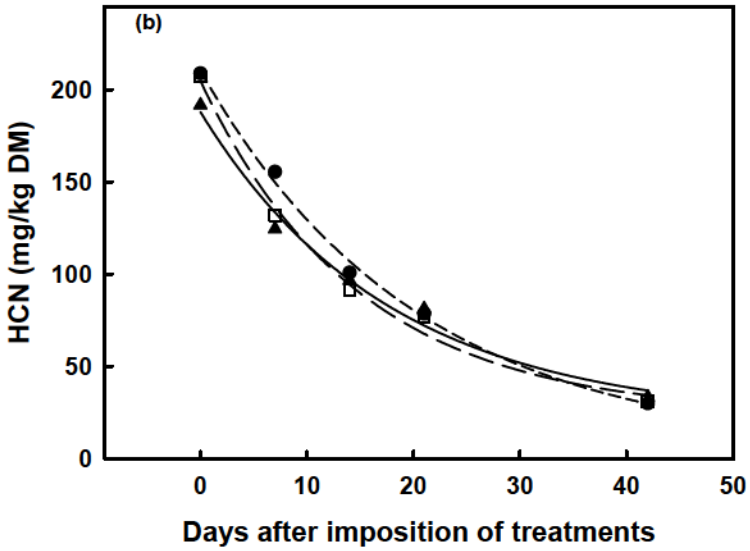
Experiments 4 and 5

It was clearly demonstrated that ensiling cassava waste, using technology appropriate to small holder farms, rapidly reduced pH to less than 4.0. The pH of high moisture content silages should be less than 4.2 for successful conservation (McDonald et al. 1991), indicating cassava bagasse silages were able to be satisfactorily stored.

Hydrogen cyanide concentrations also declined over time (Fig. 7), to about 80 mg/kg DM by 21 days. Makkar (1991) reported that 2 to 4 mg HCN/kg LW was toxic for cattle. However, cattle weighing about 150 kg and consuming 1 kg DM/day of cassava bagasse silage would only ingest 80 mg HCN/day or about 0.5 mg HCN/kg LW, indicating toxicity was unlikely.

In experiment 4, it was found the cattle took some time to adapt to cassava bagasse silage, but replacing cassava powder and rice bran in the concentrate with silage had no significant effects on growth rate. This experiment demonstrated that cassava bagasse silage could be used in supplements for cattle when the amount of concentrate fed was up to 1 kg DM/day. Feeding this amount of concentrate is more appropriate for breeding cows and low input systems than for finishing cattle.

Figure 7. Changes in hydrogen cyanide concentration when cassava bagasse was ensiled with rice bran and salt (●), molasses and salt (□) or salt (▲).



In experiment 5, the intake of concentrate supplement was reduced when it contained 85% cassava bagasse silage compared with lower inclusion rates in the supplement. However, at the lower rates of inclusion of the silage in concentrate, there were no effects on apparent organic matter digestibility, digestible organic matter intake or LW gain.

7.3.2 Australia

Literature review

The literature review, 'Associative effects between feeds when concentrate supplements are fed to grazing dairy cows: a review of likely impacts on metabolisable energy supply' by Doyle, Francis and Stockdale, was published in the Australian Journal of Agricultural Research in 2005.

In addition, two other reviews relating to efficiency of dairy feeding systems were published. The first of these, 'Profitable feeding of dairy cows in irrigated dairy farms in

northern Victoria' by Wales et al. (2006), was presented as a contract at the Australian Society of Animal Production conference in Perth. It elucidates principles of dairy cow nutrition and draws attention to the importance of measuring feeding system efficiency on dairy farms. It was well received by Australian dairy scientists attending the conference. A third review, 'Feed conversion efficiency; an important determinant of dairy farm profitability' by Beever and Doyle, was published in the Australian Journal of Experimental Agriculture in 2007. The analysis and background information in this review has been used by Richard Keenan Pty Ltd, a feed company, to develop a system of monitoring feed conversion efficiency on dairy farms and to offer this as a service to their clients.

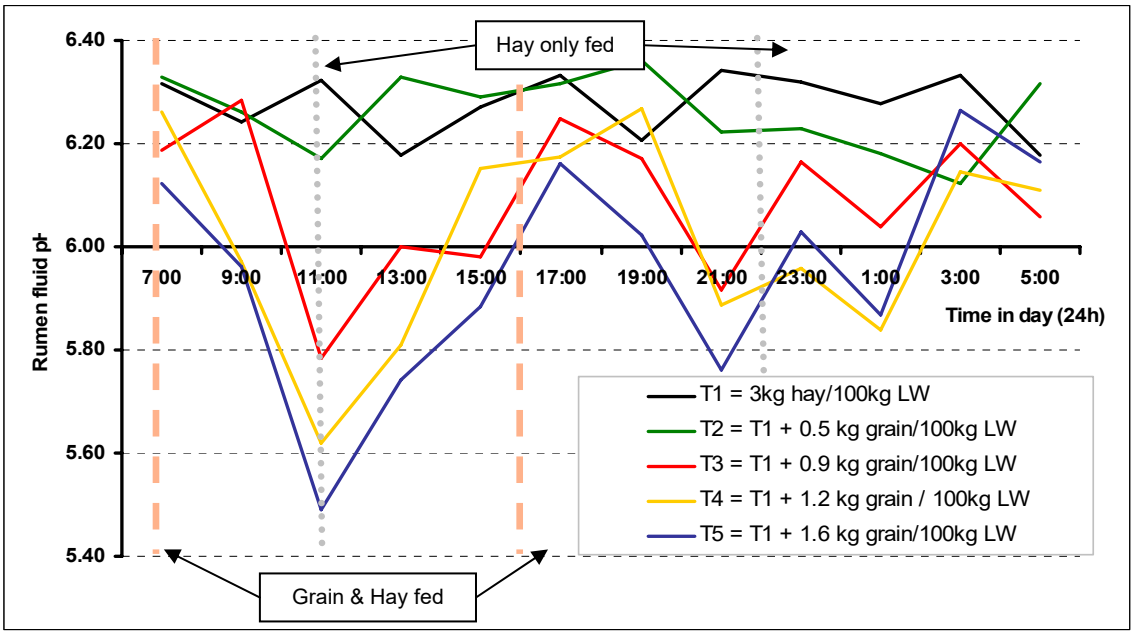
Experiments

Understanding associative effects between feeds has become a significant issue in the nutritional management of dairy cows in pasture-based systems as the amounts of concentrates fed to cows have increased. In experiment 1, a basal diet of chopped perennial ryegrass hay was chosen to reflect the characteristics of paspalum pastures that occur in northern Victoria during summer. It had an in vitro DM digestibility of 72%, an estimated ME concentration of 10.2 MJ/kg DM, and a NDF concentration of 52% DM.

Cows on the basal diet consumed 16.8 kg DM/day, with an in vivo apparent DM digestibility of 64%. This digestibility indicates the ME content of the hay may have been only 8.9 MJ/kg DM, compared with the laboratory estimate of 10.2 MJ/kg DM. The difference may be associated with the high intake of the hay, due in part to chopping.

Supplementation with grain increased digestible organic matter intake from 9.4 kg/cow/day to 13.6 kg/day, but rumen fluid pH fluctuated more and declined to lower values as the amount of grain consumed increased (Fig. 8). These rumen conditions led to a 4.4 percentage unit reduction in NDF digestibility, or about a 0.4 MJ decline in estimated ME of the forage, as the amount of supplement consumed increased. Although the decline in NDF digestibility seems small, when taken across a herd of 500 cows with a daily intake of 15 kg DM forage, the overall decline in ME is equivalent to 3,000 MJ. At 5 MJ/kg energy corrected milk, this equates to 600 kg milk/day or 180,000 kg over a 300-day lactation.

Figure 8. Rumen fluid pH in dairy cows fed a basal diet of perennial ryegrass hay and supplemented with different amounts of crushed wheat. All cows were fed the hay 4 times/day.



It is important to note that the management used in the experiment, namely feeding the hay 4 times per day, buffered the effects of concentrate on rumen pH compared with measurements made at grazing (see Wales et al. 2006).

In experiment 2, the rumen fluid pH in cows consuming Persian clover (about 18 kg DM/day) without grain was below 6.0 for an average of 17 hours/day. The rumen pH in these cows declined to 5.7 after grazing in the morning, and to 5.6 after grazing in the evening. The rumen fluid pH in cows fed grain supplements was below 6.0 for at least 20 hours/day, fluctuated more and declined to lower values than in the pasture-fed cows. At lower amounts of grain consumption, the pH declined to 5.6 and 5.5 after feeding in the morning and evening. At higher amounts of grain consumption, these minimum pH values were 5.4 and 5.25. Rumen fluid pH was below the critical value for sub-acute acidosis (pH<5.6) on at least one measurement occasion in nearly all cows consuming grain. This reflects the situation where cows graze highly digestible annual pastures on farms. The NDF and starch digestibility estimates in this experiment will need to be interpreted with care due to the short faecal collection periods.

7.4 Activity 4 - Understanding current cattle production systems, opportunities to improve these and testing changes to feeding practices

Existing practices/systems

The cattle production systems existing in Hanh Phuoc and Son Trung Communes are described in Table 5. Although many lowland farmers were ‘producers’ of cattle participating in a market economy, the highland households were cattle ‘keepers’.

The RUDEP evaluation reports indicated that previous demonstration activities met the needs of the Activity Group members as well as local households in general. For example, cattle finishing Activity Groups in Thach Thang and Van Ha villages in Duc Phong Commune indicated that the cattle finishing demonstrations were appropriate for their local conditions. However, the percentage of households fully adopting technologies was very low (2% within Activity Groups; 0% outside groups), whereas partial adoption was reasonable (52% in Activity Groups; 6% outside groups). Estimates of profit gained from the demonstrations was about VND540,000 for feeding 1 animal for 4 months. This is higher than the estimates presented in Table 4, primarily because we have included ‘true’ costs of labour and forage in our analysis, as well as a lower sale price for finished cattle. However, the RUDEP reports indicate ‘Households did not have sufficient resources to take care of cattle in accordance with the demonstration requirements because it was difficult to source or purchase enough of the nutritious feeds used in the demonstration rations. Consequently, farmers utilized available ingredients to save money, and also used extra elephant or super-dan grass. They did not have sufficient money to purchase fish meal, soy powder or bone powder. As a result, the percentage of farmers found with partial adoption was much higher than that for full adoption’.

An important lesson from these RUDEP demonstrations was that full participation of farmers in the design of such activities was important to increasing the likelihood of the technologies being used after the activity concluded. In the Activity 4 on-farm study, farmers were involved in the design of the study, in deciding the composition of the formulated concentrate, and individual farmers decided how much concentrate and grass they would feed.

The farmer/extension interface

The evaluation of the farmer/extension interface revealed a complex organisational structure typical of the agricultural extension system in Vietnam. At the provincial level, the

Quang Ngai Provincial Centre for Agricultural Extension (PCAE) has the role of supporting farmers to improve their agricultural production. At the district level, there is a District Station of Agricultural Extension (DSAE). Technically, the district staff are co-ordinated by the PCAE, but administratively they are managed by the District Peoples' Committee. The DSAE functions as a middle organization between the PCAE and commune extension workers. At commune level, there is one extension operative or 'paravet' in each village. These commune extension workers are not paid a salary, but are given financial incentives by local government. They receive annual training in accordance with the programs of the PCAE.

Table 5. Cattle production systems in Hanh Phuoc and Son Trung Communes

	Hanh Phuoc	**Son Trung**
Cattle breeds	Laisind (62%)/Yellow (38%)	Yellow (94%)/Laisind (6%)
Focus	Meat (major)/Breeding	Breeding (major)/Meat
Feeding systems	Cut & carry (major)/Lead grazing	Free and tethered grazing (major)/ grazing + cut and carry, or cut and carry
Available feeds and use		
Forages	- Sown grass (elephant grass) - Native grasses - Rice straw & other agricultural by-products ----> fully used	Native grasses
Concentrates	- Rice bran, cassava powder, maize (amount 0.5–2.0 kg based on availability) ---> Used for finishing beef cattle, growing cattle, and for breeding cattle before and after calving.	Very rare
Feed shortages	June – July (dry) Sept–Nov (flood & wet season)	June – July (dry) Sep–Nov (flood, wet-cold season)
Extension services	Access relatively convenient	Access difficult
Knowledge/skills - cattle production	Relatively better than Son Trung	Low (Experiences farmer to farmer)
Marketing awareness	High	Low/not concerned
Intervention strategy	Optimum use of available concentrates for growing & finishing cattle (On-farm study)	Better use of available feed resources for year round feeding. (Training and demonstrations)

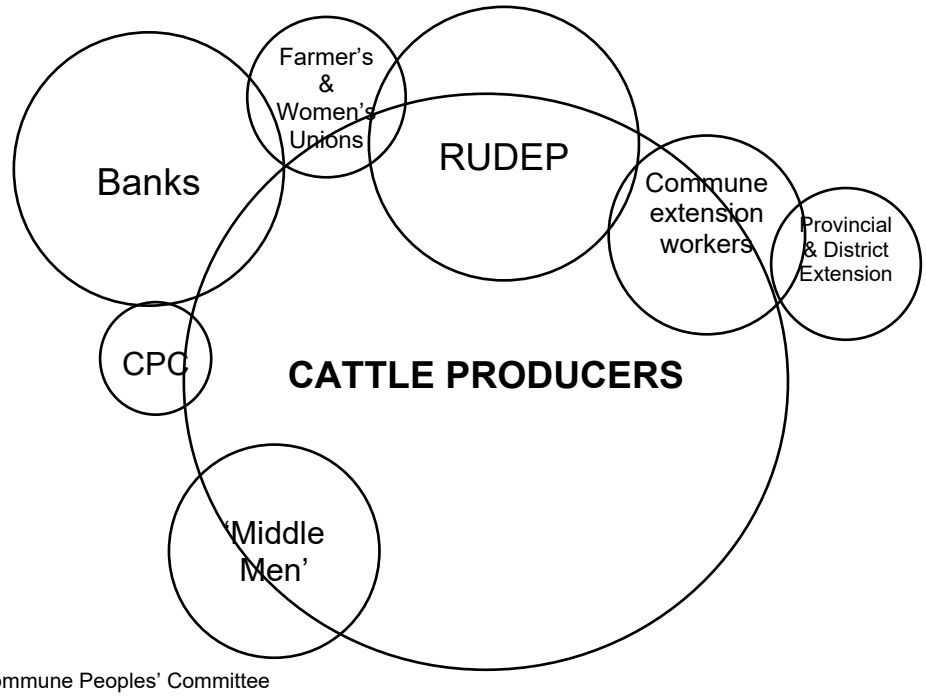
The RUDEP supports agricultural extension services through technical training, monitoring and evaluation of extension activities, and by providing credit to farmers. The program engages PCAE staff as contractors for farmer Activity Groups. For instance, in Hanh Phuoc, Mr. Do Kim Cuong, PCAE staff member, co-ordinates the RUDEP livestock program. The PCAE staff engaged by RUDEP have received training in technical issues and extension methodology. Under these arrangements, it was not possible to attribute impacts of development activities to RUDEP or to the PCAE.

In addition, other agencies, such as the Farmers' Union, Womens' Union, Bank for Agriculture and Rural Development, and Bank for the Poor, provide agricultural services, though not technical advice.

The complexity of the farmer/extension interface is presented in a stakeholder map (Fig. 9). Cattle producers said that the banks and RUDEP were of equal importance to

them and were very important as they are a source of credit. Most information on cattle production came from the 'middle men' and commune extension workers. The PCAE (RUDEP), DSAE and Farmers' Union and Womens' Union also provide information, but to varying degrees to different cattle producers.

Figure 9. Farmer/extension interface: stakeholder map. The size of the circles reflects the farmers perceptions of the relative importance of stakeholders. Stakeholder circles positioned closer to the centre of the figure indicate greater contact with farmers.



Note: CPC is Commune Peoples' Committee

The RUDEP has good contact with, and delivers many activities that directly influence, cattle producers. This includes establishing credit and savings groups, and providing short training courses on beef cattle production, grass cultivation and animal health. Technical staff of the PCAE, contracted by RUDEP, visit communes frequently to monitor and evaluate the activities initiated by the development program. The farmers believed these extension staff were better trained, technically more competent, and higher paid than the commune extension workers. Despite these differences, RUDEP-contracted staff have good relationships and work cooperatively with the commune extension workers. A challenge in the future will be to maintain these relationships and improve the knowledge of commune extension workers to sustain cattle development activities post-RUDEP.

'Middle men' provide information on price, source cattle for farmers, and buy finished animals. They participate in most activities related to buying and selling cattle. There were two groups of 'middle men' in Hamlet 17, one operating inside the village and the other from outside. Although they operate separate businesses, they often exchange information on buying and selling prices to the farmers' disadvantage.

In communes, the paravet (1 per village) is recognized and subsidised by the commune peoples' committee and the DSAE. These commune extension workers have closer relationship with the DSAE and the PCAE than with the Farmers' Union, Womens' Union and 'middle men'. They often conduct training activities under direction of the DSAE and the PCAE. However, a second group, the owners of veterinary medicine and animal feed outlets, also provide advice on cattle production in addition to services such as vaccination and disease treatment.

The Farmers' Union and Womens' Union play a role as a bridge between farmers and banks, and they also facilitate and organise interest groups, and credit and saving groups. These activities are supported by the commune peoples' committee, and development projects (such as RUDEP).

Field study results

At the second evaluation meeting, 11 neighbouring farmers volunteered and joined the study, increasing the number of participating households to 31. As farmers were sourcing and selling cattle throughout the study period, the time feeding options were applied on farms varied. Selected information on the range in feeds used, the cost of concentrates, LW gain, and concentrate cost in relation to LW gain is given in Table 6. The average costs of concentrate per kg LW gain were lower using the formulated concentrate strategy, which included the practice of feeding it 2-3 times a day. For a LW gain of 100 kg, the difference in costs of concentrates would be about VND140,000. The formulated concentrate had a lower cost (by VND 150/kg fesh) than that used in Activity 3 experiments because of the inclusion of cassava powder. The increased rate of LW gain would also lead to reduced time and labour in finishing a group of animals and the opportunity to finish more cattle. These benefits would be influenced by the amount of concentrate fed (see Fig. 10 below). However, there was a great deal of variation around the average data, which would be due to differences in amounts and nutritive characteristics of forages fed, in starting LW and condition of the cattle, in animal health and in housing and management.

Table 6. Feeds used, cattle performance and preliminary economic analysis in the on-farm study in Hanh Phuoc Commune.

	Test group (n = 57 animals)	Control group (n = 10 animals)
Green grass (kg fresh/day)	17 (15 - 20)	17 (15 - 20)
Rice straw (kg fresh/day)	2.5 (2 - 3)	2.5 (2 - 3)
Concentrates (kg fresh/day)	1.8 (0.5 – 3.0)	1.5 (0.5 - 2.5)
Concentrate cost (VND x 10^3/day)*	5.3 (1.5 - 9.0)	4.0 (1.4 - 7.0)
Average LW change (kg/month)	18 (10 - 35)	12 (8 - 18)
Concentrate cost/kg LW gain (1,000VND)	8.5 (3.5 – 15.0)	9.9 (6.0-14.0)

* Concentrate cost was VND3,000 for the formulated concentrate and on average VND2,800 for the control group concentrate.

The improvements in average growth rates and reductions in average cost of concentrates per kg gain may be a reflection of a more stable rumen fermentation, due in part to the frequent feeding and mix of fermentable energy sources (rapidly fermented starch in cassava powder and more slowly digested starch in maize and rice bran). It is probably also due to the protein provided in the formulated concentrate.

Most of the farmers in the control group did not mix the concentrates they used. For example, a farmer might feed cassava powder one day and rice bran the next. No farmers in this group used protein or non protein nitrogen supplements. Some of the control group fed the supplement once a day, while others fed it twice a day. Most farmers in the group cooked the concentrate prior to feeding, in the belief that as the volume increased the animal was getting more or that it increased digestion.

Despite the diversity in feeding systems between farms and the number of factors that could affect the response to amount of supplement fed, there was a reasonable relationship between amount of concentrate fed and LW gain (Fig. 10). All cattle on the control group of farms had LW gains below the line of best fit.

The perceptions of farmers at the second and third evaluation meetings are presented in Table 7. In general, they thought the formulated concentrate improved LW gains, the technology was easy to implement, and they would continue using the formulated concentrate. However, a small number indicated they would only continue full adoption if the protein and urea was subsidised. These results reflect the farmers' view that they could see the LW response because cattle were generally finished quicker, and this impacted on their cash flow.

Figure 10. Relationship between amount of concentrate fed (kg fresh/day) and daily LW gain (open circles are control animals).

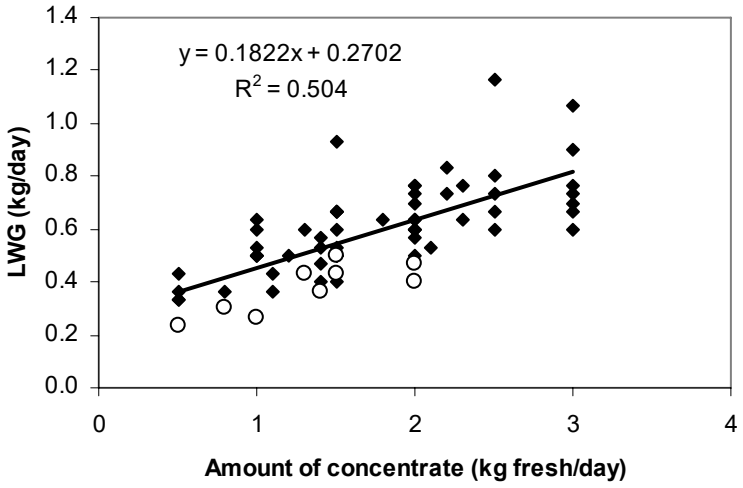


Table 7. Participating farmers' perceptions of the formulated concentrate feeding strategy.

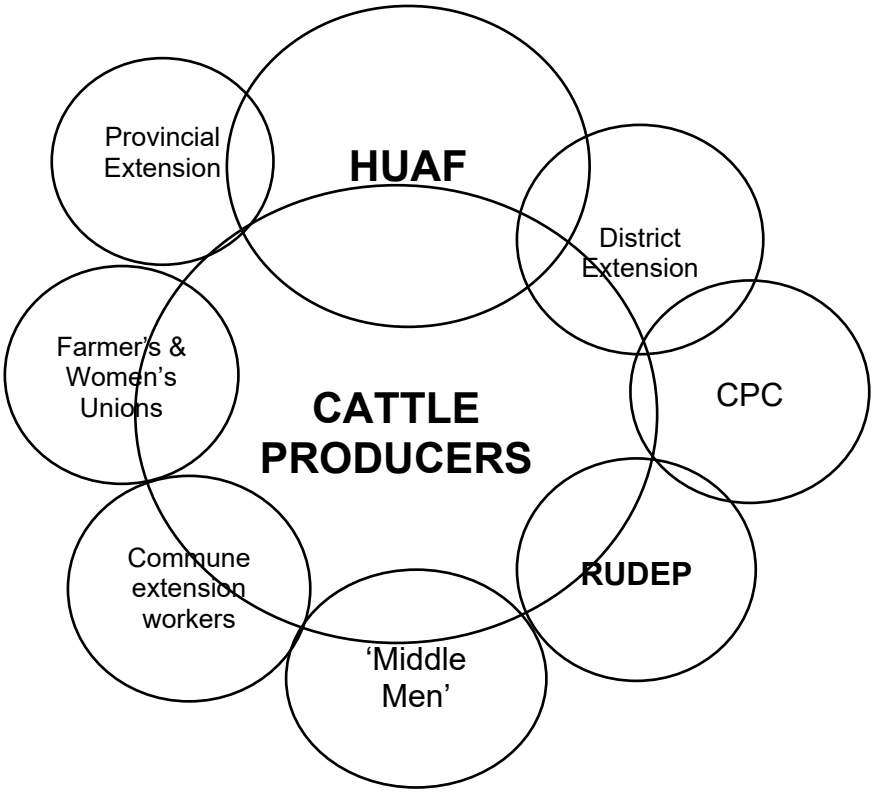
Parameters	2nd evaluation (April)		3rd evaluation (June)	
	No. of farmers	% of total	No. of farmers	% of total
LW gain:				
Good	14	93	26	100
Fair	1	7	0	0
Not good	0	0	0	0
Technique application:				
Very easy	13	87	26	100
Easy	2	13	0	0
Difficult	0	0	0	0
Technique adoption:				
Well adopted	13	87	26	100
Adopted	2	13	0	0
Not yet	0	0	0	0
Continuing to apply:				
Continuing	12	80	25	96
Continuing if support	3	20	1	4
No	0	0	0	0

In the socio-economic research conducted by Ms Huynh Thi Anh Phuong, it was found that the opportunities for primary labour (people from 17 to 60 years of age) to obtain off-farm employment and the availability of secondary labour would be major determinants of the number of cattle a household would finish each year, and the times of year they would do this. This illustrates that the resources (human and other) available within a household are primary determinants of whether they will adopt the formulated concentrate technology and how profitable it might be.

Research/extension/farmer interface

Near the end of the on-farm study, farmer perceptions of the research/extension/farmer interface were collected (Fig. 11). During the on-farm study, researchers from HUAF had the strongest influence on the cattle producers through the initial training, frequent discussions with farmers, and the monitoring and evaluating sessions. The HUAF was seen as the coordinator who involved PCAE, DSAE, RUDEP and the Commune Peoples' Committee in the activity. The other organisations had roles in the process. The RUDEP provided credit to farmers for cattle rearing (this was done before HUAF's intervention) and guided farmers in how to use the money effectively. The DSAE provided advice/guidance to farmers on technical issues, and the staff participated in the monthly consultation meetings with farmers. Commune and village leaders participated in the group meetings, and helped to maintain the interest groups. However, roles of the PCAE, commune extension workers and 'middle men' were unchanged from the picture gained at the start of the study.

Figure 11. Research/farmer/extension interface: stakeholder map. The size of the circles reflects the farmers' perceptions of the relative importance of stakeholders. Stakeholder circles positioned closer to the centre of the figure indicate greater contact with farmers.



Lessons learnt

- Involvement of farmers in the design of the study and formulation of the concentrate was critical to their involvement and commitment to the study.
- Participatory involvement of key stakeholders (researchers, extension staff, and commune and village leaders) was critical to success of the process of transferring knowledge and technology to the farmers.
- The role of the researcher was important in assisting farmers, extension workers, commune and village leaders, and 'middle men' in understanding the technology and subsequent adoption.

- Involvement of the DSAE and local government extension staff was important in ensuring the sustainability of transferring the technology.
- An understanding of the socio-economic situation of a household and the resources it has are critical determinants of whether a technology will be adopted and the profit gained.

7.5 Activity 5 - Develop the knowledge and technical skills of scientists and extension staff in Vietnam and Australia.

Capacity development activities were carried out in accordance with original plans. From a human resource perspective, they improved leadership, management and scientific capacity in the project team through:

- Exchange visits and interaction between the team in Vietnam and Australia.
- Research activities and travel programs that built research capability in the scientists in the project.
- The linkage with RUDEP that built knowledge and networks across the R,D&E spectrum.
- Employing a systems approach in the program which included participatory research to improve the range of communication skills in the team.

The capacity development in scientists was complemented by skill development in support staff in both Vietnam and Australia. More specific information is provided in Section 8.2.

The planned cattle facility with capacity of 20-head of cattle and a sample preparation area were constructed at the HUAF farm. In addition, the project provided computers and extension equipment, cattle and desk top scales, and sample processing and storage equipment.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The process developed for peer review of experimental protocols has been implemented more widely in HUAF to ensure the integrity of experiments and as a learning platform for younger staff. This process has led to important changes in scientific practices, namely:

- Thorough review of existing literature/knowledge prior to implementation of experiments.
- Establishing clear hypotheses that are testable within the experimental design.
- Use of appropriate measurements, techniques and data analysis to interpret the underlying reasons for results/responses.
- Thorough planning to ensure resources are adequate to complete experiments or field activities.

This will lead to on-going improvements in the efficiency and quality of ruminant and other livestock research and development conducted by HUAF staff by drawing on the experiences of senior staff and sharing learning and knowledge across the faculty. The HUAF has a focus on improving research output and recognition as a research provider. A review to achieve this goal is currently in progress and will include development of policy

on scientific practices as well as for recognition of staff for research output, comparable with the current reward system based on teaching activities. It is likely HUAF will take the protocol process from the Faculty of Animal Science and implement it more broadly, including as a basis for securing University funding.

The peer review process for publications also implemented in the project will ensure efficiencies in documentation of future research so that subsequent experiments are designed to add to existing published knowledge. The scientific papers from project research that are published or in the process of publication are evidence of the effectiveness of this process. By November 2007, 1 scientific paper arising from the research conducted in Activity 3 in Vietnam had been published in the Vietnamese Agricultural Science and Technology Journal and a further 4 papers had been submitted to international and national journals. Benefits also accrued in Australia, where 4 papers were published in Australian scientific journals during the project and a further 2 papers are expected to be published. Publication of the research will enable access by the broader scientific community and should contribute to future work adding new knowledge.

The emphasis within the on-station research in Activity 3 on 'dose response' experiments has demonstrated the value of this approach relative to comparison of discrete treatments. These benefits include the ability to determine the underlying reasons for responses and the ability to conduct robust economic analysis of feeding strategies. This second benefit is crucial to the development and extension process. The HUAF leaders intend to use this approach in future research.

Science is very much about networking with, and obtaining knowledge from, peers and research leaders in the field of interest. The project team presented 8 papers at international or national conferences during the project to build their contacts. Further papers are expected/planned to be presented in upcoming conferences of the Australian Society of Animal Production in Brisbane and the Asian Australasian Animal Science Congress to be held in Hanoi. Prof Le Duc Ngoan is a member of the organising and editorial committees for the latter event.

8.2 Capacity impacts – now and in 5 years

The knowledge and skills of scientists involved in LPS/2002/078 have been enhanced through formal and on-the-job training in the following areas:

Skill area	Formal training	On-the-job training
Leadership and management	Nguyen Xuan Ba, Clare Leddin	Nguyen Xuan Ba, Clare Leddin
Experimental design and planning		Nguyen Xuan Ba, Nguyen Huu Van, Clare Leddin, Janna Heard
Experimental techniques		Nguyen Xuan Ba, Nguyen Van Phong, Nguyen Huu Van, Clare Leddin, Janna Heard
Data analysis	Nguyen Ngoc Huy, Ms Giang Thi Thanh Duyen	Nguyen Xuan Ba, Nguyen Huu Van, Clare Leddin
Scientific writing	Nguyen Xuan Ba, Le Van Phuoc, Clare Leddin	Nguyen Xuan Ba, Nguyen Huu Van, Clare Leddin, Janna Heard
Knowledge of the literature		Nguyen Xuan Ba, Nguyen Huu Van, Clare Leddin, Janna Heard
Systems research	Nguyen Huu Van	Nguyen Xuan Ba, Nguyen Huu Van, Clare Leddin

Some of this knowledge and skills have already been used outside the project in HUAF in on-going teaching of undergraduate and post graduate students and in-service training of extension staff in provinces in central Vietnam. Nguyen Xuan Ba and Nguyen Huu Van indicate they are now more confident and competent in delivering ruminant livestock courses. As an example, the response relationships to supplementation with concentrates, and principles underpinning them, have been incorporated in teaching materials. The skills are also being used in a new cattle production project, 'Improved productivity and meat quality of beef cattle production in Vietnam, Laos and Cambodia', funded by the Norwegian Program for Development, Research and Education.

In addition to the capacity development in HUAF staff, 4 postgraduate students and 13 undergraduate students completed experiments or projects as part of LPS/2002/078 in partial fulfilment of their degrees. Three post graduate students are from other central province teaching universities and have returned to their positions. The fourth, Ms Huynh Thi Anh Phuong, is continuing her socio-economic research with Le Duc Ngoan. The undergraduate students are now variously employed by provincial and district DARDs or private companies. Mr Nguyen Hai Quan has joined the staff in the Faculty of Animal Science, HUAF. It is expected the knowledge these students acquired from their involvement will be used in their roles.

In Australia, Stephanie Muir, an undergraduate student who participated in the research at Kyabram, is enrolled for a PhD at the University of Melbourne.

During the project, HUAF staff contributed to training of DARD extension staff in Quang Ngai as part of RUDEP activities. These training exercises included formal classroom type components and 'learning by doing' exercises. Competency testing was conducted by RUDEP and indicated significant knowledge acquisition. In Activity 4, knowledge in ruminant nutrition and husbandry was enhanced in those DARD staff participating in the farm research. A participatory approach was used in which information from Activity 3 was presented to and discussed with extension staff and participating farmers. These participants then inputted into the design and monitoring of the on-farm activity. In Dong Giang, HUAF staff delivered training in cattle production for district extension and World Vision staff and key farmers within communes. This training drew on work conducted in LPS/2002/078 and drew on the experiences and material used in training DARD staff in Quang Ngai.

The HUAF's charter is to develop extension services in the provinces and districts of central Vietnam through undergraduate and postgraduate training and in-service courses for DARD staff. This means impacts from use of extension material and knowledge derived from LPS/2002/078 will be enhanced over the next 5 years. Each staff member from the project delivers 3-4 in-service training courses to extension staff in central provinces each year. However, the low technical skill base of provincial, district and commune service providers will not be easily rectified.

As part of this project, ACIAR provided funding for the construction of an animal house at HUAF farm, and for sample processing and storage equipment needed in the conduct of ruminant research. This investment in infrastructure was used by Prof Le Duc Ngoan in a case that secured funding for new laboratory facilities from the Ministry of Education and Training. Technical training in laboratory techniques and animal research methodology provided during LPS/2002/078 should ensure on-going and appropriate use of these facilities, for example in the new Norwegian Program for Development, Research and Education.

In DPI, Clare Leddin and Janna Heard gained experience, skills and knowledge in ruminant digestive physiology. Capacity in this discipline area in Australia has declined markedly over recent years. Considerable effort was also invested in the development of

technical capability to support the conduct of complex metabolism experiments. The failure of the dairy industry to co-invest in the research conducted and changes in DPI priorities make it difficult to forecast how this capacity development may be utilised in the future.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

This was a category 2 ACIAR project, with most impacts forecast to occur post project and to be captured in Quang Ngai through RUDEP activities. Hence, the current impacts of the project are limited to the 31 households in the commune that participated in Activity 4 and their immediate neighbours. Importantly, 11 of the participating households joined the study during its conduct, reflecting acceptance of the technology and the effectiveness of the participatory approach.

If a household finished three groups of three cattle per year, which is not unreasonable given use of the formulated concentrate, the time taken to finish cattle will fall to around 50-60 days resulting in a farm-level profit from cattle. The returns to the research and extension activities can then be estimated by combining this figure with project and extension costs (assuming there would be an additional annual cost of 'scaling out' activities over three years in Quang Ngai) and a forecast maximum adoption level of 5000 households, and a 30 year simulation period (Table 8). Even assuming discount rate of 15%, the benefit cost ratio is between 3:1 and 2:1. If a 5% discount rate is used (which is standard practice for ACIAR impact assessments) the benefit-cost ratio ranges from 6:1 to 11:1. Naturally, additional benefits would accrue from further adoption in Quang Ngai and in other central provinces.

Table 8. Estimated benefits ($A) from technology uptake in Quang Ngai.

	Scenario 1		
Discount Rate	**15%**	**10%**	**5%**
Net Present Value	784,746	2,122,951	5,381,574
Present value of benefits	1,607,831	3,053,093	6,763,655
Present value of costs	823,086	930,142	1,060,002
Benefit-Cost Ratio	**2:1**	**3:1**	**6:1**
	Scenario 2		
Discount Rate	**15%**	**10%**	**5%**
Net Present Value	1,829,836	4,107,462	9,568,598
Present value of benefits	2,652,922	5,037,603	11,160,031
Present value of costs	823,086	930,142	1,060,002
Benefit-Cost Ratio	**3:1**	**5:1**	**11:1**

8.3.2 Social impacts

Current impacts are limited. However, if adoption of the feeding technologies that have been developed is scaled out, it is likely that significant social benefits would accrue. The improved use of concentrates is likely to accelerate the adoption of sown grass technologies. This, together with increased LW gains, would reduce the time women and children spent in tending grazing cattle or in collecting native grass. The extent to which such benefits are captured would depend on whether households expand their cattle finishing enterprises. The technologies would also improve cash flow and profit through

reduced times to finish cattle, which provides the opportunity for families to invest in the education of their children.

The participatory planning conducted by RUDEP in Quang Ngai indicated households desired to diversify and increase income, with cattle production being the most preferred option. Diversification of income is important to counteract the greater variability and trend for declines in prices received by households for traditional cash crops as a result of globalisation. Hence adoption of the project results will empower the farming families providing them with the ability to increase income security.

Project LPS/2002/078 also facilitated improved relationships between cattle producers and those providing services in Hanh Phuoc. This is critical in the adoption process.

Finally, the project provided an opportunity to develop linkages with the World Vision Area Development Program in Dong Giang. This has led to significant changes in the cattle husbandry practices of ethnic minority groups in the district, with adoption of simple technologies, such as housing cattle and use of sown grasses and available crop residues, leading to labour savings.

8.3.3 Environmental impacts

No adverse environmental impacts are envisaged from adoption of the technologies developed and tested in LPS/2002/078. These technologies have focused on improved conversion of crop residues and tropical grasses into saleable product through the use of supplements produced in rural households. These feeding systems also increase manure production and quality, which can be usefully used in composting or for field application for vegetable, crop or grass production. Enhancing the organic matter content of lowland soils will improve soil structure, and better use of manure may reduce to some degree the dependence on chemical fertilizers. However, ultimately the environmental benefits will depend on the extent of adoption of the feeding strategies.

The research on ensiling cassava bagasse provides an option to use this waste from starch extraction factories. Although a great deal of this material is dried for use in pig rations, increasing cassava production is likely to outstrip demand by this intensive industry. Feeding to cattle has been shown to be a viable alternative means of disposal.

8.4 Communication and dissemination activities

The key stakeholders in the project, ACIAR and DPI in Australia, and HUAF, Ministry of Education and Training, RUDEP and Quang Ngai DARD in Vietnam, were kept informed through the six-monthly and annual reports, PCC meetings, travel reports and briefings by the project leaders and staff.

The science community has been informed through conference papers and presentations, and scientific publications (see Section 10).

8.4.1 Seminar and workshop presentations

Twenty one seminar and workshop presentations have been made to a range of audiences. These were:

- Doyle PT ‘Presentation of project LPS/2002/078 to ACIAR livestock systems workshop’. Brisbane, August 2007.
- Doyle PT ‘Findings of project LPS/2002/078’. Seminar to DPI Program Investors. April 2007.

- Doyle PT ‘Dairy production in Australia with a focus on irrigated dairying in northern Victoria’. Seminar to staff at Faculty of Animal Science, HUAF. April 2007.
- Leddin CM ‘Associative effects between forage and grain in dairy cows’. Seminar to Animal Production Sciences management team. February 2007.
- Nguyen Xuan Ba and Nguyen Huu Van ‘Effects of amount of concentrate supplement on forage intake, diet digestibility and live weight gain in yellow cattle in Vietnam’. Seminar to staff at Faculty of Animal Science, HUAF. January 2007.
- Leddin CM ‘Feed resources for cattle production in central Vietnam and possible associative effects between feeds when feeding grain to lactating dairy cows.’ Seminar to staff at DPI Kyabram. October 2006.
- Leddin CM ‘Improved beef cattle production in central Vietnam.’ Presentation to DPI research directors. September 2006.
- ‘Project LPS/2002/78 Improved beef production in central Vietnam’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. November 2005.
- Nguyen Xuan Ba ‘Project LPS/2002/78 Improved beef production in central Vietnam’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. November 2005.
- Doyle PT ‘Estimating the metabolisable energy content of feeds for ruminants and factors affecting feed intake and production by cattle’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. November 2005.
- Vu Chi Cuong ‘Use of agro-industrial by products for fattening cattle – some research results from NIAH’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. November 2005.
- Leddin CM and Doyle PT ‘Pasture and grain – how much metabolisable energy does the grazing cow actually receive?’ Seminar to the northern Victorian dairy industry. October 2005.
- Doyle PT ‘Vietnam – the place, people and agriculture’. Project seminar delivered to staff at DPI Kyabram. September 2005.
- Doyle PT and Gloag CM ‘AS2/2002/078 Improved Beef Production in Central Vietnam’. Presentation to ACIAR board. December 2004.
- Le Duc Ngoan ‘Cattle Production in Vietnam - Background paper’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. September 2004.
- Vu Chi Cuong ‘Key Findings from ACIAR project AS2/1997/18 – Profitable Beef cattle development in Vietnam’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. September 2004.
- Doyle PT ‘Approaches to estimating the metabolisable energy (ME) content of feeds’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. September 2004.
- Nguyen Xuan Ba ‘Feed inventory and feed nutritive characteristics in Quang Ngai’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. September 2004.
- Doyle PT ‘Why are associative effects between feeds important in dairy cows?’ Project Workshop, Hue University of Agriculture and Forestry, Vietnam. September 2004.
- Gloag CM ‘Associative effects between conserved forage and grain in dairy cows’. Project Workshop, Hue University of Agriculture and Forestry, Vietnam. September 2004.

- Doyle PT 'Are associative effects important to you?' Seminar to the northern Victorian dairy industry. July 2004.

8.4.2 Web

Information was posted on the LPS/2002/078 Project web site in Vietnam (www.rdviet.net/aciar078/index.htm)

A supplementary feeds database was posted on the DPI web site at www.dpi.vic.gov.au/farming/dairying.

Databases of nutritive characteristics of perennial and annual pastures were uploaded to the DPI web site at www.dpi.vic.gov.au/pasturedatabases.

8.4.3 Extension activities

Extension activities in Quang Ngai (funded by RUDEP)

- Two training courses in animal nutrition and feed resources for extension staff at district and provincial levels of Quang Ngai DARD. Duration: 3 days/course in 2005.
- Training course in animal feed conservation and processing for farmers of Nghia Tho commune (RUDEP site), Tu Nghia district. Duration: 2 days in 2005.
- Training course in goat production for District Development Officers and district level extensionists of Quang Ngai DARD. Duration: 2 days in 2005.
- Training course in cattle production for District Development Officers of RUDEP and district level extension officers of Quang Ngai DARD. Duration: 2 days in 2004.

Extension activities for the World Vision Organisation in Quang Nam province

- Training course in project management for commune project leaders and commune coordinators and world vision staff. Duration: 4 days in June 2005.
- Training course in cattle production for district extension staff and world vision staff. Duration: 4 days in Feb/Mar 2006.
- Training course in cattle production (focus on feeds and feeding) for district extension staff and world vision staff. Duration: 3 days in Mar/Apr 2006.
- Study tour for district extension staff, commune project leaders, commune coordinators, world vision staff and selected farmers to Quang Ngai. Duration: 3 days in April 2006.
- Training course in extension methodology for district extension staff and world vision staff. Duration: 3 days in June 2006.
- Training course in 'semi-intensive cattle production for smallholders' for selected farmers and district extension staff. Duration: 3 days in July 2006.
- Training course in cattle production for village facilitators (5 communes). Duration: 4 days in August 2006.
- Training course in extension methodology for facilitators (5 communes). Duration: 3 days in September 2006.
- Training course in cattle production for village facilitators (5 communes). Duration: 4 days in October 2006.
- Training course in extension methodology for facilitators (5 communes). Duration: 3 days in December 2006.

- Conducted the midterm workshop and study tour in Thua Thien Hue with Dong Giang project management board and extension staff. Duration: 2 days in August 2006.
- Training of Trainers on cattle production in small households for ADP Dong Giang. Duration: 4 days in June 2007.
- Training of Trainers on cattle production in small households for ADP Tien Phuoc, Quang Nam province. Duration: 7 days in June 2007.
- Training course in project planning and management for District Project Management Board, and commune coordinators and world vision staff in Tra Bong ADP, Quang Ngai province. Duration: 3 days in September 2007.
- Study tour in Quang Binh province for Dong Giang project management board and extension staff. Duration: 2 days in August 2007.
- Training course in project planning and management for District project management Board, and commune coordinators and world vision staff. Duration: 4 days in October 2007.
- Preparation of a training manual on cattle production specific to small households in mountainous areas.

8.4.4 Newsletter articles

- Australian Consul General and ACIAR Country Manager Vietnam visited LPS/2002/078 project sites in Quang Ngai and Quang Nam. ACIAR in Vietnam Newsletter. September 2007, p 6.
- The participation of villagers in livestock research activities (from LPS/2002/078 project) ACIAR in Vietnam Newsletter. September 2007, pp 16-17.
- John Dillon Fellowship – Opportunities for Agricultural Research Project Managers. ACIAR in Vietnam Newsletter. September 2007, pp 26-27.
- Improved beef production in Central Vietnam (AS2/2002/078). ACIAR in Vietnam Newsletter. Februaury 2005 - August 2005.
- Gloag CM Feeding grain to dairy cows – are there limits? Target 10 Newsletter. June 2005.
- Improved beef production in Central Vietnam (AS2/2002/078). ACIAR in Vietnam Newsletter. July 2004 - January 2005.

9 Conclusions and recommendations

9.1 Conclusions

9.1.1 Activity 1:

The PCC fulfilled the crucial task of ensuring alignment of project activities with the needs of RUDEP and DARD. The committee also contributed to the scientific integrity and relevance of the research conducted. The collegiate approach within the group enabled the project partners (HUAF and DPI) to build strong relationships with the key stakeholders in Quang Ngai (RUDEP and DARD) and with NIAH.

9.1.2 Activity 2:

The feed resources for ruminants varied between zones in Quang Ngai and between households. Developing feed plans requires quantitative knowledge of the feed resources

available, which means strategic and tactical feeding options will vary between households. The feed resources inventory indicated that a large proportion of lowland households had sufficient access to concentrate supplements to enable the design of tactical feeding options for finishing cattle.

There has been a significant shift to confinement systems of feeding and use of sown grasses in lowland communes. However, the amount of concentrate offered remains low, is generally less than 1 kg/day irrespective of age, LW or condition of the cattle, and is usually based on single feeds (as opposed to formulated concentrate). This provides opportunities to effectively implement improved supplementary feeding strategies.

By-products produced in factories, such as molasses, cassava and soybean residues, were not available for use by rural farmers because of cost and competing uses. This situation is unlikely to change.

Information on nutritive characteristics of feed resources for central Vietnam was limited. Development of the nutritive characteristics database was useful in educating scientists and extension staff on the considerable variation that exists within and between feed. There is a clear lack of Information on the estimated ME value of feeds in Vietnam.

The inventory of feed resources and nutritive characteristic data were critical to the design of relevant tactical feeding options for testing in Activity 3 and on-farm (Activity 4).

9.1.3 Activity 3:

The supplementary feeding response data (experiments 1-3) for Vietnam are valuable information for researchers, extension workers and farmers. It has provided a basis for predicting LW gain to recommended feeding options and for estimating likely profitability of feeding different amounts of supplement. The responses were consistent with known principles of ruminant nutrition.

There were limits to how much cassava powder cattle would eat and, because it was highly digestible, it had significant effects on rumen digestion. The amount of this supplement offered to cattle should be less than 0.7 to 1.0% LW, and it would be better utilised in mixtures with maize and/or rice bran.

The amounts and types of protein needed for effective responses to supplementation with readily digestible energy feeds require further investigation.

These dose response experiments in Vietnam have provided a platform on which to develop the knowledge of scientists (and extension staff) of the principles underpinning response relationships to different amounts of supplement. The formulated concentrate and cassava powder supplements substituted for forage, particularly when high amounts were fed. In addition, these supplements depressed NDF digestibility, which means that estimates of ME of forages from laboratory analysis or book values will be higher than what is available to the animal. Such effects were not understood prior to the project.

Economic analyses indicated that the profitability of cattle finishing could be increased by VND 0.22 to 0.37 million per animal by feeding the formulated concentrate at 2.0% LW per day compared with current practice.

Cassava bagasse can be effectively ensiled, using technology appropriate to smallholder farms, for use as a ruminant feed. However, its availability for cattle is likely to remain limited by alternative uses, such as in the intensive pig industry.

The literature reviews and experiments conducted with dairy cows in Australia highlighted challenges for the dairy industry in ensuring nutrition advice leads to productivity and profitability improvements on farms. The laboratory estimates of ME content of forages did not necessarily reflect what was available to lactating cows with high feed intakes. In addition, interactions between grain and the forage during digestion, although small, would have further affected the energy available. The lack of quantitative information in this area remains a constraint to improving the efficiency and profitability of dairy farms where feed costs comprise 40 to 65% of total costs.

9.1.4 Activity 4:

Improved cattle production in Quang Ngai (and other central provinces) remains limited by the knowledge of farmers and their service providers. The farmer/extension interface was found to be extremely complex and a constraint to technology adoption.

The participatory approach used in the on-farm study was effective in achieving adoption of the recommendation to feed a formulated concentrate. The study illustrated the importance of amount of supplement fed in determining LW gain, and the time taken to finish cattle. The approach also enhanced the relationships between cattle producers and service providers in the commune. However, how to scale out this approach, given limitations in skilled staff, remains a challenge in Quang Ngai, a challenge that exists in other central provinces too.

Changing the supplementary feeding practice from low amounts of unmixed concentrates fed irregularly to reasonable amounts of formulated concentrate fed in a consistent manner improved the profitability of cattle finishing. The effects on profit were similar to those estimated in Activity 3. At the household level, adoption of the technology and the extent of its use will depend on labour availability and resources available on a farm.

9.1.5 Activity 5:

The planned capacity development in HUAF and DPI was achieved.

9.2 Recommendations

9.2.1 Principal recommendation

LPS/2002/078 has provided valuable information and field testing of improved feeding strategies to finish cattle in central Vietnam. The HUAF has emerged as a key provider of training at the field level in central Vietnam and the project has ensured leadership capacity in the staff to fill this role, but the number of staff is limited and they have other commitments. At the same time, the low knowledge and skill base of service providers throughout central Vietnam remains a key constraint to adoption of the technologies that were successfully tested and implemented. It is recommended a scale out project be developed to capture the opportunities provided by this project. Essential elements would be:

- More thorough analysis of socio-economic impacts and how these vary between households within a commune and in different communes.
- Increasing the number of staff in HUAF and recruiting young graduates to roles which would include replicating the on-farm study in communes in Quang Ngai and surrounding provinces.
- Additional experimentation aimed at better defining the needs for protein and non protein nitrogen to ensure feed costs are contained.

9.2.2 Other recommendations

We recommend that new and similar livestock projects in Vietnam adopt a similar management approach of a Project Coordinating Committee that includes key stakeholders from research providers, development programs and extension agencies as this fosters collaboration and enhances the chances of activities continuing after completion of ACIAR projects.

During the ACIAR review of this project, it became apparent there were more data on the nutritive characteristics of forages and supplements in the major national livestock research institutes (NIAH, Hanoi and the Institute for Agricultural Sciences, Ho Chi Minh). The available information should be consolidated into a national database that is maintained over time if it is to be effectively used in livestock development activities.

The 'Feed Year' model from ACIAR project AS2/1998/035 was adapted for use in Vietnam, but this was undertaken primarily by DPI staff. It is a useful educational tool for both scientists and extension staff, and further development for use in Asia, including in other ACIAR projects, is recommended. The key needs to ensure utility are:

- Creation of a user's manual that documents the functions in the model and a user-friendly interface that is flexible enough to be applied in a range of situations.
- Re-configuration of the model to predict cattle growth rates.
- Training materials and courses for Vietnamese scientists and extension service providers in the use of the program.

The approaches used in the on-farm study in training farmers and extension workers and in examining the farmer/extension interface should be fully documented by Prof Ngoan and his colleagues in HUAF so that others can share their learning and success.

There are few data on the relative rates of fermentation of supplements in central Vietnam, yet such information is important in formulating concentrate supplement mixes that reduce the impacts of supplementation on forage intake and digestion. Future projects should include research to provide knowledge in this area.

10 References

10.1 References cited in report

- Beever DE, Cammell SB, Thomas C, Spooner MC, Haines MJ, Gale DL (1988) The effect of date of cut and barley substitution on gain and on the efficiency of utilisation of grass silage by growing cattle 2. Nutrient supply and energy partition. *British Journal of Nutrition* **60,** 307-319.
- Bui Van Chinh, Bui Thi Oanh, Nguyen Ngoc Ha, Tran Quoc Viet, Doan Thi Khang, Nguyen Thi, Tinh, Le Hoa Binh, Nguyen Huu Tao, Vu Duy Giang, Hoang Van Tien, Dao Van Huyen, Nguyen Nghi, Vo Van Su, Le Thi Binh (2001) Composition and nutritive value of animal feeds in Vietnam. Nha Xuat Ban Nong Nghiep Agriculture Publishing House, Hanoi.
- Crabtree JR, Williams GL (1971) The voluntary intake and utilisation of roughage-concentrate diets by sheep. 1. Concentrate supplements for hay and straw. *Animal Production* **13,** 71-82.
- Department of Agriculture and Rural Development of Quang Ngai (2006) Annual report on animal production in Quang Ngai province.

- Dixon RM, Stockdale CR (1999) Associative effects between forages and grains: consequences for feed utilisation. *Australian Journal of Agricultural Research* **50,** 757-773.
- Doyle PT (1987) Supplements other than forages. In 'The Nutrition of Herbivores'. (Ed JB Hacker and JH Ternouth) Ch 19, pp 429-464. Academic Press, Sydney, New South Wales.
- Doyle PT, Devendra C, Pearce GR (1986) Rice straw as a feed for ruminants. International Development Program of Australian Universities and Colleges Limited, Canberra, Australia.
- Doyle P, Malcolm B, Ho C, Nesseler R (2002) DAV 10769 Future dairy farming systems in irrigation regions. Phase 1 Final Report. Department of Primary Industries, Kyabram, Victoria.
- Fulkerson WJ, Hough G, Goddard M, Davison T (2000) The productivity of Friesian cows: effect of genetic merit and level of concentrate feeding. Final Report – DAN 082 to the Dairy Research and Development Corporation. NSW Agriculture, Wollongbar, New South Wales.
- Elliott R, McMeniman NP (1987) Supplementation of ruminant diets with forage. In 'The Nutrition of Herbivores'. (Ed JB Hacker and JH Ternouth) Ch 18, pp 409-428. Academic Press, Sydney, New South Wales.
- Grant RJ, Mertens DR (1992) Influence of buffer pH and raw corn starch addition on *in vitro* fiber digestion kinetics. *Journal of Dairy Science* **75,** 2762-2768.
- Gulbranson B (1974) Utilization of grain supplements by roughage-fed cattle. *Proceedings of the Australian Society of Animal Production* **10,** 74-77.
- Hennessy DW, Murrison RD (1982) Cottonseed meal and molasses as sources of protein and energy for cattle offered low quality hay from pastures of the north coast of New South Wales. *Australian Journal of Experimental Agriculture and Animal Husbandry* **22,** 140-146.
- Hennessy DW, Kohun PJ, Williamson PJ, Brown DA, Nolan JV (1995) The effect of nitrogen and protein supplementation on feed intake, growth and digestive function of steers with different *Bos indicus*, *Bos taurus* genotypes when fed a low quality grass hay. *Australian Journal of Agricultural Research* **46,** 1121-1136.
- Hogan JP (1982) Digestion and utilization of protein. In 'Nutritional Limits to Animal Production from Pastures'. (Ed JB Hacker) pp 245-257. Commonwealth Agricultural Bureau, Farnham Royal, UK.
- Heard JW, Cohen DC, Doyle PT, Wales WJ, Stockdale CR (2004) Diet Check - a tactical decision support tool for feeding decisions with grazing dairy cows. *Animal Feed Science and Technology* **112,** 177-194.
- Huhtanen P (1991) Associative effects of feeds in ruminants. Norwegian Journal of Agricultural Sciences 5, 37-57.
- Doan Thi Khang and Cu Xuan Dan (2001) Chemical composition of several crop by products as animal feeds in Vietnam. In 'Workshop on improved utilization of by-products for animal feeding in Vietnam', National Institute of Animal Husbandry, Hanoi University of Agriculture, Agricultural University of Norway, NUFU id No: 96/25 Hanoi - Vietnam, pp. 44-49.
- Kempton TJ, Nolan JV, Leng RA (1979) Protein nutrition of growing lambs. 2. Effect on nitrogen digestion of supplementing a low-protein-cellulosic diet with either urea, casein or formaldehyde treated casein. *British Journal of Nutrition* **42,** 303-315.

- Lee GJ, Hennessy DW, Nolan JV, Leng RA (1987) Responses to nitrogen and maize supplements by young cattle offered a low-quality pasture hay. *Australian Journal of Agricultural Research* **38,** 195-207.
- Leibholz J, Kellaway RC (1984) The utilization of low quality roughages. 1. The role of nitrogen and energy supplements. AMRC Review No. 48. Australian Meat Research Committee, Sydney, New South Wales.
- Makkar HPS (1991) Anti-nutritional factors in food for livestock. In 'Animal Production in Developing Countries'. Proceedings of a Symposium of the British Society of Animal Production, Occasional Publication No. 16.
- McDonald P, Henderson AR, Heron SJE (1991) The Biochemistry of Silage. Chalcombe Publications, Marlow, UK.
- Mould FL, Ørskov ER, Gauld SA (1983a) Associative effects of mixed feeds. II. The effect of dietary addition of bicarbonate salts on the voluntary intake and digestibility of diets containing various proportions of hay and barley. *Animal Feed Science and Technology* **10,** 31-47.
- Mould FL, Ørskov ER, Mann SO (1983b) Associative effects of mixed feeds. I. Effects of type and level of supplementation and the influence of the rumen fluid pH on cellulolysis in vivo and dry matter digestion of various roughages. Animal Feed Science and Technology 10, 15-30.
- Opatpatanakit Y (1994) 'Cereal Grains/forage Interactions in Ruminant Diets.' PhD Thesis, The University of Sydney.
- Opatpatanakit Y, Kellaway RC, Lean IJ, Annison G, Kirby A (1994) Microbial fermentation of cereal grains *in vitro*. *Australian Journal of Agricultural Research* **45,** 1247-1263.
- Opatpatanakit Y, Kellaway RC, Lean IJ, Annison G, Kirby A (1995) Effects of cereal grains on fibre digestion *in vivo*. *Australian Journal of Agricultural Research* **46,** 403-413.
- Osbourn DF, Terry RA, Cammell SB, Outen GE (1970) Some effects of feeding supplements of maize meal and sodium bicarbonate upon the digestion of forage cellulose by sheep. *Proceedings of the Nutrition Society* **29,** 12A-13A.
- Pozy P, Dehareng D, Vu Chi Cuong (2002) Feeding cattle in northern Vietnam: Animal requirements and nutritive value of feedstuffs. Nha Xuat Ban Nong Nghiep Agriculture Publishing House, Hanoi.
- Standing Committee on Agriculture (1990) Feeding Standards for Australian Livestock. Ruminants Subcommittee. CSIRO, East Melbourne, Victoria.
- Stockdale CR (2000) Levels of pasture substitution when concentrates are fed to grazing dairy cows in northern Victoria. *Australian Journal of Experimental Agriculture* **40,** 913-921.
- Stockdale CR, Dellow DW, Grainger C, Dalley D, Moate PJ (1997) Supplements for Dairy Production in Victoria. Dairy Research and Development Corporation, Glen Iris, Victoria.
- Terry RA, Tilley JMA, Outen GE (1969) Effect of pH on cellulose digestion under *in vitro* conditions. *Journal of Science of Food and Agriculture* **20,** 317-320.
- Thomas C, Gibbs BG, Beever DE, Thurnham BR (1988) The effect of date of cut and barley substitution on gain and on the efficiency of utilisation of grass silage by growing cattle 1. Gains in live weight and its components. *British Journal of Nutrition* **60,** 297-306.

- Tudor GD, Norton BW (1982) The nutritive value of cassava for cattle. *Proceedings of the Australian Society of Animal Production* **14,** 599.
- Vearasilp T, Mikled C (2001) Site and extent of cassava starch digestion in ruminants. http://www.mekarn.org/procKK/choc.htm

10.2 List of publications produced by project (some of which have been cited in the text)

10.2.1 Scientific journal

- Ba Nguyen Xuan, Van Nguyen Huu, Ngoan Le Duc, Leddin CM, Doyle PT (2007a) Effects of amount of concentrate supplement on forage intake, diet digestibility and live weight gain in yellow cattle in Vietnam. *Asian-Australasian Journal of Animal Science* (submitted).
- Ba Nguyen Xuan, Van Nguyen Huu, Ngoan Le Duc, Leddin CM, Doyle PT (2007b) Amount of cassava powder fed as a supplement affects feed intake and live weight gain in Laisind cattle in Vietnam. *Asian-Australasian Journal of Animal Science* (submitted).
- Ba Nguyen Xuan, Van Nguyen Huu, Ngoan Le Duc (2007c) Fattening Laisind cattle on diets containing cassava bagasse silage. *Vietnamese Agricultural Science and Technology Journal* (submitted).
- Ba Nguyen Xuan, Van Nguyen Huu, Ngoan Le Duc, Leddin CM, Doyle PT (2007d) Ensiled cassava bagasse can be used as a supplement for cattle fed rice straw. *Vietnamese Agricultural Science and Technology Journal* (submitted).
- Ba NX, Van NH, Ngoan LD, Leddin CM, Doyle PT (2007e). Some results of using supplements for cattle production in Central Vietnam. *Vietnamese Agricultural Science and Technology Journal* 4, 15-18.
- Beever DE, Doyle PT (2007) Feed conversion efficiency as a key determinant of dairy herd performance: a review. *Australian Journal of Experimental Agriculture* **47,** 645-657.
- Heard JW, Francis SA, Doyle PT (2006). Nutritive characteristics of annual species in irrigated pasture in northern Victoria. Australian Journal of Experimental Agriculture 46, 1015-1022.
- Wales WJ, Heard JW, Ho C, Leddin CM, Stockdale CR, Walker GP, Doyle PT (2006) Profitable feeding of dairy cows in irrigated dairy farms in northern Victoria. *Australian Journal of Experimental Agriculture* **46,** 743-752.
- Doyle PT, Francis SA and Stockdale CR (2005). Associative effects between feeds when concentrate supplements are fed to grazing dairy cows: a review of likely impacts on metabolisable energy supply. Australian Journal of Agricultural Research 56, 1315-1329.

10.2.2 Conference papers

- Ba NX, Van NH, Ngoan LD, Leddin CM, Doyle PT (2006) Cassava bagasse silage can be used as a supplement for cattle fed rice straw. XIIth AAAP Animal Science Congress 2006, Congress Proceedings - Abstracts p. 671. Hosted by Korean Society of Animal Science and Technology, Federation of Korean Societies of Animal Science in Busan Korea.

- Doyle P, Stockdale CR (2006) Feed conversion efficiency in grazing dairy cows. In 'Dairy Science 2006', Proceedings of the Australian Dairy Science Symposium, Mt Gambier. Vol. 2, p. 32. (National Dairy Alliance).
- Ba NX, Ngoan LD, Gloag CM, Doyle PT (2005a) Feed resources for cattle in Quang Ngai, south central Vietnam. Proceedings of AHAT/BSAS International conference: Integrating systems to meet the challenges of globalisation. Vol. 2, P4.
- Ba NX, Van NH, Hang DT, Ngoan LD, Gloag CM, Doyle PT (2005b) Nutritive characteristics of feeds for cattle in central Vietnam. Proceedings of AHAT/BSAS International conference: Integrating systems to meet the challenges of globalisation. Vol. 2, P3.
- Gloag CM, Heard JW, Ba NX, Doyle PT (2005) Possible associative effects between feeds when lactating dairy cows on a hay ration are fed grain. Proceedings of AHAT/BSAS International conference: Integrating systems to meet the challenges of globalisation. Vol. 2, T123.
- Gloag, CM, Doyle PT, Stockdale CR and Heard JW (2005) Rumen fluid pH in lactating cows consuming irrigated annual clovers. Recent Advances in Animal Nutrition in Australia 15, 25A.
- Doyle PT, Ho C, Armstrong DP, Malcolm LR (2004) Feeding system efficiency and profitability of an irrigated dairy farm. Animal Production in Australia **25**, 45-48.
- Heard JW, Doyle PT, Wales WJ, Stockdale CR (2004) Decision support tools to optimise conversion of pasture to milk. Animal Production in Australia **25**, 89-92.

10.2.3 Books and extension manuals

- Le Duc Ngoan, Nguyen Xuan Ba, Nguyen Huu Van (2007) Feed resources for ruminants in households in central Vietnam, (Ed. Vu Duy Giang) pp 127. Agriculture Publishing House, Hanoi.
- Vu Duy Giang, Nguyen Xuan Trach, Le Duc Ngoan, Nguyen Xuan Ba, Nguyen Huu Van, Vu Chi Cuong (in preparation) Ruminant nutrition and feeding. Agriculture Publishing House, Hanoi.
- Nguyen Xuan Ba, Nguyen Huu Van, Nguyen Xuan Trach (2007) Training manual for cattle production in highland households. Hue University of Agriculture and Forestry, Hue.

10.2.4 Theses

- Dr Nguyen Xuan Ba (2006) Evaluation of mulberry (*Morus alba*) and hibiscus (*Hibiscus rosasinensis*) as ruminant feeds in central Vietnam. PhD Thesis, Hue University, Hue, Vietnam.
- Mr Nguyen Huu Minh (2007) Effect of cassava powder supplement on feed intake, digestibility and live weight gain in Laisind cattle. MSc Thesis, Hue University, Hue, Vietnam.
- Mr Bui Van Loi (2007) Effect of supplementation of ensiled cassava bagasse for Laisind cattle fed rice straw on their feed intake, digestibility and live weight gain. MSc Thesis, Hue University, Hue, Vietnam.
- Mr. Dinh Van Dung (in progress) Effects of different amounts of concentrate supplement on intake, ration digestibility and live weight gain of yellow cattle fed a basal ration of grass and rice straw. MSc Thesis, Hue University, Hue, Vietnam.

- Ms Huynh Thi Anh Phuong (in progress) Factors affecting market participation of rural small-holder beef producers: A case study in Hanh Phuoc, Nghia Hanh District, Quang Ngai Province, Vietnam.
- Ms Clare Leddin (in progress) Efficiency of feeding dairy cows in pasture-based systems. MAgr Sc Thesis, University of Melbourne, Australia.

10.2.5 Project reports

- Peter Doyle and Le Duc Ngoan (2007) Annual report ACIAR Project LPS/2002/078 'Improved beef production in central Vietnam'. (DPI and HUAF, June 2007).
- Peter Doyle and Le Duc Ngoan (2007) Milestone report ACIAR Project LPS/2002/078 'Improved beef production in central Vietnam'. (DPI and HUAF, January 2007).
- Peter Doyle (2006) Consultants Report: ACIAR Project C2004/045 ‘Capacity building in cattle production in Dong Giang District, Quang Nam Province’. ACIAR program area: Central Region of Vietnam. (DPI, November 2006).
- Peter Doyle and Le Duc Ngoan (2006) Annual report ACIAR Project LPS/2002/078 'Improved beef production in central Vietnam'. (DPI and HUAF, July 2006).
- Peter Doyle and Le Duc Ngoan (2006) Milestone report ACIAR Project AS2/2002/078 'Improved beef production in central Vietnam'. (DPI and HUAF, January 2006).
- Peter Doyle and Le Duc Ngoan (2005) Annual report ACIAR Project AS2/2002/078 'Improved beef production in central Vietnam'. (DPI and HUAF, July 2005).
- Peter Doyle and Le Duc Ngoan (2005) Milestone report ACIAR Project AS2/2002/078 'Improved beef production in central Vietnam'. (DPI and HUAF, January 2005).
- Peter Doyle and Nguyen Xuan Ba (2004) Report prepared for World Vision Vietnam on ‘Capacity building for improved cattle production in Hien’ Project. (DPI and HUAF, May 2004).

11 Appendixes

11.1 Appendix 1 Nutritive characteristics of feeds for cattle in Vietnam: summary output of the database developed in LPS/2002/078

Nutritive Characteristics of Feeds Used in Central Vietnam

This list of feeds was compiled by staff of Hue University of Agriculture and Forestry and Primary Industries Research Victoria, Department of Primary Industries, as a component of ACIAR project LPS/2002/078 'Improved beef production systems in central Vietnam'. The information on nutritive characteristics was sourced from published information (see below for list of sources). Nutritive characteristics were limited to estimates of dry matter, estimated metabolisable energy, crude protein and neutral detergent fibre for commonly used or available feeds. We acknowledge the financial support provided by the Australian Centre for International Agricultural Research.

	Dry matter (%)				Metabolisable Energy (MJ/kgDM)				Crude Protein (%)				Neutral Detergent Fibre (%)			
Feed Category	Average	Range	std. dev.[1]	n[2]	Average	Range	std. dev.[1]	n[2]	Average	Range	std. dev.[1]	n[2]	Average	Range	std. dev.[1]	n[2]
FORAGES																
Native grasses	24.2	(13.8 - 41.4)	6.23	69	9.1	(8.7 - 9.8)	0.29	13	12.0	(6.8 - 21.6)	2.90	69	62.3	(49.4 - 73.5)	5.09	54
Rice straw	87.2	(52.8 - 94.4)	9.33	26	8.5	(7.8 - 9.2)	0.37	16	5.6	(4.5 - 7.6)	0.87	26	72.9	(62.9 - 79.8)	4.71	10
Maize stover	34.4	(23.2 - 61.6)	12.54	17	9.1	(8.1 - 11.8)	1.76	4	7.9	(1.6 - 13.0)	2.24	17	66.2	(58.8 - 71.9)	4.79	12
Cassava tops	19.5	(15.8 - 24.8)	3.57	5	11.0	(9.7 - 12.5)	1.20	5	26.5	(20.5 - 30.4)	3.71	5	-	-	-	-
Sugarcane tops	27.2	(18.0 - 31.6)	4.50	11	9.2	(8.7 - 9.8)	0.41	6	5.3	(2.5 - 9.3)	2.54	11	65.3	(47.4 - 76.5)	12.02	5
Peanut vines	25.1	(18.4 - 34.2)	4.77	8	9.8	(8.1 - 10.5)	0.74	8	16.1	(8.5 - 19.3)	3.51	8	-	-	-	-
Sweet potato vines	12.5	(9.9 - 20.0)	3.88	6	9.7	(9.0 - 10.5)	1.03	2	16.5	(11.0 - 21.7)	4.10	6	-	-	-	-
Banana plant	14.1	(5.7 - 22.5)	11.88	2	9.2	(8.5 - 9.9)	0.98	2	11.7	(10.5 - 12.9)	1.67	2	-	-	-	-
Elephant grass	16.0	(6.7 - 29.3)	4.52	90	8.9	(8.2 - 9.5)	0.38	22	13.1	(4.5 - 29.8)	5.39	90	63.4	(39.7 - 84.4)	9.07	63
Guinea grass	20.6	(11.1 - 29.7)	4.15	27	9.1	(8.4 - 11.7)	0.69	20	12.1	(4.9 - 22.5)	3.79	27	71.5	(62.7 - 76.0)	5.97	4
TREE FORAGES																
Leucaena	25.7	(25.9 - 25.9)	-	1	11.8	(11.8 - 11.8)	-	1	28.5	(28.5 - 28.5)	-	1	-	-	-	-
Hibiscus rosa	20.6	(18.5 - 22.3)	1.9	3	10.3	(10.1 - 10.5)	0.30	2	18.7	(18.5 - 18.9)	0.20	2	32.6	(32.3 - 32.8)	0.35	2
Mulberry	31.7	(30.2 - 33.8)	1.9	3	12.0	(11.3 - 12.6)	0.92	2	22.6	(20.8 - 24.8)	2.00	3	23.0	(22.5 - 23.5)	0.71	2
Jackfruit	43.0	(43.0 - 43.0)	-	1	10.0	(10.0 - 10.0)	-	1	17.2	(17.2 - 17.2)	-	1	-	-	-	-
ON-FARM SUPPLEMENTS																
Rice bran	89.1	(80.4 - 92.1)	2.56	22	11.6	(9.6 - 12.7)	1.33	6	11.8	(7.9 - 15.4)	2.33	22	-	-	-	-
Cassava root - dry	87.7	(85.5 - 90.1)	1.56	12	12.2	(12.1 - 12.3)	0.10	3	2.4	(1.7 - 3.3)	0.64	12	7.7	(5.4 - 8.5)	1.50	4
Cassava root - fresh	29.6	(24.0 - 36.3)	3.32	13	12.1	(12.0 - 12.3)	0.09	12	3.1	(1.3 - 4.1)	0.71	13	-	-	-	-
Cassava bagasse dry	87.6	(86.2 - 89.0)	2.01	2	12.2	(12.1 - 12.3)	0.10	2	2.2	(2.0 - 2.3)	0.20	2	-	-	-	-
Cassava bagasse fresh	13.7	(10.0 - 18.0)	3.97	5	11.8	(11.6 - 12.0)	0.30	2	2.7	(1.8 - 3.6)	0.86	5	31.3	(31.2 - 31.3)	0.07	2
Corn (seed)	86.9	(80.1 - 91.0)	2.68	36	12.4	(11.9 - 12.6)	0.13	23	10.4	(9.0 - 12.5)	0.85	36	-	-	-	-
OFF-FARM SUPPLEMENTS																
Molasses	75.4	(63.1 - 85.1)	11.26	3	11.4	(11.4 - 11.4)	-	1	10.2	(2.5 - 14.1)	6.70	3	-	-	-	-
Brewer's grain	21.3	(20.7 - 22.1)	0.75	3	11.2	(11.2 - 11.2)	-	1	29.1	(23.8 - 32.0)	4.60	3	-	-	-	
Groundnut cake	91.1	(89.3 - 93.1)	1.15	9	13.5	(12.3 - 15.3)	1.08	6	49.2	(42.0 - 56.3)	4.49	9	-	-	-	-

[1] std dev = standard deviation
[2] n = number of entries

References

Nguyen Xuan Ba (2006) Evaluation of *Morus alba* and *Hibiscus rosasinensis* L. for rumianant in central Vietnam, PhD thesis.

Bui Van Chinh, Bui Thi Oanh, Nguyen Ngoc Ha, Tran Quoc Viet, Doan Thi Khang, Nguyen Thi Tinh, Le Hoa Binh, Nguyen Huu Tao, Vu Duy Giang, Hoang Van Tien, Dao Van Huyen, Nguyen Nghi, Vo Van Su and Le Thi Binh, 2001. Composition and nutritive value of animal feeds in Vietnam. Agriculture Publishing House, Hanoi. pp391

Doan Thi Khang and Cu Xuan Dan, 2001. Chemical composition of several crop by products as animal feeds in Vietnam. In 'Workshop on improved utilization of by-products for animal feeding in Vietnam', National Institute of Animal Husbandry, Hanoi University of Agriculture, Agricultural University of Norway, NUFU id No: 96/25 Hanoi – Vietnam, 44-49

Doyle, P.T., C. Devendra and G.R. Pearce, 1986. Rice straw as a feed for ruminants. International Development Program of Australian Universities and Colleges Limited, Canberra, Australia. pp117

Pozy, P., D. Dehareng and Vu Chi Cuong, 2002. Feeding cattle in northern Vietnam: Animal requirements and nutritive value of feedstuffs. Agriculture Publishing House, Hanoi. pp124

Standing Committee on Agriculture, 1990. Feeding Standards for Australian Livestock. Ruminants Subcommittee, CSIRO: East Melbourne, Australia. pp266