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2 Executive summary

Demand for beef in Indonesia is increasing by 4% per annum, which is unable to be met from domestic supply alone under prevailing cattle management systems. Small-holder farmers within the crop-livestock system of eastern Indonesia have the opportunity to capitalise on this increased demand for beef. An Integrated Village Management System (IVMS) established in Nusa Tenggara Barat successfully increased reproductive output by introducing natural mating, early weaning and more appropriate allocation of available feed resources to match nutrient demands of cattle. It is anticipated that wide scale implementation of the IVMS will result in a large population of early weaned calves across eastern Indonesia and that if these calves are retained by small-holder farmers, and growth rates improved, significant increases in cash flow will ensue. The objective of this project was to evaluate a range of feeding strategies to increase growth rates of 6 month old weaned Bali calves at four sites across eastern Indonesia.

A total of 53 feeding strategies were evaluated in 14 on-station experiments conducted at Sulawesi Tengah, Jawa Timur, Nusa Tenggara Barat and Nusa Tenggara Timur. The best-bet feeding strategy at each site was then implemented, monitored and adapted in villages for a period of 6 months. The results indicate that Bali calves can be successfully weaned at 6 months of age and will grow well if fed a diet high in crude protein. On-station studies demonstrated that the potential growth rate of 6 to 12 month old Bali calves is approximately 0.65 kg/d. Simple feeding strategies which are available to farmers can potentially increase growth rates of Bali calves from 0.1 - 0.2 kg/d, under prevailing feeding scenarios, to over 0.4 kg/d. These strategies include the provision of feeds high in protein, such as *Leucaena leucocephala*, *Sesbania grandiflora* or copra meal and rice bran. At low levels of inclusion (10 g DM/kg W/d) these protein supplements resulted in financially beneficial increases in live weight gain. In Australia, studies were conducted to investigate strategies to increase microbial protein (MCP) production of cattle grazing low quality forages. It was demonstrated that ruminants fed low quality, tropical forages had lower MCP and efficiency of MCP production (EMCP) compared to ruminants fed high quality forages. It was concluded that rumen degradable protein (RDP) was the primary factor limiting EMCP, irrespective of the source of nitrogen. High EMCP was associated with a short retention time in the rumen and high feed intake. Once RDP is no longer limiting EMCP, a source of RDP rich in true protein, nucleic acids, fatty acids, vitamins and minerals, such as Spirulina algae, enabled higher EMCP to be achieved.

While the strategy of early weaning of Bali calves will increase reproductive efficiency within the herd, strategic supplementation will provide small-holders with more flexibility in their cattle marketing options and provide better utilisation of scarce high quality feed resources. These strategies can be successfully implemented by small-holders within the complex crop-livestock systems which exist across eastern Indonesia. Small-holder farmers who participated and visited on-station and village demonstration activities indicated that their involvement changed their perceptions of calf management and would consider adopting a preferential supplementation strategy of early weaned calves due to its ease of implementation, increased calf growth rates and opportunities for increased profits.

The engagement of scientists previously trained in Australia and young scientists and honours students provided an opportunity to continue the professional development of experienced scientists and to develop the capacity of the next generation of ruminant nutrition researchers. The integration of a diverse group of organizations provided an opportunity for sharing of ideas and resources between organizations which may not have previously had the opportunity to interact. This research network approach will improve the efficiency and effectiveness of research and dissemination of findings in the future. The involvement of farmers in the project was critical to the successful demonstration and likely adoption of research findings.

3 Background

This project supported the Indonesian government's initiative to increase beef cattle production across the eastern islands of Indonesia. This project specifically focused on feeding strategies to enhance growth of the early weaned Bali calf whilst building capacity of Indonesian scientists to conduct farmer relevant ruminant nutrition research.

The Indonesian government has placed a high priority on increasing domestic beef cattle production (Percepatan Pencapaian Swasembada Daging Sapi 2010, P2SDS). Domestic beef consumption is presently increasing at approximately 4% per annum (Indonesian Department of Agriculture, 2007). Under the present beef cattle production systems domestic demand for beef is unable to be met from local supply alone. Small-holder farmers within the crop-livestock systems of eastern islands of Indonesia have the potential to meet this increased local demand for beef; with Bali cattle (*Bos sondaicus*) the predominant breed in this region. However, the Indonesian government has also recently stated that all available land should be used for food production (Bamualim *et al*., 2007), placing increasing pressure on land and feed resources for the proposed expansion of the domestic beef industry.

A previous ACIAR initiative (AS2 2000 103) successfully introduced an Integrated Village Management System (IVMS) into villages in Nusa Tenggara Barat (Panjaitan *et al*., 2008). The IVMS matches feed supply with the nutrient demands of animals and is based on natural mating of Bali cows over a restricted period of time and early weaning of the calf at 5 to 6 months of age, to increase conception rate, calf output and farmer cash flow. The key to the IVMS is early weaning of the calf to remove the increased nutrient demands imposed on the cow during lactation. Early weaning allows the cow to recover body condition for her subsequent lactation and to increase the likelihood of a fast re-conception, under only moderate feed inputs. This strategy allows less abundant high quality feeds to be directed to the weaned calf. The scenario promotes more efficient feed resource utilisation as a smaller amount of high quality feed is required for growth of the calf, compared with the joint requirements of the lactating cow with growing calf at foot. Other benefits of early weaning and preferential feeding of the calf include flexibility in cattle marketing and labour savings. Components of the IVMS are currently been scaled-up across Nusa Tenggara Barat (NTB; SMAR 2006 096) and Sulawesi Selatan (Sulsel, South Sulawesi; SMAR 2006 061) with an expected overall impact of increased reproductive efficiency resulting in increased calf numbers per year.

Economic analysis of the IVMS indicated a 65% increase in farm cash flow if the IVMS was introduced and weaned calves were retained and grew at moderate levels of 0.2 kg/d, as recorded in village studies under prevailing management practices. However, a 120% increase in farm cash flow was generated if the weaned calves were retained until 12 months of age and grew at 0.36 kg/d. While this modest increase in growth rate could result in significant financial benefits to farmers, the potential to further increase growth rates, and cash flow, is unknown as no comprehensive studies of feeding and growth of Bali calves weaned at approximately 6 months of age exist under controlled experimental conditions.

It is anticipated that the scale-up initiatives in progress in NTB and Sulsel will result in increased calf numbers and financial benefits to small-holder farmers if they retain and increase growth rates of these calves. Therefore, there is a need to determine how best to manage and feed these calves to enhance their growth rates from 6 to 12 months of age. Marsetyo *et al*. (2006) reviewed the available literature regarding feeding and growth of Bali cattle and reported a large variation in growth rates across a range of experiments. However, these studies rarely investigated responses of early weaned Bali calves and were rarely conducted with intensive measures of live weight change, feed intake and the nutritive value of the feedstuffs. Presently the specific nutritional requirements of early weaned Bali calves and feeding and management strategies to enhance their growth are unknown.

A range of feed options are readily available at low-cost to small-holder farmers across eastern Indonesia (grasses, tree legumes, agro-industrial by-products). However, little is known regarding their suitability for weaned Bali cattle or the optimum combinations of feed resources. In addition, other ACIAR initiatives have integrated new feed options (forage legumes and new grass varieties) into the current crop-livestock systems across the eastern islands of Indonesia, specifically in Sulsel and NTB (LPS 2004 005), and as a relay crop within the maize production system in Nusa Tenggara Timur (NTT; SMAR 2006 003). These new feed resources may also be suitable to increase growth rates of the early weaned Bali calf; however this also requires validation under controlled experimental conditions. Some of these feed options were evaluated within this project.

The Indonesian research activities were conducted at Jawa Timur (Jatim; East Java), NTB, NTT and Sulawesi Tengah (Sulteng; Central Sulawesi) which are located across the eastern islands of Indonesia (Figure 1). The four sites were chosen as they varied significantly in terms of environmental conditions, types of feed resources available and prevailing cattle management systems. A range of locally available feeding strategies were evaluated on-station at each site. The best of these strategies were then implemented, monitored and adapted over a 6 month period in villages in each of the four different sites.

Figure 1. Location of project research activities conducted at Jawa Timur (Δ), Nusa Tenggara Barat (+), Nusa Tenggara Timur (O) and Sulawesi Tengah ( ) Indonesia.

Cattle in northern Australia and Indonesia are faced with a protein deficient diet during the dry season. Microbial crude protein is the main source of protein supplied to ruminants. Several studies report that the EMCP from tropical forages is low due to low RDP content. Increasing protein supply to the intestine is a potential means to achieve additional live weight gain of cattle grazing tropical grasses (Poppi and McLennan, 1995). Microbial crude protein production is influenced by digestible organic matter (DOM) intake and the EMCP. Increasing EMCP can be achieved through supplementation of nutrients that enhance microbial growth. As microbial protein supply is the main source of protein available to ruminant animals, strategies which can enhance MCP production will have a direct impact on live weight gain of cattle in both northern Australia and Indonesia. The Australian component of this project investigated strategies to increase MCP production in cattle. A series of studies were conducted in Australia by an Indonesian scientist (Mr

Tanda Panjaitan, John Allwright Fellow) to investigate supplementation strategies to increase MCP production of cattle fed low quality tropical forages.

A large number of Indonesian scientists have been trained in ruminant nutrition in Australia. However, they rarely have the opportunity to use these skills for the benefit of small-holder farmers when they return to Indonesia. Further, these scientists are increasingly moving into leadership roles and are involved in research management, with a dearth of young scientists available to conduct farmer relevant research. This project aimed to address these issues by re-engaging scientists previously trained in Australia, identifying and training junior scientists and undergraduate students in the conduct of farmer relevant nutrition research and to train one PhD student in ruminant nutrition research at the University of Queensland, Australia. The project also aimed to establish better collaborative linkages between research institutes across the eastern islands of Indonesia.

In conclusion, this project aimed to develop robust feeding strategies to increase growth rates of the anticipated increased number of early weaned Bali calves across eastern Indonesia. It is anticipated that this enhanced growth of calves will further increase farmer cash flows which will result from the increased rates of reproduction, a consequence of the early weaning strategy. The project did this through on-station evaluation of feeding strategies, village implementation and monitoring and a range of dissemination activities with farmers. Strategies to enhance MCP production were evaluated in Australia, with the results applicable to cattle production, both in northern Australia and Indonesia. The project continued ACIAR support of scientists previously trained in Australia and developed the capacity of younger scientists to conduct farmer relevant ruminant nutrition research.

4 Objectives

1. To develop profitable feeding options for the post-weaning growth of calves.
2. To promote and monitor the adoption of promising feeding options.
3. To develop the capacity, particularly of junior staff, in the conduct of farmer relevant nutritional research.
4. To investigate strategies to increase microbial protein production in Brahman cattle in Australia.

5 Methodology

5.1 Develop profitable feeding options for the post-weaning growth of calves

5.1.1 Review current knowledge of feeding options from the perspective of potential profitability and farmer acceptability

Existing literature and data on previous feeding and live weight gain studies with Bali cattle was reviewed, collated and presented at the 4th International Seminar on Tropical Animal Production, Gadjah Mada University, Yogyakarta, Indonesia in 2006. The review was published in the seminar proceedings and is listed in Section 10.2 of this report.

5.1.2 Conduct on-station trials that evaluate a range of feed options

A series of on-station feeding and live weight gain studies were conducted at four sites across eastern Indonesia. The research activities were conducted at the following locations (partner organisation in brackets)

- Jawa Timur (Jatim) (BCRI, Grati)
- Nusa Tenggara Barat (NTB), Lombok (University of Mataram)
- Nusa Tenggara Timur (NTT), West Timor (BPTP-NTT)
- Sulawesi Tengah (Sulteng) (Tadulako University)

During the course of this project a separate project (SMAR 2007 013) was initiated in Sulawesi Tenggara (Sultra, South East Sulawesi) in partnership with BPTP-Sultra and the University of Haluoleo. The experiments conducted at Sultra, reported in the SMAR 2007 013 Final Report, were directed towards the use of cocoa-pods as a potential feed resource for cattle but followed the same experimental procedures as described here.

The original four sites were selected as they were predominately small-holder Bali cattle production areas (or had areas with a high density of Bali cattle), so the information generated was directly applicable to regions where there is potential to increase Bali cattle production. The four sites had different environmental conditions, cattle production systems and feeding options available to farmers. The collaborating partner organisation project leader at three of the four sites had previously received post-graduate training in Australia and this allowed continued support and development of these scientists.

The on-station evaluation process at each site was similar and involved three broad stages.

Stage 1. Identification of promising feeding strategies

- List feeding strategies likely to enhance growth rates of early weaned Bali calves.
- List feeding strategies likely to be adopted by farmers.
- List potential new or novel feeding strategies, or feed resources, which could be introduced.
- Common and scientific names of all feed resources used in studies conducted in Indonesia are listed in Appendix 11.2.

- Grasses and legumes were either fed fresh (cut and carried to on-station experiment daily) or conserved as hays. Those feeds dried and fed as hay, are described as such throughout the document. All other feeds were fed fresh and this is not described further, when a feedstuff is mentioned without reference to it being fed as a hay, it should be assumed it was fed fresh. Agro-industrial by-products, concentrates, commercial feeds and grains were fed in the raw state in which they were purchased. Dry matter units are used throughout this report unless specified.

Stage 2. Development of experimental protocols for on-station research activities

- General experimental protocols developed to measure live weight gain, feed intake, digestibility and feed quality in on-station studies.
- Class of experimental animal determined.
- General experimental protocols modified depending on individual site resources and facilities.
- Ring-test established between sites for laboratory analysis of feedstuffs.
- Templates for data recording and entry and protocols for data cross checking and backing up introduced.
- General experimental protocols developed to monitor feeding and live weight gain response of cattle in villages.

Stage 3. Evaluation of feeding strategies on-station

- Three or four on-station experiments were conducted at each site.
- Three or four feeding strategies were investigated in each experiment.
- Each experiment used a randomised block design with similar experimental protocols, where animals were ranked and blocked on a full live weight at the start of each experiment and randomly allocated to pens and treatments within blocks.
- Each experiment used weaned, male Bali calves, approximately 6 months of age.
- Each experiment prepared photographic and audio visual materials of experimental activities in progress for extension purposes.
- Each experiment measured
  - Live weight, once or twice each week
  - Feed quality (dry matter, organic matter, crude protein, ash-free neutral detergent fibre, ash-free acid detergent fibre, ether extract), each week
  - Feed intake, each day
  - Digestibility, by collection of total faecal output over seven consecutive days, on three separate occasions
  - Water intake, each day during each digestibility measurement period
  - Change in wither height and chest circumference, over the experiment.

All procedures used in each of the on-station experiments and in village monitoring were conducted in accordance with the guidelines of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes and were reviewed and approved by the University of Queensland Animal Ethics Committee.

In the various studies within this report, samples of feed, refusals and faeces were analysed for dry matter, ash (AOAC, 1984), nitrogen by the Kjeldahl method, ash-free neutral detergent fibre (NDF) and ash-free acid detergent fibre (ADF) (Goering and Van Soest, 1970).

Metablisable energy content of the various feeds was estimated according to CSIRO (2007), where:

ME (MJ/kg DM) = 0.0157 x Digestible Organic Matter in Dry Matter (DOMD) (g/kg)

DOMD (g/kg) = ((OM intake (kg/d) – OM faeces (kg/d))/ DM intake (kg/d)) x 1000

All data were analysed by analysis of variance procedures in GenStat 2008 (GenStat for Windows, 11th Edition. VSN International Ltd.).

Jawa Timur (Beef Cattle Research Institute, Grati)

Three experiments were conducted at the BCRI, Grati, Jatim, between February 2006 and May 2007.

Experiment 1. The growth of early weaned Bali calves fed native grass, elephant grass, leucaena or elephant grass supplemented with leucaena.

Twenty male Bali calves, approximately 6 months of age, and 59.1 ± 1.9 kg live weight, were allocated to one of four different feeding strategies. The experiment was conducted in the late wet / early dry season and consisted of a four week preliminary period followed by an eleven week experimental period. The four experimental treatments were:

- elephant grass *ad libitum*
- elephant grass supplemented with leucaena (10 g DM/kg W/d)
- leucaena *ad libitum*
- native grass *ad libitum* (Appendix 11.2; Table 15)

Experiment 2. The growth of early weaned Bali calves fed increasing amounts of crude protein.

The same calves used in Experiment 1 were used in Experiment 2. The calves, approximately 10 months of age and 81.0 ± 3.1 kg in live weight, were allocated to one of four different feeding strategies. The experiment was conducted during the dry season and consisted of a three week preliminary period followed by an eight week experimental period. The calves were fed an elephant grass (10 to 15% of ration on dry matter basis) and concentrate ration consisting of maize grain, limestone and a mineral premix with increasing levels of soybean meal in an attempt to supply:

- 9.5% crude protein (actual 9.2% crude protein)
- 13.0% crude protein (actual 16.7% crude protein)
- 16.5% crude protein (actual 18.8% crude protein)
- 20.0% crude protein (actual 24.5% crude protein)

Experiment 3. The growth of early weaned Bali calves fed a commercially available complete feed supplemented with increasing amounts of leucaena.

Twenty male Bali calves, approximately 6 months of age, and 67.2 ± 2.3 kg live weight, were allocated to one of four different feeding strategies. The experiment was conducted in the late wet / early dry season and consisted of a two week preliminary period followed by an eight week experimental period. The four experimental treatments were:

- 'Prima feed' *ad libitum*
- 'Prima feed' and leucaena (65:35) *ad libitum*
- 'Prima feed and leucaena (35:65) *ad libitum*
- leucaena *ad libitum*

Prima feed is a commercially available, 'complete' feed in Jatim manufactured from a range of agro-industrial by-products. The ingredients of Prima feed, and hence the nutritive value, vary depending upon availability.

Nusa Tenggara Barat (University of Mataram)

Four experiments were conducted at the University of Mataram, Teaching and Research Farm, Lingsar, NTB, between February 2006 and March 2008. A long-term, growth path study was also conducted at Lingsar from February 2007 until December 2009, within SMAR 2007 013.

Experiment 1. The growth of early weaned Bali calves fed native grass, native grass supplemented with sesbania, sesbania or sesbania supplemented with rice bran.

Twenty male Bali calves, approximately 6 months of age, and 72.8 ± 1.7 kg live weight, were allocated to one of four different feeding strategies. The experiment was conducted in the late wet / early dry season and consisted of a two week preliminary period, for adaptation to diets, followed by an eight week experimental period. The four experimental treatments were:

- native grass *ad libitum*
- native grass *ad libitum* supplemented with sesbania (10 g DM/kg W/d)
- sesbania *ad libitum*
- sesbania *ad libitum* supplemented with RB (10 g DM/kg W/d)

Experiment 2. The growth of early weaned Bali calves fed sesbania, leucaena, moringa and gliricidia (plus sesbania) hay.

The same Bali calves used in Experiment 1 were used in Experiment 2. The calves, approximately 9 months of age and 89.6 ± 3.2 kg in live weight were allocated to one of four different feeding strategies. The experiment was conducted during the dry season and consisted of a two week preliminary period, for adaptation to diets, followed by a ten week experimental period. The four experimental treatments were:

- sesbania hay *ad libitum*
- leucaena hay *ad libitum*
- moringa hay *ad libitum*
- gliricidia hay *ad libitum* supplemented with sesbania hay (10 g DM/kg W/d)

Experiment 3. The growth of early weaned Bali calves fed grasses and forage legumes.

Twenty Bali calves approximately 6 months of age and 80.6 ± 2.5 kg in live weight were allocated to one of four different feeding strategies. The experiment was conducted in the late dry / early wet season and consisted of a two week preliminary period, for adaptation to diets, followed by an eight week experimental period. The four experimental treatments were:

- *Brachiaria mulato ad libitum* (mulato)
- King grass *ad libitum*
- *Stylosanthes hamata* cv. verano hay *ad libitum* (stylosanthes)
- *Centrosema pascuorum* hay *ad libitum* (centrosema)

Experiment 4. The growth of early weaned Bali calves fed Brachiaria mulato and Brachiaria mulato with various supplements.

The same 20 Bali calves used in Experiment 3 were used in Experiment 4. The calves, approximately 9 months of age and 89.5 ± 3.1 kg in live weight, were allocated to one of four different feeding strategies. The experiment was conducted in the wet season and consisted of a two week preliminary period, for adaptation to diets, followed by a five week experimental period. The four experimental treatments were:

- Mulato *ad libitum*
- Mulato *ad libitum* plus sesbania (10 g DM/kg W/d)
- Mulato *ad libitum* plus stylosanthes hay (10 g DM/kg W/d)
- Mulato *ad libitum* plus RB (10 g DM/kg W/d)

Nusa Tenggara Timur (University of Nusa Cendana)

One experiment was conducted at the Noelbaki farmer training centre, Kupang, NTT, between March and June 2006.

Experiment 1. The growth of early weaned Bali calves fed leucaena and forage legumes.

Twenty male Bali calves, approximately 6 months of age, and 71.1 ± 1.5 kg live weight, were allocated to one of four different feeding strategies. The experiment was conducted during the late wet/early dry season and consisted of a four week preliminary period, for adaptation to diets, followed by a nine week experimental period. The four experimental treatments were:

- Native grass hay *ad libitum*
- Native grass hay *ad libitum* supplemented with leucaena (10 g DM/kg W/d)
- leucaena *ad libitum*
- leucaena *ad libitum* supplemented with palm pith (10 g DM/kg W/d)

Nusa Tenggara Timur (Balai Pengkajian Teknologi Pertanian)

Three additional experiments were conducted at Lili Research Station NTT (BPTP-NTT), between July 2007 and March 2008.

Experiment 2. The growth of early weaned Bali calves fed leucaena and forage legumes.

Twenty male Bali calves, approximately 6 months of age, and 72.5 ± 2.0 kg live weight, were allocated to one of four different feeding strategies. The experiment was conducted during the dry season and consisted of a one week preliminary period, for adaptation to diets, followed by a seven week experimental period. The four experimental treatments were:

- *Centrosema pascuorum* hay *ad libitum*
- *Clitoria ternatea* hay *ad libitum*
- *Desmodium* spp. hay *ad libitum*
- Leucaena *ad libitum*

Experiment 3. The growth of early weaned Bali calves fed crop residues and crop residues with rice bran and leucaena supplementation.

The same Bali calves used in Experiment 2 were used in Experiment 3. The calves, approximately 9 months of age and 84.0 ± 2.9 kg in live weight, were allocated to one of four feeding strategies. The experiment was conducted during the dry season and consisted of a four week experimental period. The four experimental treatments were:

- corn stover *ad libitum*
- mungbean stover *ad libitum*
- mungbean stover *ad libitum* supplemented with RB (10 g DM/kg W/d)
- mungbean stover *ad libitum* supplemented with leucaena (10 g DM/kg W/d)

Experiment 4. The growth of early weaned Bali calves fed leucaena and leucaena supplemented with rice bran or maize grain.

The same Bali calves used in Experiments 2 and 3 were used in Experiment 4. The calves, approximately 11 months of age and 94.5 ± 3.1 kg in live weight, were allocated to one of four feeding strategies. The experiment was conducted during the wet season and consisted of a two week preliminary period, for adaptation to diets, followed by an eight week experimental period. The four experimental treatments were:

- leucaena *ad libitum*
- leucaena *ad libitum* supplemented with RB (10 g DM/kg W/d)
- leucaena *ad libitum* supplemented with maize grain (10 g DM/kg W/d)
- leucaena *ad libitum* (without rumen fluid drench)

Animals offered leucaena *ad libitum* or leucaena *ad libitum* supplemented with RB or maize grain were drenched with rumen fluid (RF drench) collected from a mature Bali bull, which had previously been fed leucaena and tested negative for the presence of 3-hydroxy-4(1H)-pyrodine (3,4-DHP) in the urine, indicative of the presence of Synergesti jonesii (Jones, 1997). Animals offered the leucaena *ad libitum* (without rumen fluid drench) treatment received no rumen fluid drench but were fed the same leucaena as the other treatments.

Sulawesi Tengah (Tadulako University)

Three experiments were conducted at the Tadulako University, Experimental Farm, Palu, Sulteng, between February 2006 and February 2007.

Experiment 1. The growth of early weaned Bali calves fed native grass or native grass supplemented with rice bran or rice bran plus copra meal.

Eighteen male Bali calves, approximately 6 months of age, and 91.8 ± 3.5 kg live weight, were allocated to one of three different feeding strategies. The experiment was conducted in the late wet / early dry season and consisted of a two week preliminary period, for adaptation to diets, followed by an eight week experimental period. The three experimental treatments were:

- native grass *ad libitum*
- native grass *ad libitum* supplemented with rice bran (RB; 10 g DM/kg W/d)
- native grass *ad libitum* supplemented with a mixture of rice bran and copra meal in equal proportions (RBCM; 10 g DM/kg W/d)

Experiment 2. The growth of early weaned Bali calves fed elephant grass hay, elephant grass hay plus gliricidia or gliricidia.

The same calves used in Experiment 1 were used in Experiment 2. The calves, approximately 9 months of age and 105.3 ± 4.8 kg in live weight, were allocated to one of three different feeding strategies. The experiment was conducted during the dry season and consisted of a two week preliminary period, for adaptation to diets, followed by an eight week experimental period. The three experimental treatments were:

- elephant grass hay *ad libitum*
- elephant grass hay *ad libitum* supplemented with gliricidia (10 g DM/kg W/d)
- gliricidia *ad libitum*

Experiment 3. The growth of early weaned Bali calves fed corn stover or corn stover supplemented with gliricidia or supplemented with rice bran plus copra meal.

Fourteen calves used in Experiment 2 were used in Experiment 3. The four largest calves at the completion of experiment 2 were replaced with four calves of similar age and live weight to the remaining calves to be used in experiment 3. The calves, approximately 12 months of age and 108.9 ± 4.7 kg in live weight, were allocated to one of three different feeding strategies. The experiment was conducted in the late dry / early wet season and consisted of a two week preliminary period, for adaptation to diets, followed by an eight week experimental period. The three experimental treatments were:

- corn stover *ad libitum*
- corn stover *ad libitum* supplemented with gliricidia (10 g DM/kg W/d)
- corn stover *ad libitum* supplemented with RBCM (10 g DM/kg W/d)

5.2 Promote and monitor the adoption of promising feeding options

5.2.1 Initiate farmer interest in feeding options through their involvement in the on-station research activities

During each on-station experiment, small-holder farmers from local villages were invited to visit the experiment. Farmers were introduced to the project, with information on the importance of early weaning and strategic feeding of the calf presented with results from the on-station experiment in progress. Depending on the site, farmers also received training on bhokasi fertiliser production by composting faeces, measuring live weight with cattle scales, establishment of forages and hay making. At the completion of the visit a survey was conducted with individual farmers to gather information on their current cattle management system and to ascertain their perceptions of early weaning and the feeding strategies they were presented with during the day.

5.2.2 Undertake on-farm demonstration of feeding options

At each of the four sites a best-bet feeding strategy was introduced into a village within the crop-livestock system. The feeding strategy was implemented, monitored and adapted over a minimum period of 6 months. Upon completion a farmer demonstration day was held and the results of the on-farm demonstration and on-station studies were disseminated to participating and visiting farmers and, in some cases, extension officers and government officials.

Jawa Timur (Beef Cattle Research Institute, Grati)

Based on the results of the three on-station studies conducted at the BCRI, Grati and the availability and price of feedstuffs for farmers it was decided that the best-bet feeding strategy to enhance the growth of weaned Bali calves in Jatim was leucaena supplementation. This activity also included the establishment of larger areas of leucaena in villages in Jatim.

An initial scoping trip to Prigen sub-district, Pasuruan district identified two suitable villages to participate in the on-farm experiment. Nganti village was identified as the control village, while Sukolilo village was identified as the intervention village. The two villages were approximately 5 km apart and experienced similar climatic conditions during the study. The study was conducted between August 2007 and February 2008 and has been described in detail by Pamungkas *et al*. (2008).

Nganti sub-village (Control). Bali calves (n=15 males; n=5 females), aged approximately 6 months (195 ± 5 days) and 87 ± 2 kg live weight were given an individual identification number and treated for internal and external parasites with 2 mL of Valbazen. These cattle were maintained under normal feeding management practices, consisting of native grass (70%), rice straw (10%), corn stover (5%) and other crop residues (15%) fed to calves tethered permanently in fully enclosed, individual farmer kandangs. Calf live weight was recorded once each month over a 6 month period, and average daily gain was determined.

Sukolilo village (Intervention). Weaned Bali calves (n=12 males; n=8 females), aged approximately 6 months (189 ± 4 days) and 85 ± 2 kg live weight were given an individual identification number and were treated for internal and external parasites with 2 mL of Valbazen. Those animals not previously weaned were removed from their mothers for an initial separation period of at least three weeks. Leucaena was distributed to individual farmers in daily allowances of 10 g DM/kg W/d, such that each animal was allocated a daily feed allowance bundle of leucaena leaves. The amount of leucaena offered was adjusted at each monthly weighing. Farmers were required to feed leucaena leaves prior to the usual feeding management of their calves. The normal feeding management of this class of cattle in Sukolilo village consisted of native grass (50%), elephant grass (26%), rice straw (12%), corn stover (5%) and crop residues (7%) fed to calves tethered permanently in fully enclosed, individual farmer kandangs. Calf live weight was recorded once each month over a 6 month period and average daily gain was determined.

The economic evaluation of the leucaena supplementation strategy was based on the assumptions cattle live weight was valued at 30,000 rupiah/kg, and that the price of leucaena leaves was fixed at 200 rupiah/kg on an as fed basis; the typical basal forages in these villages were valued at 150 rupiah/kg on an as fed basis. Farmers in the two villages were surveyed at the commencement and conclusion of the 6 month monitoring period.

Nusa Tenggara Barat (University of Mataram)

Based on the results of the four on-station studies conducted at the University of Mataram and the availability and price of feedstuffs for farmers it was decided that the best-bet feeding strategy to enhance the growth of weaned Bali calves in NTB was sesbania supplementation.

Three suitable villages in Central Lombok were selected to participate in the on-farm experiment. Kelebuh and Sukaraja villages were identified as control villages, while Tandek was identified as the intervention village. The treatment and control villages were approximately 7 km apart, with Tandek typically experiencing a higher rainfall. The study was conducted between April and October, 2008.

Kelebuh and Sukaraja villages (Control). Bali calves (n=15 males; n=5 females), aged approximately 8-9 months and 121.0 ± 4.9 kg live weight were given an individual identification number. These cattle were maintained under normal feeding management practices, consisting of native grass and gliricidia. Cattle were typically maintained in a communal kandang overnight before moving to the farmer's individual kandang or tethered on bunds or roadsides, during the day. Calf live weight was recorded once each month over a 6 month period and average daily gain was determined.

Tandek village (Intervention). Weaned Bali calves (n=13 males; n=12 females), aged approximately 9 months (251.8 ± 6.1 days) and 109.2 ± 4.5 kg live weight were given an individual identification. Those animals not previously weaned were removed from their mothers for an initial separation period of at least three weeks. Farmers collected a daily allocation of sesbania from their own plots each morning and offered the equivalent of 10 g sesbania DM/kg W/d to each calf prior to their usual feeding management. The amount of sesbania was checked randomly several times each week throughout the experiment. The amount of sesbania offered was adjusted at each monthly weighing. The normal feeding management of this class of cattle in Tandek village consisted of native grass and sesbania, when available, usually fed as single feeds rather than in combination. Cattle were typically maintained in a communal kandang overnight before moving to the farmer's individual kandang or tethered in backyards or on bunds or roadsides, during the day. Calf live weight was recorded once each month over a 6 month period and average daily gain was determined.

The economic evaluation of the sesbania supplementation strategy was based on the assumptions cattle live weight was valued at 35,000 rupiah/kg, and that the price of sesbania was fixed at 350 rupiah/kg on an as fed basis; the typical basal forages in these villages were valued at 250 rupiah/kg on an as fed basis. A field day was held at Tandek and farmers from Tandek, Kelebuh and Sukaraja and other villages in Central Lombok were surveyed at the conclusion of the 6 month monitoring period.

Nusa Tenggara Timur (BPTP-NTT)

Based on the results of the four on-station studies conducted in NTT and the availability and price of feedstuffs for farmers and the likely wide-scale incorporation of forage legumes into the maize cropping system in NTT it was decided that the best-bet feeding strategies to enhance the growth of weaned Bali calves would be leucaena (treatment 1) or forage legume (treatment 2) supplementation.

Two villages were selected which were already co-operating farmers within SMAR 2006 and had established, or had the potential to establish, areas of forage legume for long-term feeding studies. The villages were Oebola in Timor Tengah Selatan district and Usapinonot in Timor Tengah Utara district. The villages were approximately 130 km apart; with Usapinonot having less local forages available and a more severe dry season. Due to the extremely different conditions in the two villages it was decided to monitor the two treatments and controls in both villages, as opposed to the other sites which established separate treatment and control villages. The study was conducted between April and September 2008 in Oebola and between April 2008 and November 2009 in Usapinonot.

In Oebola the calves were 98.9 ± 3.5 kg at the commencement of the study, while in Usapinonot the calves were 69.3 ± 3.6 kg. In both villages, control animals were unweaned and maintained under normal feeding practices, which consisted of native grass, local legumes and leucaena in Oebola (n=5), and native grass, jackfruit leaves, kapok leaves, ficus, Acacia leucophloea and banana stem in Usapinonot (n=5). In each village, treatment animals were offered either leucaena at 15 g DM/kg W/d (n=5 in Oebola; n=6 in Usapinonot) or forage legumes at 15 g DM/kg W/d (n=5 in Oebola; n=5 in Usapinonot) prior to commonly available and typically used feedstuffs *ad libitum*. While the amount of forage legume was set at approximately 15 g DM/kg W/d throughout, the species used varied throughout the experiment. The forage legume species used included *Clitoria ternatea*, *Centrosema pascuorum*, *Stylosanthes* spp. and *Lab-lab purpureus* and were fed as hays. In both villages, treatment and control calves were weighed fortnightly from April to September 2008; fortnightly monitoring continued in Usapinonot until November 2008, and live weight gain was determined.

The economic evaluation of the leucaena and forage legume supplementation strategies were based on the assumptions cattle live weight was valued at 24,000 rupiah/kg, and that the price of leucaena / forage legume was fixed at 250 rupiah/kg on an as fed basis; the typical basal forages in these villages were valued at 250 rupiah/kg on an as fed basis. A field day was held at Usapinonot at the conclusion of the seven month monitoring period and participating and visiting farmers were surveyed.

Sulawesi Tengah (Tadulako University)

Based on the results of the three on-station studies conducted at Tadulako University and the availability and price of feedstuffs for farmers it was decided that the best-bet feeding strategy to enhance the growth of weaned Bali calves in Sulteng was supplementation with a mixture of rice bran and copra meal.

An initial scoping trip to Donggala district, Sulteng province, identified two suitable villages to participate in the on-farm evaluation. Lembah Mukti village, was identified as the control village, while Malonas village was identified as the intervention village. The two villages were approximately 10 km apart and experienced similar climatic conditions during the study. A description of the climatic conditions, crop-livestock system and cattle herd structure are provided in detail elsewhere (Damry *et al*., 2009). The study was conducted between February and August, 2007.

Lembah Mukti village (Control). Bali calves (n=9 males; n=11 females), aged approximately 6 months (194 ± 5 days) and 83 ± 3 kg live weight were given an individual identification number and were treated for internal and external parasites with 2 mL of Ivomec and 3 mL of vitamin B complex. No other interventions were implemented at this village. The normal feeding management of this class of cattle in Lembah Mukti village consisted of calves tethered or free grazing native grass on roadsides or on areas surrounding crops and plantations. Calf live weight was recorded once each month over a 6 month period, and average daily live weight gain was determined.

Malonas village (Intervention). Bali calves (n=8 males; n=12 females), aged approximately 6 months (186 ± 5 days) and 85 ± 3 kg live weight were given an individual identification number and were treated for internal and external parasites with 2 mL of Ivomec and 3 mL of vitamin B complex. Those animals not previously weaned were removed from their mothers for an initial separation period of at least three weeks. Rice bran and copra meal were mixed in equal proportions (50:50, on an as fed basis), which was then distributed to individual farmers in daily allowances, of 10 g DM/kg W/d, such that each animal was allocated a daily feed allowance package. The amount of supplement offered was adjusted at each monthly weighing. Farmers were required to feed this supplement to the calves in the kandang, prior to their usual feeding management. Calves in Malonas had never been fed copra meal previously and 2 to 3 days were required for adaptation to the treatment. The normal feeding management of this class of cattle in Malonas village consisted of calves tethered or free grazing native grass on roadsides or on the areas surrounding crops and plantations. Calf live weight was recorded once each month over a 6 month period and average daily live weight gain was determined.

The economic evaluation of the rice bran and copra meal supplementation strategy was based on the assumptions that live weight was valued at 30,000 rupiah/kg, and that the price of rice bran and copra meal were fixed at 400 and 900 rupiah/kg on an as fed basis, respectively. Farmers in the two villages were surveyed at the commencement and conclusion of the 6 month monitoring period. There were 16 control farmers and 17 intervention farmers from the two villages who responded to the questionnaires.

5.2.3 Economic analysis of feeding strategies

Several approaches are available to quantify the economic benefits of new animal technology. In this project the new technology is the development of robust feeding strategies to increase growth rates of the anticipated increased number of early weaned Bali calves across eastern Indonesia. A partial budget analysis is one approach which is simple to use and provides information about changes in the costs and benefits caused by implementation of the feeding strategies (Amir and Knipscheer, 1989). Partial budget analysis balance and examine the total gains (benefits) and losses (costs) that can be affected by the growth rate of animals over a specific time period. The major production costs will be feed-related, so that different feeding strategies can be economically evaluated based on profit, which is defined as return per unit of production minus the production and implementation costs.

Growth rate of animals is usually highly correlated with feed efficiency, in which this is illustrated by rearing animals to a certain period of age. Based on the growth rate, the profit above feed cost can be estimated as follows (Weller, 1994),

$$I = \Delta Q * PQ - k * Pk$$

Where,

I = profit above feed cost (Rupiah/period)

ΔQ = growth rate of the weaned calf (kg/d)

k = total amount of feed (kg/d)

Pk = price of feed cost (Rupiah/d)

PQ = price of cattle (Rupiah/kg live weight)

The production cost is essentially the feed costs for the given feeding strategies estimated using the current market price for each component. The labor cost to manage and feed the animals was not taken into account as this was considered as an opportunity cost. The gains on the growth rate multiplied by the rearing period and the cattle market price will generate the revenue and yield a profit above feed cost. Partial budget analysis was conducted for each of the on-station and on-farm feeding studies.

5.3 Develop the capacity, particularly of junior staff, in the conduct of farmer relevant nutritional research

The project aimed to develop the capacity of the human resources of the project team at several levels

- Engage scientists previously trained in Australia in the project to continue their development
- Appoint junior scientists at each site, to receive mentoring in ruminant nutrition research from the site project leader and from the Australian research team members. The junior scientists would ultimately become responsible for the day to day conduct of the on-station experiments
- Provide all project team members with the opportunity to attend a range of national and international meetings, training workshops, seminars and conferences
- Involve undergraduate students in the on-station experiments at each site. These students prepared their Honours thesis based on the experiments conducted within this project. This provided the next generation of livestock scientists with an opportunity to receive training in ruminant nutrition research from experienced Indonesian and Australian researchers
- One Indonesian scientist received a John Allwright Fellowship to conduct PhD studies at the University of Queensland on associated cattle nutrition studies. The JAF underwent rigorous training in all aspects of ruminant nutrition research
- Frequent communication and visits between Australian and Indonesian project team members to develop the capacity of Indonesian and Australian staff involved in the project
- Facilitate interaction and linkages between research organisations and scientists in the field of ruminant nutrition research across eastern Indonesia

5.4 Investigate strategies to increase microbial protein production in Brahman cattle in Australia

A series of feed intake and metabolism studies were conducted to investigate strategies to increase MCP production and the EMCP of Brahman cross steers fed low quality tropical grasses. The studies generated baseline MCP production data on a range of grasses, including low quality forages, and then evaluated supplementation strategies to enhance MCP production. All studies were conducted at the University of Queensland, Mt. Cotton Research Farm (27°31'S, 153°14'E) between February 2005 and September 2007. Procedures used in each of the experiments were conducted in accordance with the guidelines of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes and were reviewed and approved by the University of Queensland Animal Ethics Committee. Detailed materials and methods are described elsewhere (Panjaitan, 2009), only a brief description of the animals, treatments and variables measured is provided in this report. The work has direct implications for cattle production in Indonesia, and more specifically the research activities of the present project where strategies to increase MCP production are applicable to the overarching aim of increasing growth of early weaned Bali cattle. The research conducted in Australia was carried out by Mr Tanda Panjaitan as part of his PhD studies. Conducting the studies in Australia provided Mr Panjaitan with resources, facilities and training which may not have been readily accessed in Indonesia, thereby further developing the capacity of Indonesian scientists to conduct ruminant nutrition research.

The experiments were conducted in conjunction with, and jointly funded by, a MLA funded project "Increased efficiency of microbial protein production in the rumen through manipulation of nutrients and rumen microbial populations". In experiments 1, 3, 4 and 5 below, samples were collected from the rumen of all steers for determination of the microbial genetic profile (MGP) by denaturing gradient gel electrophoresis (DGGE) to be reported to MLA. Experiments 1 and 5 were funded by MLA, experiments 2 and 6 by ACIAR and experiments 3 and 4 were jointly funded by MLA and ACIAR. The experiments are reported in their entirety here as they represent the work conducted by Mr Panjaitan for his PhD studies while he was funded by ACIAR as a John Allwright Fellow.

Experiment 1. Effect of forage type on intake, digestibility, retention time, microbial protein production and the efficiency of microbial protein production in cattle.

Microbial protein production and the EMCP was determined in steers fed low quality, tropical speargrass (*Heteropogon contortus*) and Mitchell grass (*Astrebla* spp) hays, medium quality, tropical pangola grass (*Digitaria eriantha*) hay and high quality, temperate ryegrass (*Lolium multiflorum* cv. aristocrat) hay. Eight rumen-cannulated Brahman cross steers (424 ± 37 kg) were randomly allocated to one of four forage treatments, in two 4x4 latin squares (four forages x four runs). Steers were fed treatment forages *ad libitum*. Feed intake, digestibility, retention time of liquid and solid markers in the rumen, rate of digestion, rumen pH, rumen ammonia and volatile fatty acid concentrations and MCP production, estimated by measuring urinary purine derivatives, were determined.

Experiment 2. The effect of different sources of nitrogen on the digestion rate of forages varying in quality.

The rate of disappearance of speargrass, Mitchell grass and ryegrass hays were determined in the rumen of Brahman cross steers fed a speargrass basal diet supplemented with various sources of nitrogen (urea, cottonseed meal, casein, yeast, algae, amino acids). The speargrass hay supplied 35 g RDP/kg DOM, while nitrogen sources were supplied to provide approximately 170 g RDP/kg DOM. The dry matter disappearance of speargrass, Mitchell grass and ryegrass forages was determined by incubation in nylon bags in the rumen of steers for 0 to 96 h. Rumen pH, rumen ammonia and volatile fatty acid concentrations and plasma urea nitrogen were determined.

Experiments 3 and 4. The effect of rumen degradable protein or specific amino acids on microbial protein production in cattle fed low and medium quality tropical forages.

The effect of increasing levels of non-protein nitrogen (US), a highly degradable source of protein (casein) and non-protein nitrogen plus branched chain amino acids and phenylalanine (USAA) on MCP production and the EMCP of cattle fed low and medium quality tropical forages were determined. Thirteen rumen-cannulated Brahman cross steers (219 ± 9 kg) were randomly allocated to supplement treatment levels in an incomplete Latin square design, consisting of four levels of each of the three supplements, plus one control, over three runs when fed a medium quality pangola grass hay. The steers were then reallocated to supplement levels and fed a low quality Mitchell grass hay, under the same design as above. Steers were fed both hays *ad libitum* during the preliminary period and at 90% of *ad libitum* intake during the measurement period. Feed intake, digestibility, retention time of liquid and solid markers in the rumen, rate of digestion, rumen pH, rumen ammonia and volatile fatty acid concentrations and microbial protein production, estimated by measuring urinary purine derivatives, were determined.

Experiment 5. The effect of Spirulina platensis on microbial protein production and the efficiency of microbial protein production in cattle fed a low quality tropical forage.

The effect of increasing levels of single cell protein or non-protein nitrogen supplements on the EMCP of cattle fed low quality Mitchell grass hay was determined. Nine rumen-cannulated Brahman cross steers (271 ± 17 kg) were randomly allocated to supplement treatment levels in an incomplete Latin square design, consisting of four levels of each of two supplements plus one control with no supplement, over three consecutive runs. The two supplements used were urea plus ammonium sulphate (US), mixed with the daily hay offered, and *Spirulina platensis* (Spirulina), administered through the cannula. Steers were fed Mitchell grass hay *ad libitum* during the preliminary period and at 90% of *ad libitum* intake during the measurement period. Feed intake, digestibility, retention time of liquid and solid markers in the rumen, rate of digestion, rumen pH, rumen ammonia and volatile fatty acid concentrations and microbial protein production, estimated by measuring urinary purine derivatives, were determined.

Experiment 6. The effect of increasing concentration of Spirulina platensis in the drinking water on its acceptability and the proportion bypassing the rumen of cattle fed a low quality tropical forage.

The effect of including increasing amounts of a single cell protein source in the drinking water of cattle on feed and water intake, water by-passing the rumen and water acceptability was determined. Five rumen-cannulated Brahman cross steers (219 ± 9 kg) were randomly allocated to treatments in a 5 x 3 incomplete Latin square design (five treatments x three runs). Steers were fed low quality pangola grass hay. Increasing amounts (0%, 1.0%, 2.0%, 2.7% and 3.5%) of Spirulina algae were added to a fixed amount of drinking water offered to animals at the same time each day, for approximately 3 hours or until completed. Daily drinking water intake, with and without Spirulina, and feed intake were determined. In addition, the amount of drinking water containing Spirulina by-passing the rumen was determined by measuring the amount of Cr-EDTA labelled water with treatment levels of Spirulina consumed and the amount which was present in the rumen. Finally, the preference of steers for drinking water containing Spirulina was compared with their preference for drinking water without Spirulina.

6 Achievements against activities and outputs/milestones

Objective 1: To develop profitable options for post-weaning growth of calves

no.	activity	outputs/ milestones	completion date	comments
1.1	Review current knowledge of feeding options from the perspective of potential profitability and farmer acceptability.	Data collated within 4 months of start. Journal publications (ICARD) and national seminar.	November 2006	Review entitled 'Growth performance of young Bali cattle under various feeding management' (Marsetyo, Pamungkas and Priyanti) was presented at the "4th International Seminar on Tropical Animal Production", Gadjah Mada University, Yogyakarta, 2006. The review was published in the seminar proceedings.
1.2	Conduct on-station trials that evaluate a range of feed options taking account of seasonal feed availability and options developed in 04/005 and 02/080.	Intake, digestibility and growth rates measured from at least three feeding trials at each of the four sites.	March 2008	A total of 14 individual experiments were conducted. Each experiment measured feed intake, digestibility and live weight gain of weaned male Bali calves. A total of 53 different feeding strategies (i.e. treatments) were evaluated; some treatments were repeated between sites. On-station activities were conducted at geographically diverse regions across eastern Indonesia. This allowed feeding strategies to be developed within the context of different environmental conditions, different cattle management systems and different feed resources.

Objective 2: To promote and monitor the adoption of promising feeding options

no.	activity	outputs/ milestones	completion date	comments
2.1	Initiate farmer interest in feeding options through their involvement in the on-station research activities.	About 100 farmers per site visit on-station experiments and discuss results and options. Video and other visual aids used to document/record the results.	March 2008	Farmers visited each on-station experiment. Surveys were conducted to ascertain their current cattle herd structure, cattle management and farming system and their general perceptions of the experimental feeding strategies evaluated. Photographic and audio visual materials of experimental activities were generated during each experiment. These materials were used in farmer engagement activities.
2.2	Undertake on-farm demonstration of feeding options through linkages with projects 04/005 and 02/080.	Up to 20 on-farm demonstrations established at each of the 4 sites. Information on the growth of the calves, all aspects of resource use and financial returns monitored. Involvement of scientists in farmer relevant research.	December 2008	At each site at least 20 calves were introduced to a best-bet feeding strategy. This strategy included weaning the calf at 6 months of age, feeding the calf a best-bet feeding strategy and monitoring calf live weight over a 6 month period (i.e. weaned calves were fed feeding strategies from 6 to 12 months of age). Farmers were surveyed at the start and end of the period. Perceptions of feeding strategy and likely adoption were gathered. Economic data was collected and benefit-cost analysis conducted. At each site, senior and junior scientists were actively involved in on-farm research.

2.3	Publication of on-farm results linked with the promotion and training activities of projects 04/005 and 02/080.	Farmer orientation publications. National seminar presentations. Best practice material for DINAS staff and train the trainer program 02/081	December 2008	Preliminary results have been published and have been extended through reviews presented at National and International seminars. Relevant information has been included in newsletters distributed to farmers, scientists and extension staff through SMAR 2006 096.

Objective 3: To develop the capacity, particularly of junior staff, in the conduct of farmer relevant nutritional research

no.	activity	outputs/ milestones	completion date	comments
3.1	Mentoring of junior scientists by senior Indonesian scientists	The development and contribution to Indonesia of scientists recently trained in Australia is sustained. Junior staff trained in the conduct of farmer relevant research for development.	November 2008	The Indonesian partner organisation project leader at three of the four sites had received postgraduate training in Australia (Dr Marsetyo, Tadulako University; Dr Dahlanuddin, University of Mataram; Dr Esnawan Budisantoso; BPTP NTT). An Australian trained John Dillon Fellow (Dr Atien Priyanti) was also involved in the management of the project, particularly activities at the Beef Cattle Research Institute. Dr Priyanti also conducted the socio-economic analysis and interpretation of the projects impact. At each site, at least one junior scientist was appointed. The junior scientists were mentored by the project leader at each site and over time took responsibility for the day to day management of the project activities. They closely liaised with the Indonesian project leaders, Australian scientists and farmers in the conduct of the project activities. All senior and junior staff involved in the project were provided with the opportunity to attend various ACIAR training workshops during the course of the project.
3.2	Involve honours and postgraduate students in on-farm and on-station research and monitoring	Honours and postgraduate qualifications obtained in association with the Indonesian research program.	March 2008	51 undergraduate students were involved in the project on-station experiments for their Indonesian honours programs. Thirty-five of these honours students provided an abstract of their thesis in English; these students received a non-award certificate from the University of Queensland in appreciation of their contribution to the project. These abstracts have been compiled into a small booklet and distributed to the partner organisations and the collaborating universities. The students were enrolled at Tadulako University (Sulteng), University of Mataram (NTB), University of Nusa Cendana (NTT) and Brawijaya University (Jawa Timur).

Objective 4: To investigate strategies to increase microbial protein production in Brahman cattle in Australia

no.	activity	outputs/ milestones	completion date	comments
4.1	Conduct experiments which measure rate of digestion and microbial protein production in Brahman cattle, complementing MLA funded experiments in a separate project.	The efficacy of various nutrients (e.g. degradable protein, amino acids, branched chain fatty acids, nucleic acids) to increase rate of digestion and microbial protein production will be assessed. A wider range of nutrients can be assessed than can be met by funding from MLA or ACIAR alone.	June 2008	Mr Tanda Panjaitan (John Allwright Fellow) conducted 6 separate experiments, as part of his PhD program at the University of Queensland, to investigate feeding strategies to increase microbial protein production of Brahman cattle grazing low quality tropical pastures. The thesis was submitted on the 20th June 2008. Experiments determined microbial protein production in a range of forages, typically found in grazing systems in northern Australia. Experiments then investigated response of microbial protein production to increasing levels of a range of supplements (non-protein nitrogen, branched chain amino acids and single cell protein sources). Supplementation with a single cell protein source had the greatest positive effect on feed intake and microbial protein production. Samples from all these experiments were collected for analysis of the microbial genetic profile to be conducted with MLA funds.

7 Key results and discussion

7.1 Develop profitable feeding options for the post-weaning growth of calves

7.1.1 Review current knowledge of feeding options from the perspective of potential profitability and farmer acceptability

A comprehensive review of the available literature revealed significant variation in live weight gain (0.02 to 0.87 kg/d) of Bali cattle depending on feeding strategy. The majority of the studies reviewed do not fully describe the feeding management, age or class of the animals, the experimental design or the level of replication used. Very few of these studies describe growth of weaned Bali cattle 60 to110 kg in live weight. Some of these results are presented in Appendix 11.3. A review entitled ‘Growth performance of young Bali cattle under various feeding management’ (Marsetyo, Pamungkas and Priyanti) was presented at the “4th International Seminar on Tropical Animal Production”, Gadjah Mada University, Yogyakarta, 2006, and published in the seminar proceedings.

7.1.2 Conduct on-station trials that evaluate a range of feed options

Jawa Timur (Beef Cattle Research Institute)

The growth response of 6 to 12 month old weaned Bali cattle to a range of feedstuffs, typically available in Jatim, was evaluated. Experiment 2 specifically examined the growth response to increasing crude protein content of the diet and determined the growth potential of Bali calves age 6 to 12 months. Experiment 3 evaluated the suitability of a commercially available feed (Prima feed), manufactured from a range of agro-industrial by-products. The nutritional composition of the feedstuffs evaluated in the three on-station experiments conducted at the Beef Cattle Research Institute did not vary from week to week during each of the experiments and were within the range of values expected for each of the feedstuffs investigated (Table 1).

Table 1. Nutritive composition of feedstuffs offered to early weaned Bali calves in on-station feeding studies conducted in Jawa Timur[1]

Feedstuff	DM[2] (g/kg)	OM[2] (g/kg DM)	CP[2] (g/kg DM)	NDF[2] (g/kg DM)	ADF[2] (g/kg DM)	EE[2] (g/kg DM)
Experiment 1						
Elephant grass	219[a]	815[b]	82[a]	709[b]	421[b]	23[a]
Leucaena	287[c]	843[c]	254[b]	379[a]	276[a]	47[b]
Native grass	252[b]	769[a]	100[a]	678[b]	391[b]	19[a]
SEM[1]	8	6	9	24	27	2
Experiment 2						
Elephant grass	221[a]	820[a]	94[a]	690[d]	425[b]	27[a]
Concentrate[3] 9.2%	915[b]	864[b]	92[a]	267[c]	120[a]	42[b]
Concentrate[3] 16.7%	917[b]	861[b]	176[b]	231[bc]	107[a]	35[ab]
Concentrate[3] 18.8%	917[b]	856[b]	204[c]	209[ab]	125[a]	37[b]
Concentrate[3] 24.5%	917[b]	850[b]	264[d]	171[a]	90[a]	40[b]
SEM	15	15	10	27	35	5
Experiment 3						
Prima feed[4]	875[b]	746[a]	105[a]	385	231[a]	21[a]
Leucaena	293[a]	836[b]	243[b]	380	279[b]	48[b]
SEM	10	19	14	21	10	5

1 Values are means and SEM is standard error of differences of means, over 11 weeks (experiment 1) and 8 weeks (experiments 2 and 3); different alphabetical superscripts within a column within an experiment are significantly different (P<0.05).
2 Dry matter (DM), organic matter (OM), crude protein (CP), ash-free neutral detergent fibre (NDF), ash-free acid detergent fibre (ADF), ether extract (EE).
3 Concentrate contained maize grain, limestone and a mineral premix with increasing levels of soybean meal.
4 Prima feed is commercially available product manufactured from a range of agro-industrial by-products.

In Experiment 1, weaned Bali cattle fed leucaena *ad libitum* grew faster than cattle fed elephant grass, elephant grass supplemented with leucaena and native grass (Table 2; Figure 2). Total dry matter intake did not differ between treatments but dry matter digestibility and digestible organic matter intake were higher for animals which received leucaena. While drinking water intake was highest for animals fed leucaena there was no difference in estimated total water intake between the four treatments.

In Experiment 2, weaned Bali cattle fed the 9.2% crude protein diet had a lower average daily live weight gain than cattle fed higher crude protein content diets (Table 2; Figure 2). There was no difference in dry matter intake, digestible organic matter intake or dry matter or organic matter digestibility between the four treatments. While there was no difference in estimated total water intake between treatments, animals fed the 9.2% crude protein content treatment consumed less drinking water than animals fed 18.8% and 24.5% crude protein diets.

In Experiment 3, weaned Bali cattle fed Prima feed *ad libitum* lost live weight over the experimental period and this was significantly different to the live weight gain measured for cattle fed the other treatments (Table 2; Figure 2). There was no difference in live weight gain between the other treatments, regardless of the level of leucaena included in the diet. Total dry matter intake, digestibile organic matter intake and dry matter digestibility were lowest for weaned Bali cattle offered Prima feed *ad libitum* and highest for cattle offered leucaena *ad libitum*. There was no difference in drinking water consumption between the treatments, however estimated total water intake increased with increasing level of leucaena included in the diet.

Table 2. Average daily live weight gain, feed and water intake and digestibility of 6 to 12 month old weaned Bali calves fed different diets in three experiments conducted at Jawa Timur[1]

Parameter	Experiment				
	Experiment 1				
	Elephant grass	Elephant grass + leucaena[2]	Leucaena	Native grass	SEM[1]
Live weight gain[3] (kg/d)	0.102[a]	0.192[a]	0.336[b]	0.122[a]	0.04
Feed intake (kg DM[4]/d)	1.56[ab]	1.14[a]	1.82[b]	1.90[b]	0.2
Supplement intake (kg DM/d)	-	0.85	-	-	0.19
Total intake (kg DM/d)	1.56	1.68	1.82	1.90	0.23
Total intake (g DM/kg W/d)	24.3	26.3	26.8	29.4	2.5
DM digestibility (g/kg)	579.3[a]	608.5[a]	698.6[b]	623.0[a]	23.4
DOMI[5] (g/kg W/d)	12.5[a]	13.9[ab]	16.9[c]	16.2[bc]	1.2
Drinking water intake (kg/d)	2.1[ab]	1.3[a]	3.0[b]	0.7[a]	0.6
Total water intake[6] (g/kg W/d)	151.3	141.7	130.4	124.1	14.7
	Experiment 2				
	9.2% CP[7]	16.7% CP[7]	18.8% CP[7]	24.5% CP[7]	SEM
Live weight gain (kg/d)	0.306[a]	0.556[b]	0.646[b]	0.591[b]	0.09
Roughage intake (kg DM/d)	0.38	0.33	0.40	0.33	0.05
Concentrate intake (kg DM/d)	2.16	2.38	2.44	2.40	0.16
Total intake (kg DM/d)	2.54	2.71	2.84	2.74	0.20
Total intake (g DM/kg W/d)	25.4	26.2	26.9	25.8	0.8
DM digestibility (g/kg)	755.4	748.7	760.4	786.9	13.8
DOMI (g/kg W/d)	18.3	18.0	18.6	18.7	0.4
Drinking water intake (kg/d)	7.9[a]	8.3[ab]	9.6[b]	9.7[b]	0.7
Total water intake (g/kg W/d)	102.6	101.8	112.5	115.8	9.2
	Experiment 3				
	100% Prima[8,9]	65% Prima + 35% leucaena[9]	35% Prima + 65% leucaena[9]	100% leucaena[9]	SEM
Live weight gain (kg/d)	-0.039[a]	0.161[b]	0.191[b]	0.243[b]	0.05
Leucaena intake (kg DM/d)	-	0.63[a]	1.22[b]	1.99[c]	0.07
Prima feed intake (kg DM/d)	1.07[b]	0.99[b]	0.66[a]	-	0.05
Total intake (kg DM/d)	1.07[a]	1.62[b]	1.88[b]	1.99[b]	0.22
Total intake (g DM/kg W/d)	15.9[a]	22.6[b]	25.3[bc]	25.5[c]	1.2
DM digestibility (g/kg)	510.7[a]	658.7[b]	651.0[b]	675.1[b]	28.1
DOMI (g/kg W/d)	8.2[a]	13.1[b]	14.5[bc]	15.1[c]	0.7
Drinking water intake (kg/d)	4.9	5.6	4.6	4.5	0.6
Total water intake (g/kg W/d)	75.5[a]	106.2[b]	111.5[bc]	134.5[c]	7.0

1Values are treatment means; SEM is standard error of the difference of the means; alphabetical superscripts across the rows indicate significant difference between treatment means (P<0.05).
[2]Leucaena fed at 10 g DM/kg W/d before feeding basal diet.
[3]Average daily gain over the experimental period (11 weeks experiment 1; 8 weeks experiments 2 and 3).
[4]Dry matter (DM); [5]Digestible organic matter intake (DOMI).
[6]Estimated total water consumed from drinking water and feed intake.
[7]CP is crude protein; 20% elephant grass + 80% concentrate to supply increasing levels of CP, fed ad libitum.
[8]Prima feed is a commercially available 'complete' feed in Jawa Timur from agro-industrial by-products.
[9]Final diet was fed ad libitum.

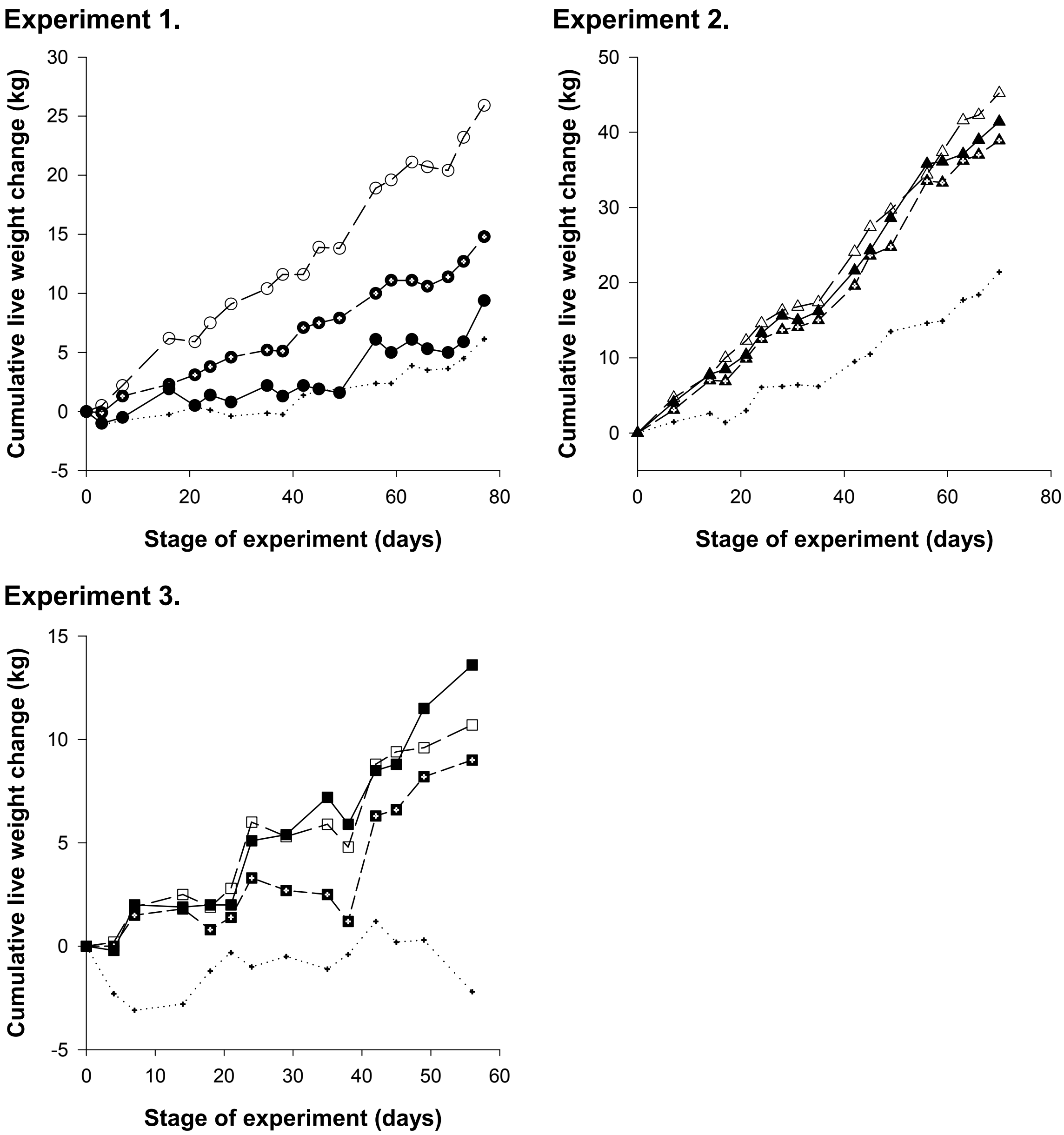


Figure 2. Cumulative live weight change of young Bali cattle offered a range of diets in three experiments conducted at Jawa Timur. (Experiment 1, elephant grass, elephant grass + leucaena, leucaena, native grass; Experiment 2, 9.2% crude protein, 16.7% crude protein, 18.8% crude protein, 24.5% crude protein; Experiment 3, 100% prima feed, 65% prima feed: 35% leucaena, 35% prima feed + 65% leucaena, 100% leucaena).

Nusa Tenggara Barat (University of Mataram)

The growth response of 6 to 12 month old weaned Bali cattle to a range of feedstuffs, typically available in Nusa Tenggara Barat, was evaluated. The experiments focussed on the use of tree legumes and new forage species to enhance growth of early weaned Bali calves. The nutritional composition of the feedstuffs evaluated in the four on-station experiments conducted did not vary from week to week during each of the experiments and were within the range of values expected for each of the feedstuffs investigated with the exception of *Stylosanthes hamata* fed in experiment 3 (Table 3). The low crude protein value measured for this legume is attributed to the late stage of maturity at which it was harvested and conserved. The reason for the harvesting at a late stage of maturity was an attempt to collect sufficient biomass for the experiment resulting in a relatively high proportion of stem to leaf. Further leaf loss may have occurred during the drying and hay making process. This issue appeared several times during the project and some discussion of this is made in the general discussion of this section and in section 9.2 of this report.

Table 3. Nutritive composition of feedstuffs offered to early weaned Bali calves in on-station feeding studies conducted at Nusa Tenggara Barat[1]

Feedstuff	DM2 (g/kg)	OM2 (g/kg DM)	CP2 (g/kg DM)	NDF2 (g/kg DM)	ADF2 (g/kg DM)	EE2 (g/kg DM)
Experiment 1						
Native grass	191[a]	865[a]	87[a]	618[c]	357[c]	24
Sesbania	225[b]	918[b]	232[c]	430[b]	306[b]	25
Rice bran	908[c]	839[a]	122[b]	350[a]	150[a]	16
SEM1	8	14	3	21	7	4
Experiment 2						
Gliricidia	863[ab]	902[b]	223[b]	360[a]	263[a]	24[b]
Leucaena	885[c]	919[c]	210[ab]	468[b]	267[a]	36[c]
Moringa	879[bc]	882[a]	207[ab]	455[b]	286[a]	33[d]
Sesbania	860[a]	914[bc]	194[a]	444[b]	332[b]	14[a]
SEM	8	7	10	21	16	1
Experiment 3						
Mulato	192[a]	886[a]	59[a]	730[b]	471	17
Centrosema	785[c]	902[b]	134[b]	664[b]	469	11
King grass	233[b]	881[a]	59[a]	570[a]	463	14
Stylosanthes	815[d]	943[c]	65[a]	654[ab]	520	9
SEM	13	7	6	36	19	4
Experiment 4						
Mulato	161[a]	864[a]	86[a]	637[c]	329[ab]	41
Rice bran	868[d]	861[a]	115[b]	541[b]	335[ab]	48
Sesbania	213[b]	913[b]	238[c]	436[a]	252[a]	60
Stylosanthes	240[c]	925[c]	83[a]	640[c]	413[b]	45
SEM	12	4	4	22	34	10

[1]Values are means and SEM is standard error of differences of means, over 8 weeks (experiments 1 and 3), 10 weeks (experiment 2) and 5 weeks (experiment 4); different alphabetical superscripts within a column within an experiment are significantly different (P<0.05).
[2]Dry matter (DM), organic matter (OM), crude protein (CP), ash-free neutral detergent fibre (NDF), ash-free acid detergent fibre (ADF), ether extract (EE).

In Experiment 1, weaned Bali cattle fed sesbania *ad libitum* or sesbania *ad libitum* with RB grew faster than cattle fed native grass or native grass supplemented with sesbania (Table 4; Figure 3). Total dry matter intake and digestible organic matter intake were higher for animals fed sesbania with RB, with no difference between the two supplemented groups. Dry matter digestibility was highest when sesbania was fed *ad libitum* as the sole component of the diet and lowest when native grass was offered *ad libiutm*, with no supplements. There was no difference in estimated total water intake between the four treatment groups; however drinking water consumption was lowest for animals fed native grass and highest for animals fed sesbania supplemented with RB.

In Experiment 2, weaned Bali cattle fed leucaena and sesbania hay grew faster than cattle fed moringa hay, which in turn grew faster than animals fed gliricidia hay (Table 4; Figure 3). There appeared to be a palatability or adaptation issue with the feeding of gliricidia hay to these calves. Gliricidia hay intake was extremely low when offered as the sole component of the diet, which resulted in a sharp drop in live weight over a three week period. To minimise the negative impacts on animal performance it was decided to supplement the animals with sesbania at 7 g DM/kg W/d. Despite this total dry matter and digestible organic matter intake were lowest for animals fed gliricidia supplemented with sesbania and highest for animals fed leucaena and sesbania hay. Interestingly, drinking water and estimated total water intake were greatest for cattle fed leuceana and sesbania hays, compared to the other hay treatments which were of comparable dry matter content.

In Experiment 3, weaned Bali cattle fed Centrosema hay *ad libitum* grew faster than cattle fed Brachiaria mulato, King grass and Stylosanthes hay (Table 4; Figure 3). The live weight gain of animals in this particular experiment was lower than anticipated for the King grass, mulato and Stylosanthes treatments. The low live weight gain response to Stylosanthes was attributed to the lower quality of the material fed, due to stage of maturity and leaf loss at storage, as alluded to above. The reason for the low response to King grass and mulato is unknown. Intake of the two grasses did not appear to be restricted and was above that of the two legumes. It was noted that both grasses were low in crude protein and this may have restricted live weight gain. The low crude protein content was unexpected as the grasses did not appear to have a high stem proportion or were overly mature at harvest. The crude protein content of the two grasses, which were pure swards, was lower than that measured for native grasses in other studies reported here. It is important to note that native grass describes locally available forage typically cut by small-holder farmers, and as such often comprises a proportion of forbs and legumes which would increase the crude protein content. Animals fed the forage legume hays had higher drinking water intake but lower estimated total water intake than animals fed King grass and mulato, which were both offered fresh.

In Experiment 4, weaned Bali cattle fed mulato supplemented with rice bran or sesbania grew faster than unsupplemented animals and animals supplemented with stylosanthes (Table 4; Figure 3). Dry matter digestibility and digestible organic matter intake were highest when sesbania was included as a supplement. Total dry matter intake was lowest when stylosanthes was included as a supplement. There was no difference in drinking water consumption between the four treatments, however estimated total water intake was highest for animals fed mulato and mulato supplemented with sesbania.

Table 4. Average daily live weight gain, feed and water intake and digestibility of 6 to 12 month old weaned Bali calves fed different diets in four experiments conducted at Nusa Tenggara Barat[1]

Parameter	Experiment				
	Experiment 1				
	Native grass	Native grass + sesbania[2]	Sesbania	Sesbania + RB[3]	SEM[1]
Live weight gain[4] (kg/d)	0.025^{a}	0.071^{a}	0.341^{b}	0.401^{b}	0.06
Feed intake (kg DM[5]/d)	2.07^{b}	1.53^{a}	2.17^{b}	2.08^{b}	0.14
Supplement intake (kg DM/d)	-	0.65	-	0.64	0.08
Total intake (kg DM/d)	2.07^{a}	2.02^{a}	2.17^{a}	2.71^{b}	0.20
Total intake (g DM/kg W/d)	28.1^{a}	27.5^{a}	26.9^{a}	32.3^{b}	1.4
DM digestibility (g/kg)	529.5^{a}	567.4^{b}	612.2^{c}	569.4^{b}	15.3
DOMI[6] (g/kg W/d)	14.6^{a}	15.1^{a}	16.1^{ab}	16.8^{b}	0.7
Drinking water intake (kg/d)	1.2^{a}	2.7^{b}	4.0^{c}	4.9^{d}	0.3
Total water intake[7] (g/kg W/d)	140.1	153.3	146.7	147.0	6.3
	Experiment 2				
	Gliricidia + sesbania[2]	Leucaena	Moringa	Sesbania	SEM
Live weight gain (kg/d)	0.001^{a}	0.471^{c}	0.221^{b}	0.429^{c}	0.05
Feed intake (kg DM/d)	0.98a	3.32^{c}	2.28^{b}	3.30^{c}	0.19
Supplement intake (kg DM/d)	0.59	-	-	-	0.03
Total intake (kg DM/d)	1.57^{a}	3.32^{c}	2.28^{b}	3.30^{c}	0.19

Total intake (g DM/kg W/d)	18.1^{a}	29.3^{c}	22.5^{b}	29.2^{c}	1.3
DM digestibility (g/kg)	609.1^{c}	496.6^{a}	621.5^{c}	554.4^{b}	12.6
DOMI (g/kg W/d)	10.1^{a}	14.8^{bc}	13.1^{b}	15.8^{c}	0.9
Drinking water intake (kg/d)	7.0^{a}	13.7^{c}	10.0^{a}	16.5^{d}	1.2
Total water intake (g/kg W/d)	86.3^{a}	126.4^{b}	102.5^{a}	151.5^{c}	9.0
	Experiment 3				
	Mulato	Centrosema	King grass	Stylosanthes	SEM
Live weight gain (kg/d)	0.098^{ab}	0.213^{b}	0.00^{a}	0.091^{ab}	0.06
Total intake (kg DM/d)	1.81^{ab}	1.98^{b}	2.08^{b}	1.62^{a}	0.15
Total intake (g DM/kg W/d)	22.5^{a}	22.0^{a}	26.3^{b}	20.6^{a}	1.6
DM digestibility (g/kg)	541.1^{a}	514.9^{a}	607.8^{b}	523.0^{a}	21.0
DOMI (g/kg W/d)	11.4^{a}	11.1^{a}	15.5^{b}	11.3^{a}	0.9
Drinking water intake (kg/d)	2.4^{a}	8.8^{b}	2.8^{a}	7.5^{b}	0.7
Total water intake (g/kg W/d)	131.1^{b}	104.8^{a}	125.1^{b}	99.7^{a}	8.3
	Experiment 4				
	Mulato	Mulato + RB3	Mulato + sesbania[2]	Mulato + stylosanthes[8]	SEM
Live weight gain (kg/d)	0.069	0.251	0.169	-0.066	0.11
Feed intake (kg DM/d)	1.98^{c}	1.31^{b}	1.07^{ab}	0.85^{a}	0.14
Supplement intake (kg DM/d)	-	0.98^{b}	1.21^{c}	0.66^{a}	0.09
Total intake (kg DM/d)	1.98^{ab}	2.29^{b}	2.28^{b}	1.52^{a}	0.22
Total intake (g DM/kg W/d)	21.1^{b}	23.9^{b}	22.6^{b}	16.6^{a}	1.8
DM digestibility (g/kg)	528.9^{a}	511.4^{a}	589.5^{b}	514.9^{a}	23.7
DOMI (g/kg W/d)	10.0^{a}	11.4^{ab}	13.0^{b}	10.1^{a}	1.0
Drinking water intake (kg/d)	0.9	2.8	2.0	2.0	0.7
Total water intake (g/kg W/d)	131.2^{b}	111.1^{a}	131.8^{b}	118.6^{ab}	6.8

[1]Values are means; SEM is standard error of difference of means; alphabetical superscripts across the rows indicate significant difference between treatments ($P<0.05$).
[2]Sesbania fed at 10 g DM/kg W/d before feeding basal diet, except experiment 2 when fed at 7 g DM/kg W/d.
[3]Rice bran fed at 10 g DM/kg W/d before feeding basal diet.
[4]Average daily gain over the experimental period (8 weeks experiments 1 and 3; 10 weeks experiment 2; 5 weeks experiment 4).
[5]Dry matter (DM); [6]Digestible organic matter intake (DOMI).
[7]Estimated total water consumed from drinking water and feed intake.
[8]Stylosanthes fed at 10 g DM/kg W/d before feeding basal diet.

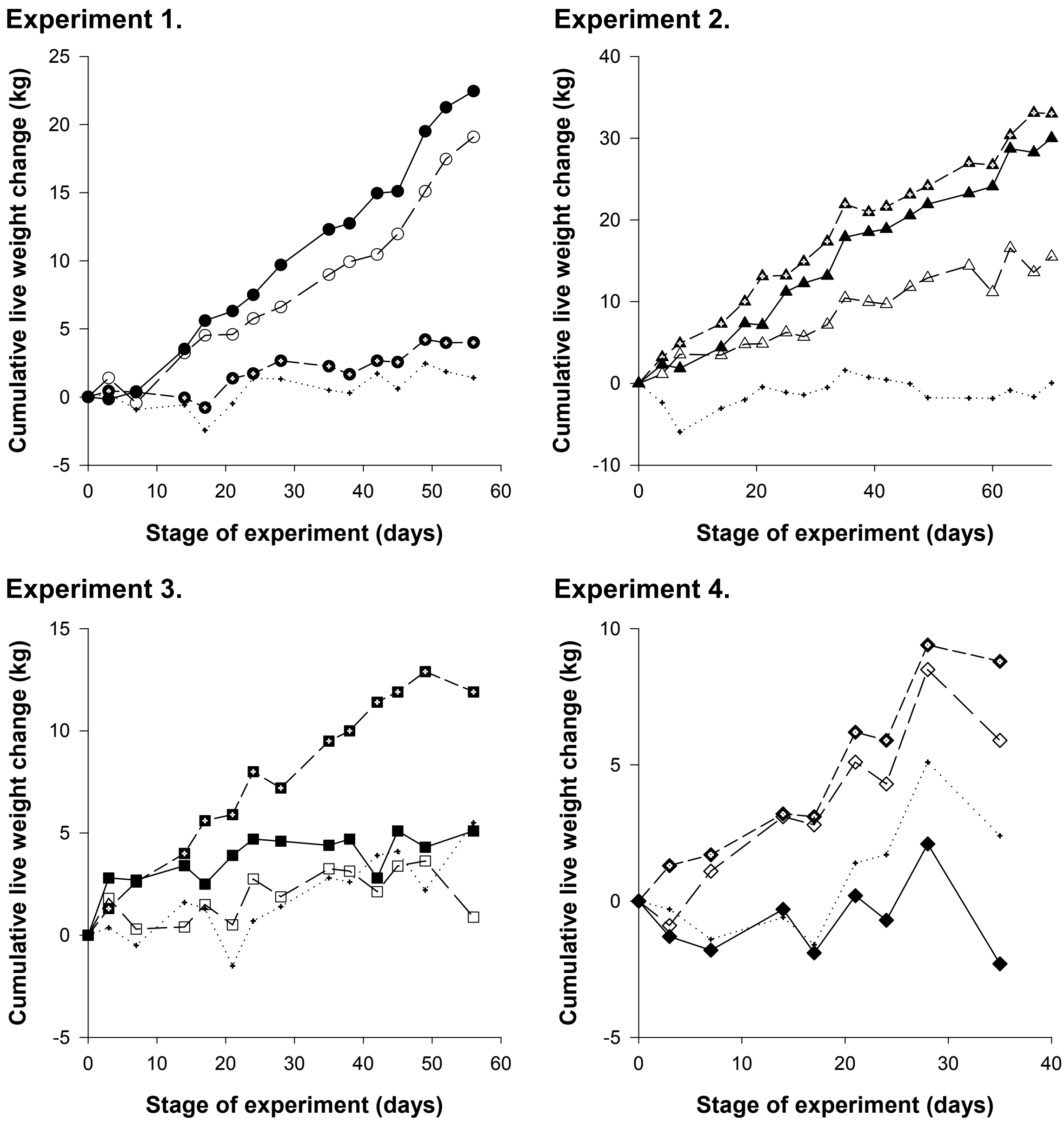


Figure 3. Cumulative live weight change of young Bali cattle offered a range of diets in four experiments conducted at Nusa Tenggara Barat. (Experiment 1, native grass, native grass + sesbania, sesbania, sesbania + rice bran; Experiment 2, gliricidia + sesbania, leucaena, moringa, sesbania; Experiment 3, mulato, centrosema, king grass, stylosanthes; Experiment 4, mulato, mulato + rice bran, mulato + sesbania, mulato + stylosanthes).

Nusa Tenggara Timur (BPTP-NTT and University of Nusa Cendana)

The growth response of 6 to 12 month old weaned Bali cattle to a range of feedstuffs, typically available in NTT, was evaluated. The experiments focussed on the use of new forage species, crop residues and leucaena to enhance growth of early weaned Bali calves. The nutritional composition of the feedstuffs evaluated in the four on-station experiments conducted did not vary from week to week during each of the experiments and were within the range of values expected for each of the feedstuffs investigated (Table 5).

Table 5. Nutritive composition of feedstuffs offered to early weaned Bali calves in on-station feeding studies conducted at Nusa Tenggara Timur[1,2]

Feedstuff	DM[3] (g/kg)	OM[3] (g/kg DM)	CP[3] (g/kg DM)	NDF[3] (g/kg DM)	ADF[3] (g/kg DM)
Experiment 1					
Leucaena	402[a]	N/M4	N/M	N/M	N/M
Native grass	848[c]	N/M	N/M	N/M	N/M
Native grass / Peureria	860[c]	N/M	N/M	N/M	N/M
Palm pith	612[b]	N/M	N/M	N/M	N/M
SEM[1]	39				
Experiment 2					
Centrosema	902[b]	908	193[b]	540[b]	445[c]
Clitoria	899[b]	909	133[a]	465[a]	344[b]
Desmondium	900[b]	900	130[a]	599[c]	449[c]
Leucaena	380[a]	895	244[c]	460[a]	304[a]
SEM	11	9	3	19	12
Experiment 3					
Corn stover	742[b]	860	69[a]	704[c]	N/M
Mungbean stover	876[c]	868	84[a]	615[b]	N/M
Leucaena	438[a]	875	243[c]	432[a]	N/M
Rice bran	901[c]	822	117[b]	456[a]	N/M
SEM	28	19	9	16	
Experiment 4					
Leucaena	293[a]	904[b]	239[c]	448[c]	N/M
Maize grain	895[b]	982[c]	90[a]	255[a]	N/M
Rice bran	916[b]	851[a]	117[b]	504[b]	N/M
SEM	11	8	3	11	

[1]Experiment 1 was conducted by the University of Nusa Cendana and experiments 2, 3 and 4 were conducted by BPTP NTT.
[2]Values are means and SEM is standard error of differences of means, over 11 weeks (experiment 1), 7 weeks (experiment 2), 4 weeks (experiment 3) and 8 weeks (experiment 4); different alphabetical superscripts within a column within an experiment are significantly different (P < 0.05).
[3]Dry matter (DM), organic matter (OM), crude protein (CP), ash-free neutral detergent fibre (NDF), ash-free acid detergent fibre (ADF).
[4]Not measured.

In Experiment 1, calves offered leucaena *ad libitum*, grew faster than calves fed other treatments (Table 6, Figure 4). Digestibility values for this experiment were higher than anticipated and were likely due to technical issues associated with the experiment.

In Experiment 2, weaned Bali cattle fed leucaena grew faster than calves fed centrosema and clitoria hays, which in turn grew faster than animals fed desmodium hay. This was associated with a higher dry matter and digestible organic matter intake by calves fed leucaena. Calves fed leucaena consumed the lowest amount of drinking water, however there was no difference in estimated total water intake between the treatments. Calves fed the local desmodium hay performed extremely poorly. The desmodium hay had a very low digestibility and resulted in low live weight gain and low intake when fed to calves. The reason for this is as yet unknown but the hay appeared to have a proportionally higher stem content than the other hays evaluated. Analysis of the fibre content of these hays may explain these differences.

In Experiment 3, early weaned Bali calves fed corn stover *ad libitum* grew slower than Bali calves fed mungbean stover alone or supplemented with leucaena or rice bran. Calves fed mungbean stover supplemented with leucaena grew faster than those supplemented with rice bran, while live weight gain of unsupplemented calves was intermediate. It should be noted that this was a short experiment and the primary aim was to establish some nutritional information regarding crop residues and their potential use in the feeding systems in NTT. These trends therefore suggest that mungbean stover may be more suitable than corn stover for feeding weaned Bali calves in NTT, however neither of the treatments are recommended as a sole diet for weaned calves. The inclusion of a leucaena supplement in the diet may provide modest benefits in live weight gain over a longer period.

In Experiment 4, weaned cattle fed leucaena supplemented with maize grain or rice bran grew faster than unsupplemented animals, there was no difference in live weight gain between the two supplementation treatments. Drenching calves with rumen fluid collected from a mature Bali bull fed leucaena which tested negative to DHP (i.e. indicative of presence of DHP degrading bacteria in the rumen), grew at the same rate as those animals which did not receive rumen fluid drench. Supplemented animals had higher dry matter intake, digestible organic matter intake and drinking water intake than unsupplemented animals. However, only those animals fed rice bran had a higher estimated total water intake. Digestibility values for this experiment were lower than anticipated and were likely due to technical issues associated with the experiment.

Table 6. Average daily live weight gain, feed and water intake and digestibility of 6 to 12 month old weaned Bali calves fed different diets in four experiments conducted at Nusa Tenggara Timur[1,2]

Parameter	Experiment				
	Experiment 1				
	Native grass	Native grass / Peureria	Native grass + Palm pith[3]	Leucaena	SEM[2]
Live weight gain[4] (kg/d)	0.024[a]	0.005[a]	0.056[a]	0.222[b]	0.03
Feed intake (kg DM[5]/d)	1.95[a]	1.66[a]	1.22[a]	3.49[b]	0.37
Supplement intake (kg DM/d)	-	-	0.75	-	0.12
Total intake (kg DM/d)	1.95[a]	1.66[a]	1.94[a]	3.49[b]	0.37
Total intake (g DM/kg W/d)	25.0[a]	21.6[a]	26.4[a]	42.4[b]	4.6
DM digestibility (g/kg)	713.0[a]	717.0[a]	800.0[a]	829.0[b]	28.4
Drinking water intake (kg/d)	4.53	4.73	4.80	3.98	0.42
	Experiment 2				
	Centrosema	Clitoria	Desmondium	Leucaena	SEM
Live weight gain (kg/d)	0.182[a]	0.159[a]	0.100[a]	0.422[b]	0.05
Total intake (kg DM/d)	1.98[a]	1.70[a]	1.65[a]	2.46[b]	0.17
Total intake (g DM/kg W/d)	25.3[bc]	22.7[ab]	21.7[a]	28.7[c]	1.7
DM digestibility (g/kg)	551.2[b]	554.5[b]	401.3[a]	591.5[b]	29.6
DOMI[6] (g/kg W/d)	12.5[b]	12.5[b]	8.0[a]	15.8[c]	1.4
Drinking water intake (kg/d)	7.17[b]	6.95[b]	7.01[b]	4.31[a]	0.59
Total water intake[7] (g/kg W/d)	93.3	94.9	93.0	108.2	8.6
	Experiment 3				
	Corn stover	Mungbean stover	Mungbean stover + leucaena[3]	Mungbean stover + rice bran[3]	SEM
Live weight gain (kg/d)	0.021[a]	0.304[bc]	0.350[c]	0.243[b]	0.04
Feed intake (kg DM/d)	1.37[ab]	2.04[c]	1.32[a]	1.55[b]	0.10
Supplement intake (kg DM/d)	-	-	1.10[b]	0.68[a]	0.06
Total intake (kg DM/d)	1.37[a]	2.04[b]	2.42[c]	2.22[bc]	0.11
Total intake (g DM/kg W/d)	16.0[a]	22.1[b]	27.0[c]	26.1[c]	1.0
DM digestibility (g/kg)	527.1	545.1	546.9	504.9	26.6
DOMI (g/kg W/d)	7.6[a]	11.6[b]	14.4[c]	12.9[bc]	0.8

Drinking water intake (kg/d)	5.89^{a}	10.07^{b}	9.12^{b}	9.21^{b}	0.59
Total water intake (g/kg W/d)	72.9^{a}	113.5^{b}	116.9^{b}	109.2^{b}	7.0
	Experiment 4				
	Leucaena (RF drench)	Leucaena (no drench)	Leucaena + maize grain[3]	Leucaena + rice bran[3]	SEM
Live weight gain (kg/d)	0.425^{a}	0.413^{a}	0.614^{b}	0.555^{b}	0.06
Feed intake (kg DM/d)	2.56^{b}	2.46^{b}	1.93^{a}	2.14^{a}	0.13
Supplement intake (kg DM/d)	-	-	1.13b	1.02^{a}	0.04
Total intake (kg DM/d)	2.56^{a}	2.46^{a}	3.06^{b}	3.16^{b}	0.14
Total intake (g DM/kg W/d)	22.3^{a}	21.7^{a}	26.0^{b}	26.6^{b}	1.1
DM digestibility (g/kg)	458.9^{a}	461.7^{a}	565.6^{b}	471.7^{a}	25.8
DOMI (g/kg W/d)	10.1^{a}	10.0^{a}	14.7^{b}	12.6^{b}	1.2
Drinking water intake (kg/d)	6.20^{ab}	5.69^{a}	6.86^{b}	9.30^{c}	0.88
Total water intake (g/kg W/d)	120.0^{a}	115.1^{a}	110.3^{a}	135.9^{b}	5.3

[1]Experiment 1 was conducted by the University of Nusa Cendana and experiments 2, 3 and 4 were conducted by BPTP NTT.
[2]Values are means; SEM is standard error of difference of means; alphabetical superscripts across the rows indicate significant difference between treatments (P<0.05).
[3]Palm pith, leucaena, rice bran and maize grain were fed at 10 g DM/kg W/d before feeding basal diet.
[4]Average daily gain over the experimental period (11 weeks, experiment 1; 7 weeks experiment 2; 4 weeks experiment 3; 8 weeks experiment 4).
[5]Dry matter (DM); [6]Digestible organic matter intake (DOMI).
[7]Estimated total water consumed from drinking water and feed intake.

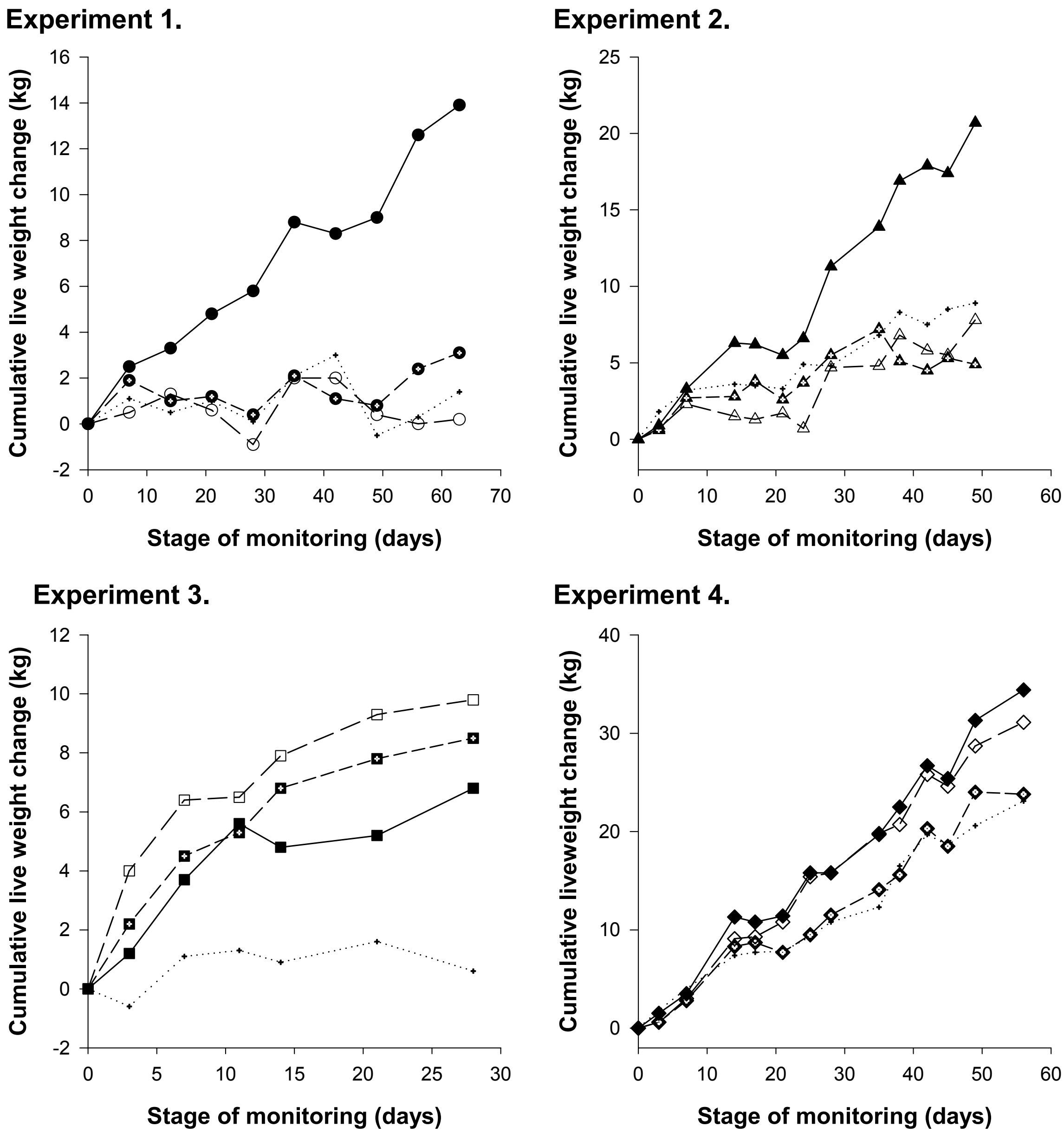


Figure 4. Cumulative live weight change of young Bali cattle offered a range of diets in four experiments conducted at Nusa Tenggara Timur. (Experiment 1, native grass, native grass + palm pith, native grass/peureria, leucaena; Experiment 2, centrosema, desmodium, clitoria, leucaena; Experiment 3, corn stover, mungbean stover, mungbean stover + leucaena, mungbean stover + rice bran; Experiment 4, leucaena (RF drench), leucaena (no drench), leucaena + rice bran, leucaena + maize grain).

Sulawesi Tengah (Tadulako University)

The growth response of 6 to 12 month old weaned Bali cattle to a range of feedstuffs, typically available in Sulawesi Tengah, was evaluated. The nutritional composition of the feedstuffs evaluated in the three on-station experiments conducted at the University of Tadulako did not vary from week to week during each of the experiments and were within the range of values expected for each of the feedstuffs investigated (Table 7).

Table 7. Nutritive composition of feedstuffs offered to early weaned Bali calves in on-station feeding studies conducted in Sulawesi Tengah[1]

Feedstuff	DM[2] (g/kg)	OM[2] (g/kg DM)	CP[2] (g/kg DM)	NDF[2] (g/kg DM)	ADF[2] (g/kg DM)	EE[2] (g/kg DM)
Experiment 1						
Native grass	332[a]	916[a]	81[a]	635[c]	487[c]	13[a]
Rice bran	944[c]	944[b]	120[b]	474[a]	255[a]	77[b]
RBCM[3]	929[b]	941[b]	166[c]	513[b]	338[b]	101[c]
SEM[1]	2	5	3	9	10	3
Experiment 2						
Elephant grass[4]	866[b]	878[a]	82[a]	664[b]	464[b]	28[a]
Gliricidia	341[a]	917[b]	211[b]	337[a]	238[a]	40[b]
SEM	8	8	5	8	7	1
Experiment 3						
Corn stover	851[b]	883[a]	83[a]	696[c]	476[b]	21[a]
Gliricidia	351[a]	888[a]	224[c]	379[a]	331[a]	30[a]
RBCM	908[c]	945[b]	188[b]	518[b]	347[a]	95[b]
SEM	4	8	4	8	17	5

[1]Values are means and SEM is standard error of differences of means, over 8 weeks; different alphabetical superscripts within a column within an experiment are significantly different (P<0.05).
[2]Dry matter (DM), organic matter (OM), crude protein (CP), ash-free neutral detergent fibre (NDF), ash-free acid detergent fibre (ADF), ether extract (EE).
[3]Rice bran (RB) and copra meal (CM) were mixed in equal proportions on an as fed basis prior to feeding.
[4]Elephant grass hay.

In Experiment 1, supplementation of weaned Bali cattle fed native grass *ad libitum* with RB or RBCM grew faster than cattle fed native grass alone (Table 8; Figure 5). Unsupplemented animals consumed more native grass than animals supplemented with RB or RBCM, with no difference in grass intake between the two supplementation treatment groups. Total dry matter intake and digestible organic matter intake were higher for animals which received RB or RBCM supplements, with no difference between the two supplemented groups. Dry matter digestibility was highest for the RBCM supplemented group. There was no difference in daily water intake or estimated total water intake between the three treatment groups.

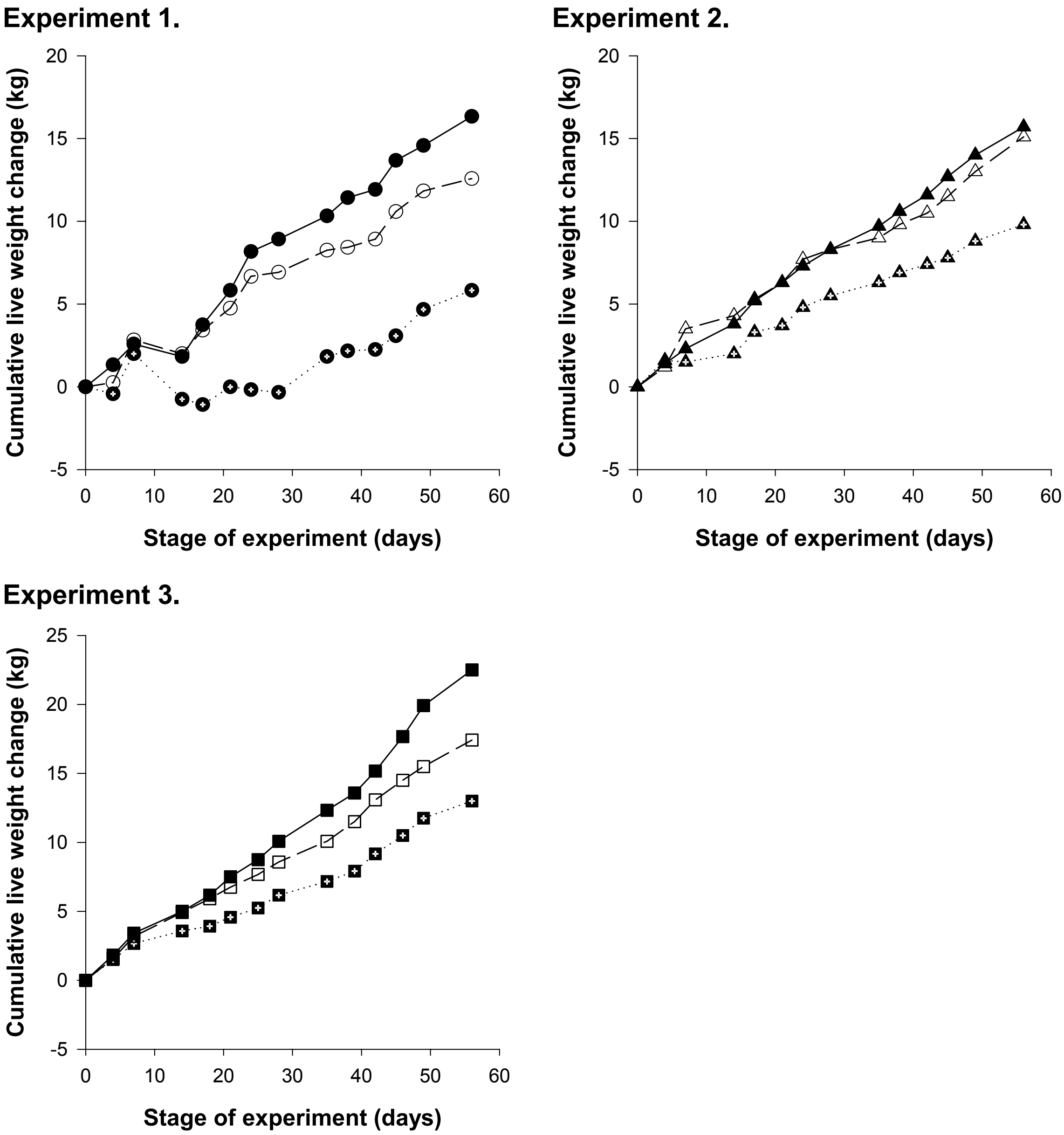
In Experiment 2, weaned Bali cattle fed elephant grass hay *ad libitum* supplemented with fresh gliricidia grew faster than cattle fed elephant grass hay alone (Table 8; Figure 5). There was no difference in live weight gain if cattle were fed fresh gliricidia as a supplement or as the sole component of the diet. Total dry matter intake of elephant grass hay and gliricidia were similar when fed as the sole component of the diet; animals fed elephant grass hay with a gliricidia supplement had a higher total dry matter intake. Dry matter and organic matter digestibility were greatest for the gliricidia treatment. There was no difference in drinking water consumption; however, estimated total water intake was greatest for animals fed gliricidia alone and lowest for animals fed elephant grass hay alone.

In Experiment 3, weaned Bali cattle fed corn stover *ad libitum* supplemented with RBCM grew faster than cattle fed corn stover alone or with a gliricidia supplement (Table 8; Figure 5). Corn stover intake was highest for unsupplemented cattle, while there were no differences in corn stover intake, supplement intake or total dry matter intake between the cattle supplemented with gliricidia or RBCM. Dry matter, organic matter and NDF digestibility and digestible organic matter intake were highest for cattle fed the corn stover with RBCM supplement treatment. There was no difference in drinking water consumption; however, estimated total water intake was greatest for animals supplemented with gliricidia.

Table 8. Average daily live weight gain, feed and water intake and digestibility of 6 to 12 month old weaned Bali calves fed different diets in three experiments conducted at Sulawesi Tengah[1]

Parameter	Experiment			
	Experiment 1			
	Native grass	Native grass + RB[2]	Native grass + RBCM[3]	SEM[1]
Live weight gain[4] (kg/d)	0.104^{a}	0.225^{b}	0.292^{b}	0.05
Feed intake (kg DM[5]/d)	2.38^{b}	2.08^{a}	2.02^{a}	0.11
Supplement intake (kg DM/d)	-	1.01^{b}	0.85^{a}	0.03
Total intake (kg DM/d)	2.38^{a}	3.08^{b}	2.87^{b}	0.16
Total intake (g DM/kg W/d)	25.9^{a}	30.4^{b}	28.4^{ab}	1.2
DM digestibility (g/kg)	581.6^{a}	581.9^{a}	628.4^{b}	11.9
DOMI[6] (g/kg W/d)	14.7^{a}	17.5^{b}	18.1^{b}	0.8
Drinking water intake (kg/d)	4.2	5.9	6.0	0.8
Total water intake[7] (g/kg W/d)	99.5	101.2	99.5	7.4
	Experiment 2			
	Elephant grass hay	Elephant grass hay + gliricidia[8]	Gliricidia	SEM
Live weight gain (kg/d)	0.174^{a}	0.280^{b}	0.269^{b}	0.03
Feed intake (kg DM/d)	3.34^{b}	2.81^{a}	3.21^{b}	0.15
Supplement intake (kg DM/d)	-	1.20	-	0.03
Total intake (kg DM/d)	3.34^{a}	4.01^{b}	3.21^{a}	0.13
Total intake (g DM/kg W/d)	30.2^{a}	33.8^{b}	28.0^{a}	1.3
DM digestibility (g/kg)	547.6^{a}	582.8^{b}	588.3^{b}	5.7
DOMI (g/kg W/d)	15.1^{a}	18.5^{b}	16.3^{a}	0.8
Drinking water intake (kg/d)	8.6	9.5	8.9	0.8
Total water intake (g/kg W/d)	82.6^{a}	102.5^{b}	131.6^{c}	6.4
	Experiment 3			
	Corn stover	Corn stover + gliricidia[8]	Corn stover + RBCM[3]	SEM
Live weight gain (kg/d)	0.232^{a}	0.311^{b}	0.402^{c}	0.03
Feed intake (kg DM/d)	3.43^{b}	2.63^{a}	2.87^{a}	0.13
Supplement intake (kg DM/d)	-	1.23^{b}	1.07^{a}	0.03
Total intake (kg DM/d)	3.43^{a}	3.85^{b}	3.95^{b}	0.13
Total intake (g DM/kg W/d)	29.1^{a}	31.1^{b}	31.1^{b}	0.5
DM digestibility (g/kg)	554.2^{a}	591.3^{b}	612.9^{c}	6.8
DOMI (g/kg W/d)	13.9^{a}	15.9^{b}	17.1^{c}	0.4
Drinking water intake (kg/d)	10.1	13.0	10.5	1.3
Total water intake (g/kg W/d)	89.1^{a}	124.5^{b}	87.2^{a}	9.5

[1]Values are treatment means; SEM is standard error of the difference of the means; alphabetical superscripts across the rows indicate significant difference between treatment means ($P<0.05$).
[2]Rice bran fed at 10 g DM/kg W/d before feeding basal diet.
[3]Rice bran and copra meal were mixed in equal proportions prior to feeding and were fed combined at 10 g DM/kg W/d before feeding basal diet.
[4]Average daily gain over the 8 week experimental period.
[5]Dry matter (DM); [6]Digestible organic matter intake (DOMI).
[7]Estimated total water consumed from drinking water and feed intake.
[8]Gliricidia fed at 10 g DM/kg W/d before feeding basal



diet.

Figure 5. Cumulative live weight change of young Bali cattle offered a range of diets in three experiments conducted at Sulawesi Tengah. (Experiment 1, native grass, native grass + rice bran, native grass + rice bran and copra meal; Experiment 2, elephant grass hay, elephant grass hay + gliricidia, gliricidia; Experiment 3, corn stover, corn stover + gliricidia, corn stover + rice bran and copra meal).

General discussion

Results from the on-station experiments conducted in this project indicate that the inclusion of small quantities (10 g DM/kg W/d) of material higher in crude protein than commonly fed basal diets, such as native grass, resulted in a significant increase in average daily live weight gain. The best strategy available to small-holder farmers across eastern Indonesia appears to be the use of leucaena, sesbania or copra meal mixed with rice bran, as supplements to more widely available grasses or crop residues. Some results were different to those anticpated and should be viewed with caution. These results, and possible explanations for the unexpected outcomes such as quality of feed, animals used and duration of experiment, are discussed in the previous results section and also below.

Across the on-station experiments it was evident that feeds typically fed to Bali calves, such as native grasses and crop residues, supplied insufficient crude protein to provide the increased growth rates required to improve farmer cash-flow (Table 9). Growth rates ranged from -0.066 to 0.646 kg/d, across all experiments. The best response in terms of live weight gain (0.646 kg/d) resulted when concentrate rations containing greater than 18.8% crude protein were fed. However these strategies are not applicable at the farm level and were conducted to develop a better understanding of the nutrient requirements of growing Bali calves from which appropriate diet formulation recommendations could be made. Similar responses resulted when calves were fed tree legumes *ad libitum* with supplements of rice bran and maize grain. In addition, tree legumes fed as a single feed also resulted in good live weight gain (~0.4 kg/d). While it was successfully demonstrated to scientists and small-holder farmers that tree legumes can safely constitute a high proportion of the diet, it is not a strategy likely to be widely adopted by farmers. Despite observing the high growth rates and differences in calf condition, small-holder farmers still indicated apprehension at feeding tree legumes as the sole component of the diet, in addition feeding sole diets of tree legumes is not sustainable on-farm as the biomass will be quickly depleted. A more strategic use of tree legumes is the recommendation that they are fed to calves at 10 g DM/kg W/d, or approximately 30% of the diet on a dry matter basis. This will still enhance growth of Bali calves, as demonstrated in the village studies described in this report, whilst ensuring an adequate supply of the high quality feed resource is maintained for an extended period of time.

Fifty three feeding treatments were evaluated across the 14 experiments, 49 of which metabolisable energy (ME) and crude protein (CP) content were estimated. Metabolisable energy and CP content across all diets ranged from approximately 5.4 to 11.0 MJ ME/kg DM and approximately 55 to 250 g CP/kg DM, respectively, providing a large range from which estimates of nutritive requirements for maintenance and growth of Bali cattle could be determined. Feed intake ranged from 16 to 33 g DM/kg W/d and averaged 25.4 g DM/kg W/d (~2.5% of live weight on a DM basis) across all experiments (Table 9), suggesting that Bali cattle have the potential to consume high quantities of feed, depending on the quality of the feed on offer. Within the cut and carry systems of eastern Indonesia water supply to animals is an often overlooked issue, despite it being essential for animal survival and production. Water supply can be unreliable and often needs to be provided daily to animals tethered in the kandang or in the field by farmers, making it a major time and labour input. The current experiments, conducted under a mean daily temperature range of approximately 25 to 30^{o}C, determined that the drinking water requirements (i.e. the amount of water to be provided by farmers, not including water present in the feed) of early weaned Bali cattle ranged from 9.1 to 146 g/kg W/d depending on the dry matter content of the diet. Our estimates of total water intake of this class of Bali cattle (water imbibed plus water in feed) across all treatments and experiments ranged from 73 to 153 g/kg W/d, with an average of approximately 115 g/kg W/d (~11-12% of live weight) or 4.6 kg water/kg dry matter intake. This is comparable to an intake of 4.75 kg water/kg dry matter intake for older (38 months) and heavier (248 kg) Banteng cattle (Moran *et al*., 1979) and 4.5 and 6.0 kg water/kg dry matter intake estimated for weaned Bos indicus cattle at 25 and 30^{o}C, respectively (CSIRO, 2007).

Table 9. Average daily live weight gain (ADG), dry matter intake (DMI), drinking water intake (DWI) and estimated total water intake (TWI) of early weaned Bali cattle (60-110 kg live weight) fed a range of feed stuffs in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah[1,2,3]

Feed type	Number of treatments	ADG (kg/d)	DMI (g/kg W/d)	DWI (g/kg W/d)	TWI[4] (g/kg W/d)
Native grass	3	0.084 (0.025-0.122)	27.8 (25.9-29.4)	24.1 (10.8-44.2)	121.2 (99.5-140.1)
Improved grass	5	0.089 (0.000-0.174)	24.9 (21.1-30.2)	35.4 (9.1-78.6)	124.3 (82.6-151.3)

Grass + supplement	8	0.177 (-0.066-0.280)	26.2 (16.6-33.8)	40.0 (21.0-79.8)	120.0 (99.5-153.3)
Crop residue	3	0.186 (0.021-0.304)	22.4 (16.0-29.1)	87.3 (67.8-109.6)	91.8 (72.9-113.5)
Crop residue + supplement	4	0.327 (0.243-0.402)	28.8 (26.1-31.1)	97.5 (82.8-105.4)	109.5 (87.2-124.5)
Forage legume	5	0.149 (0.091-0.213)	22.5 (20.6-25.3)	93.7 (90.9-97.9)	97.2 (93.0-104.8)
Tree legume	11	0.325 (0.001-0.471)	25.4 (18.1-29.3)	76.6 (44.0-146.0)	123.0 (86.3-151.5)
Tree legume + supplement	3	0.523 (0.401-0.614)	28.3 (26.0-32.2)	61.6 (49.9-77.1)	131.1 (110.3-147)
Concentrate	4	0.525 (0.306-0.646)	26.1 (25.4-26.9)	85.8 (80.0-92.2)	108.2 (101.8-115.8)
Commercial feed	1	-0.039 (N/A[5])	15.9 (N/A)	74.0 (N/A)	75.5 (N/A)
Commercial feed + supplement	2	0.176 (0.161-0.191)	24.0 (22.6-25.3)	69.8 (62.0-77.6)	108.9 (106.2-111.5)

[1]*Feeds evaluated in on-station studies were grouped into feed type categories.*
[2]*Data is mean, with range below in parenthesis.*
[3]*Excludes experiment 1 conducted at Nusa Tenggara Timur.*
[4]*Estimated from drinking water and water content of feed.*
[5]*N/A, not applicable as one treatment only.*

Across the experiments conducted, the live weight gain of animals fed forage legumes (Centrosema, Clitoria, Desmodium, Stylosanthes) and introduced grasses (Mulato) either as a sole feed or as a supplement was less than expected. Growth rates for animals fed forage legumes ranged from approximately 0.1 to 0.2 kg/d and were less than for animals fed tree legumes. Even allowing for the apparent low growth potential of Bali cattle, these growth rates appear low compared with feeding studies conducted in Australia where growth rates of approximately 0.5, 0.7-1.3 and 0.4-0.5 kg/d are reported for cattle grazing Centrosema, Clitoria and Stylosanthes pastures, respectively, depending on seasonal conditions (McCown *et al*., 1986; Tropical Forages, www.tropicalforages.info/index.htm). In the current studies, there was difficulty in producing sufficient biomass for a thorough evaluation of forage legumes in the on-station experiments. This either resulted in shortened studies, feeding not occurring *ad libitum* or at prescribed treatment levels, or feed quality being low as legumes were allowed to reach maturity before cutting in an attempt to produce greater biomass, which came at the expense of nutritive value and was associated with relatively more stem to leaf. In addition, under grazing conditions animals can preferentially select the most nutritious parts of the plant (leaf), while under cut and carry situations (such as the current pen studies) the animals do not have the same opportunity; future pen studies should offer higher levels of feed to allow *ad libitum* selection of the various constituents of the plant materials on offer. This is clearly evident in Experiment 3 conducted at NTB, where the CP content of the Stylosanthes hay was 65 g CP/kg DM, which is lower than other studies or grazing scenarios where these legumes would typically be fed at 100-200 g CP/kg DM.

These legumes and grasses clearly have an essential role within the context of the crop-livestock system, either as ley-crops within or between crops, under plantations, on rice paddy field bunds or in and around houses and kandangs, however their potential as a feed resource warrants further investigation, particularly in relation to cutting, storage and feeding management.

The use of gliricidia as a feed resource resulted in a variable response across the current experiments. Both fresh and dried gliricidia appeared to be highly digestible, with a high crude protein content (>200 g CP/kg DM) and a low NDF content (<360 g NDF/kg DM), making it suitable as a supplement for feeding to early weaned Bali calves. In experiment

2 at NTB, calves fed gliricidia hay as the sole component of the diet had very low DM intakes and low average daily live weight gains, this resulted in the inclusion of a small amount of sesbania in an attempt to stimulate intake and maintain calf condition. In contrast in Sulteng, calves fed fresh gliricidia as a supplement grew better than those unsupplemented but similar to those calves fed fresh gliricidia *ad libitum*. It appears that performance of calves fed gliricidia may depend on previous exposure and perhaps the form of feeding (i.e. dry vs. fresh). While anecdotal evidence suggests cultivar and cutting frequency will influence anti-nutritional factors present in gliricidia, these remain to be substantiated and this is an area of work that requires further investigation. Given the wide abundance of gliricidia across the eastern Islands of Indonesia it is recommended that it be included in any feeding strategies at 30-50% of the diet, after calves are adapted to it. There are significant advantages to farmers regarding the use of gliricidia in the diet in terms of labour and time savings in collecting it and ensuring a longer supply of other less readily available feed resources, even if not offering the large benefits in live weight gain that other tree legumes, such as leucaena and sesbania, do.

The power of the studies conducted within this project is the large amount of data generated using similar experimental animals and collected using similar experimental design and protocols. The data set generated provides reliable information on the nutritional requirements of early weaned male Bali cattle (60-110 kg live weight). From the project data, relationships describing the ME requirements for maintenance and growth of weaned Bali calves were generated (Figure 6). The overall relationships across all treatments and experiments, excluding the experiments conducted at NTT, suggests that this class of Bali cattle (i.e. 6 to 12 month old, 60-100 kg live weight, male Bali cattle) require 8.8 MJ ME/d to maintain live weight (0.15 MJ ME to maintain each kg of live weight) and have a gross efficiency of conversion of ME to live weight gain of 0.018 (i.e. kg live weight change/MJ ME intake). To account for any differences in maturity which may have existed between animals and experiments, possibly arising due to previous management strategies, the daily ME intake (MJ/d) was adjusted to a common metabolic weight ($W^{0.75}$). Across all treatments and experiments, excluding experiments conducted in NTT, it was determined that 0.44 MJ/kg $W^{0.75}$/d was required to maintain live weight of Bali cattle, and the gross efficiency of live weight gain was 0.85 kg live weight change/MJ ME intake/kg $W^{0.75}$.

Within the current experiments the ME requirement to maintain live weight of Bali cattle was similar in Sulteng, Jatim and NTB (0.47, 0.46 and 0.45 MJ/kg $W^{0.75}$/d, respectively). There were several technical reasons for the omission of data from NTT in the development of these overall relationships, these include the measured digestibility values being markedly different to expected values (experiments 1 and 4) and the shorter length of one experiment (3) which was considered insufficient for the accurate measurement of live weight change in response to the feeding strategies. Animals fed diets with an estimated CP content of <18% have a higher ME requirement to maintain live weight (0.49 MJ/kg $W^{0.75}$/d) than animals fed diets estimated to contain <10% and 10 to 18% CP (0.38 MJ/kg $W^{0.75}$/d) (Figure 7). This is probably attributed to the higher intake associated with higher CP feeds. The gross efficiency of live weight gain is greater when diets containing >18% CP are fed (1.3 kg live weight change/MJ ME intake/kg $W^{0.75}$) compared to diets containing <10% CP (0.44 kg live weight change/MJ ME intake/kg $W^{0.75}$) or between 10 to 18% CP (0.68 kg live weight change/MJ ME intake/kg $W^{0.75}$). It appears that increasing both the CP and ME content of the diet will increase growth rate of this class of cattle, with CP content of the diet likely to be the main constraint to increasing growth rates (Figure 8). Based on the results of the present project, Bali cattle do not appear to have ME requirements for maintenance or potential feed intakes markedly differently to other cattle species.

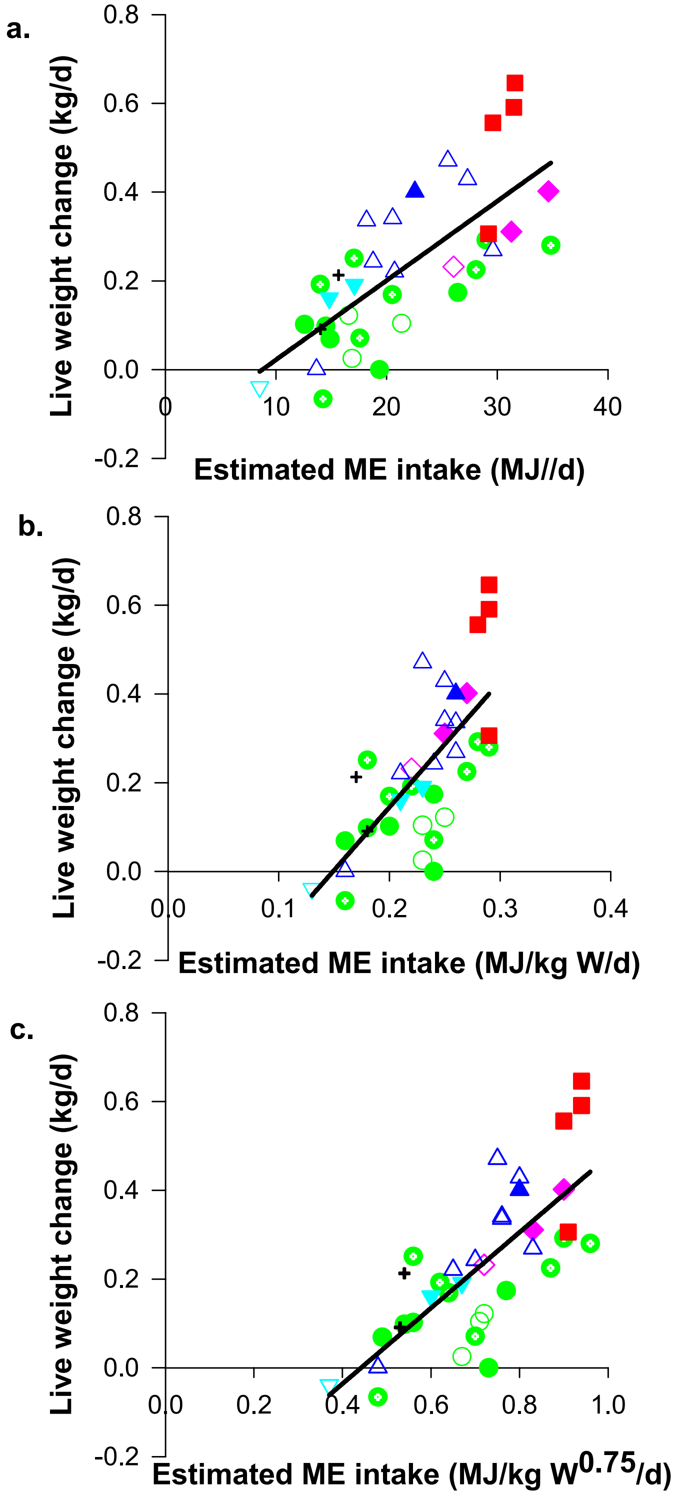


Figure 6. Relationship between estimated metabolisable energy (ME) intake (a., b. and c.) and live weight change of weaned male Bali cattle aged 6 to 12 months offered a range of feed types (○ native grass; ● improved grass; ⊙ grass + supplement; ◇ crop residue; ◆ crop residue + supplement; + forage legume; △ tree legume; ▲ tree legume + supplement; ■ concentrate; ▽ commercial feed; ▼ commercial feed + supplement). The overall relationship across all treatments and experiments is represented by the solid line (—) in each figure (a. Y=-0.157+0.018x, R^2=0.53; b. Y=-0.423+2.839x, R^2=0.50; c. Y=-0.377+0.853x, R^2=0.57). Data excludes experiments conducted at Nusa Tenggara Timur.

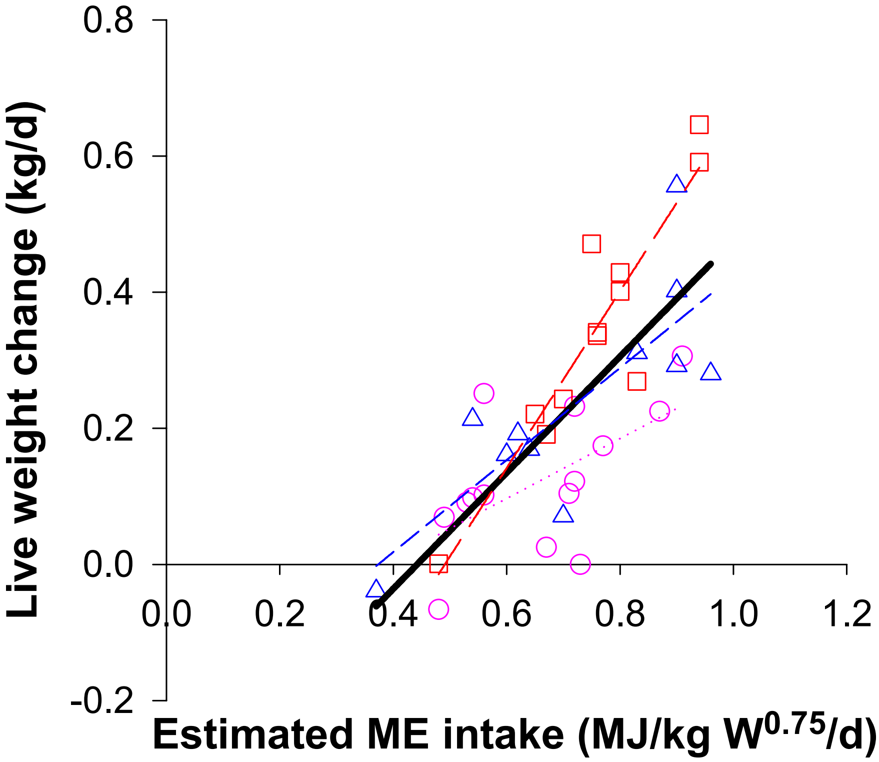


Figure 7. Relationship between estimated metabolisable energy (ME) intake and live weight change of weaned male Bali cattle aged 6 to 12 months offered feeds of different crude protein (CP) content (… ○ …,<100 g CP/kg DM, Y=-0.168+0.441x, R^2=0.29; - △ -,100 to 180 g CP/kg DM, Y=-0.253+0.677x, R^2=0.59; — □ —, >180 g CP/kg DM, Y=-0.638+1.299x, R^2=0.83). The overall relationship (Y=-0.377+0.853x, R^2=0.57) across all treatments and experiments is represented by the solid line (—). Data excludes experiments conducted at Nusa Tenggara Timur.

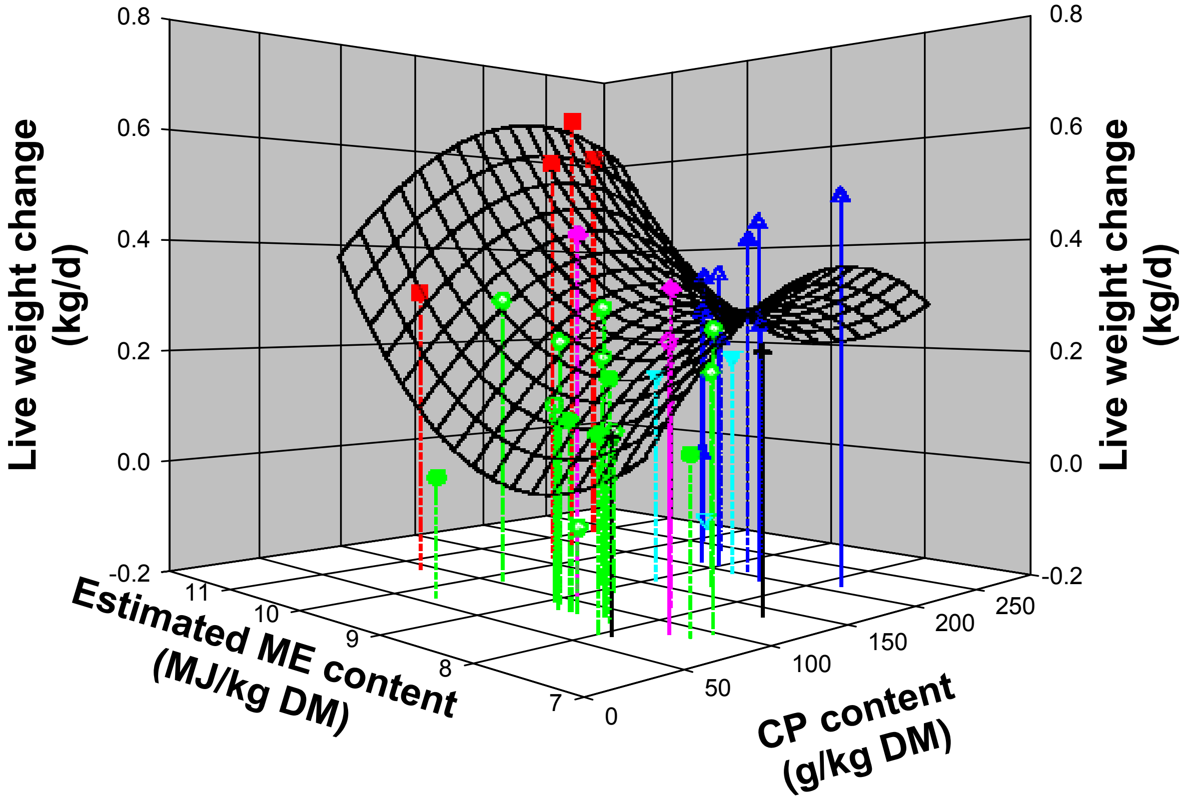


Figure 8. Relationship between estimated metabolisable energy (ME) content of feed consumed, crude protein (CP) content of feed offered and daily live weight gain of weaned male Bali cattle aged 6 to 12 months offered a range of feeds (○ native grass; ● improved grass; ⭘ grass + supplement; ◇ crop residue; ◆ crop residue + supplement; + forage legume; △ tree legume; ▲ tree legume + supplement; ■ concentrate; ▽ commercial feed; ▼ commercial feed + supplement). Data excludes experiments conducted at Nusa Tenggara Timur.

The economic evaluation of the on-station studies is presented in Appendix 11.4. An R/C (revenue/cost) value of 1, indicates a break even feeding strategy; the greater the value above 1, the greater the financial return on investment. Typically, the inclusion of supplements higher in crude protein or the feeding of high levels of tree legumes provided the greatest financial returns on investment. This further supports the rationale for a more strategic and sustainable approach to the use of tree legumes within the feeding systems of cattle within the crop-livestock systems across eastern Indonesia.

7.2 Promote and monitor the adoption of promising feeding options

7.2.1 Initiate farmer interest in feeding options through their involvement in the on-station research activities

Information generated in the on-station studies was disseminated through farmer visits conducted at the end of each experiment. The number of small-holder farmers who visited each experiment is presented in Table 10.

Table 10. Number of small-holder farmers attending dissemination activities associated with on-station studies in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah

Experiment	Jawa Timur	Nusa Tenggara Barat	Nusa Tenggara Timur	Sulawesi Tengah
1	19	20	0[1]	25
2	24	25	25	25
3	36	0	15	26
4	N/A	677[2]	25	N/A
Total	79	722	65	76

[1]Experiment conducted by University of Nusa Cendana at the Noel Baki farmer and extension training centre.
[2]677 farmers visited Lingsar during this experiment in conjunction with SMAR 2006 096 farmer training activities; a representative sample of 60 farmers were surveyed.
N/A, not applicable; no experiment conducted.

All farmers completed a questionnaire during the visit, as described in section 5.2, with the exception of the large number of farmers visiting experiment 4 at NTB where a sub-set of farmers were interviewed. Although data was not specifically collected there did appear to be regional differences in the aspects of the studies which most interested the farmers. For example, small-holder farmers were most interested in kandang construction and animal health in Jatim, the process of cattle weighing and the use and processing of faeces for fertiliser production in Sulteng, in forage production and hay making and the use of hay as a feed resource in NTT and the use of tree legumes to increase live weight gain and the establishment of new forage species, particularly *Brachiaria mulato*, in NTB. Overall, this tends to demonstrate the relative lack of importance that small-holder farmers place on nutrition. This may stem from no active nutritional management training or extension activities by local extension organisations, meaning the importance of nutrition is not fully appreciated by small-holder farmers.

A greater proportion of small-holder farmers in Jatim were cattle owners, rather than managers, compared with small-holder farmers at Sulteng and NTB (Appendix 11.5; Figure 19). While small-holder farmers in Sulteng had slightly larger herds than those in Jatim and NTT, the structure of the herds were similar between locations (Appendix 11.5; Figure 19). The majority of farmers who attended the on-station demonstrations conducted at the end of each experiment indicated that the visit changed their perception on calf management (weaning and feeding) and were likely to implement change in their own management system (Appendix 11.5; Figure 20). The major constraints to adoption, identified by small-holders, were cost of implementation and availability of the high quality forage of interest, which was influenced by seasonal supply, availability of land to plant forages and competition with other farmers (Appendix 11.5; Figure 20). No farmers currently practice preferential feeding of different cattle classes (data not presented), with differential feeding of cattle classes perceived by some farmers to potentially increase labour inputs. While the majority of farmers understood the positive effects of weaning on reproductive output, there was variation between small-holder farmers at the different sites regarding the implementation of weaning as a management tool and what is the best age to wean (Appendix 11.5; Figure 21). It is interesting to note that a large proportion (51%) of farmers from NTB provided a range of reasons not to wean when asked the reason to practice weaning; these responses included that weaning was not a common practice, slower calf growth rates, stress on cows and calves, not traditionally allowed and requires milk replacer, indicating that farmers in this region may require more guidance and assistance in implementing early weaning as a component of any IVMS scaled-up. Overall, the results indicate that the on-station demonstrations generated significant interest in weaning and preferential feeding of calves amongst the farmers. Farmers also indicated that they were likely to adopt some form of change in their calf management practices; however the extent of this adoption after their visit is presently unknown. It is likely that a significant extension program would be required to initiate and maintain these calf management strategies in villages over the long-term, and this was beyond the scope of the current project.

7.2.2 Undertake on-farm demonstration of feeding options

Best-bet feeding strategies, from the on-station studies, and early weaning were implemented, monitored and adapted at each site (Figures 9, 10, 11 and 12). The results demonstrated that strategic supplementation of the weaned Bali calf could be implemented in villages across eastern Indonesia. At all sites, with the exception of Oebola in NTT, the introduced feeding strategy significantly increased average daily gain of weaned Bali calves (Table 11) resulting in a greater change in live weight over the monitoring period (Figures 13 and 14). The lack of a response in Oebola was attributed to the high quality feeds which were offered to cattle under the prevailing cattle management system. Leucaena and local legumes comprise a large component of the diet in Oebola, which is essentially the same as the leuceana and forage legume treatments implemented. While the control calves grew at a greater rate than either treatment group in Oebola, it can not be determined if this is due to the fact that they were not weaned at 6 months of age or they were not maintained in the kandang with the treatment calves. While the unweaned control calves did grow faster than weaned treatment calves in Oebola, there may have been a negative impact of not weaning on cow condition and subsequent reproductive performance, although this was not measured.

Partial budget analysis estimates indicate that the introduction of the feeding strategies at each of the sites resulted in a modest increase in small-holder farmer profits over the 6 month feeding period, compared with control practices over the same period (Table 12), with the exception of Oebola village in NTT. The data and assumptions used for this analysis are presented in Appendix 11.4 (Table 21 and Table 22); it is interesting to note that the revenue above cost (R/C) is actually lower for the introduced feeding strategy compared with the prevailing feeding strategy in Sulteng (Table 21). It is expected that as a result of the early weaning strategy increased conception rates would follow the subsequent calving, further improving small-holder farmer cash-flows, although this was not specifically measured in the current study.

a.

b.

Figure 9. Bali calf fed leucaena supplementation strategy in traditional housing system (a.) and farmers attending the dissemination activity (b.) in Prigen sub-district, Pasuruan district, Jawa Timur.

a.

b.

Figure 10. Typical management (control) (a.) and recording the live weight (b.) of Bali calves in Donggala district, Sulawesi Tengah.

a. b.

Figure 11. Small-holder farmers from Tandek village, Central Lombok, Nusa Tenggara Barat weighing daily allocation of Sesbania (a.) and from surrounding villages attend dissemination day at Tandek (b.).

a. b.

Figure 12. Bali calf fed forage legume hay (a.) and storage of conserved forage legumes (b.) at Usapinonot village, Nusa Tenggara Timur.

Table 11. Average daily live weight gain of control and early weaned Bali cattle with strategic supplementation, from 6 to 12 months of age, in villages in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah[1]

Site	Average live weight gain (kg/d)			SEM[1]
	Control	Treatment 1	Treatment 2	
Jawa Timur[2]	0.179[a]	0.418[b]	N/A[1]	0.03
Nusa Tenggara Barat[3]	0.216[a]	0.353[b]	N/A	0.02
Nusa Tenggara Timur – Oebola[4,5]	0.359[b]	0.288[ab]	0.266[a]	0.05
Nusa Tenggara Timur – Usapinonot[4,5,6]	0.115[a]	0.308[c]	0.233[b]	0.04
Sulawesi Tengah[7]	0.289[a]	0.428[b]	N/A	0.02

[1]Values are treatment means; SEM is standard error of differences of the means; N/A, not applicable as only one treatment was implemented in villages.
[2]Treatment 1 was leucaena fed at approximately 10 g DM/kg W/d.
[3]Treatment 1 was sesbania fed at approximately 10 g DM/kg W/d.
[4]Treatment 1 was leucaena fed at approximately 15 g DM/kg W/d.
[5]Treatment 2 was forage legumes (Clitoria ternatea, Centrosema pascuorum, Stylosanthes hamata and Lab lab purpureus) fed at approximately 15 g DM/kg W/d.
[6]Study was conducted from 6 to 15 months of age.
[7]Treatment 1 was rice bran and copra meal mixed in equal proportions as fed and fed at approximately 10 g DM/kg W/d.

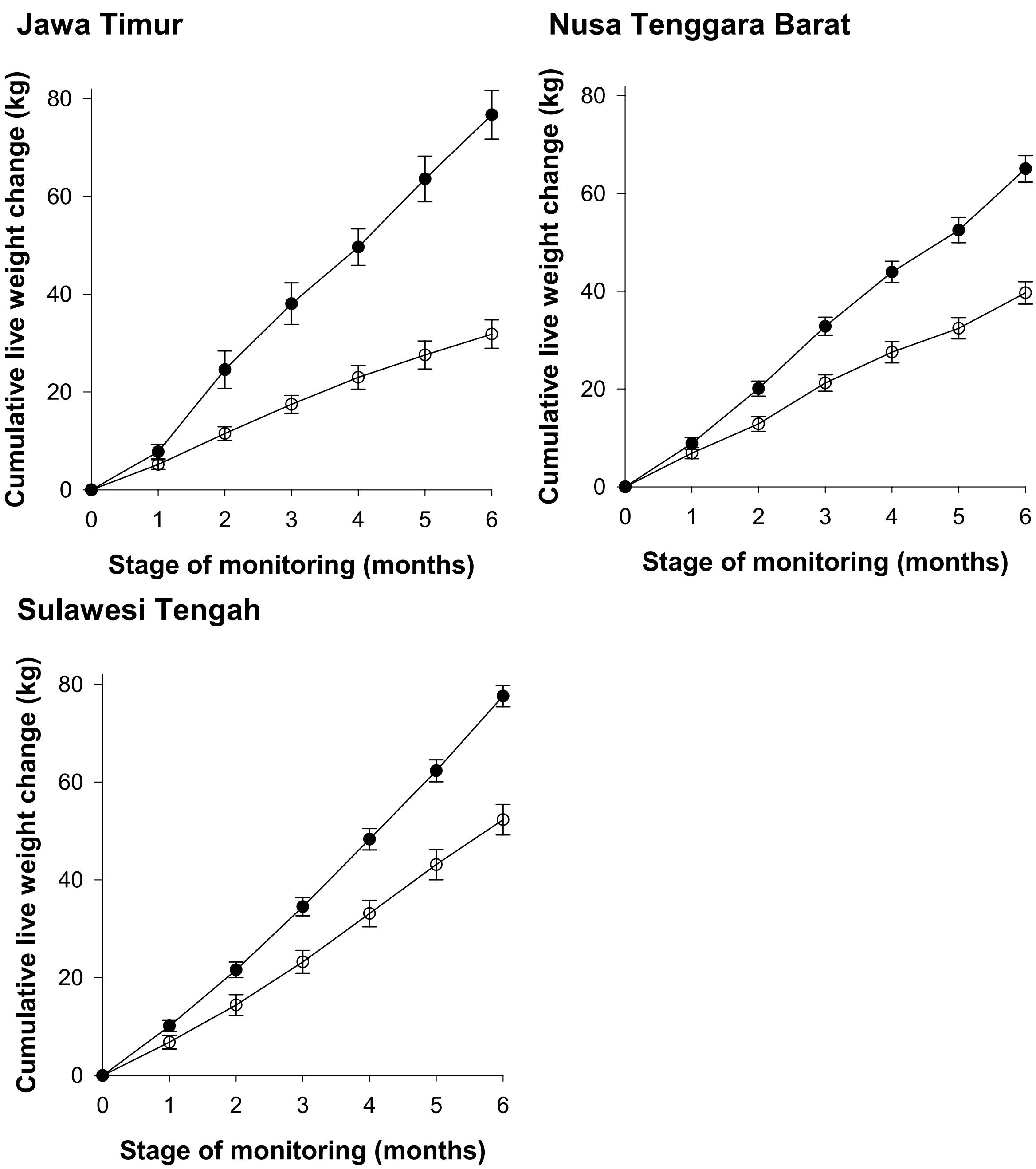


Figure 13. Cumulative live weight change of control (O) and early weaned, preferentially fed (●) Bali cattle from 6 to 12 months of age in villages across eastern Indonesia. Early weaned, preferentially fed calves were for 10 g DM/kg W/d of leucaena, sesbania and rice bran:copra meal in Jawa Timur, Nusa Tenggara Barat and Sulawesi Tengah, respectively.

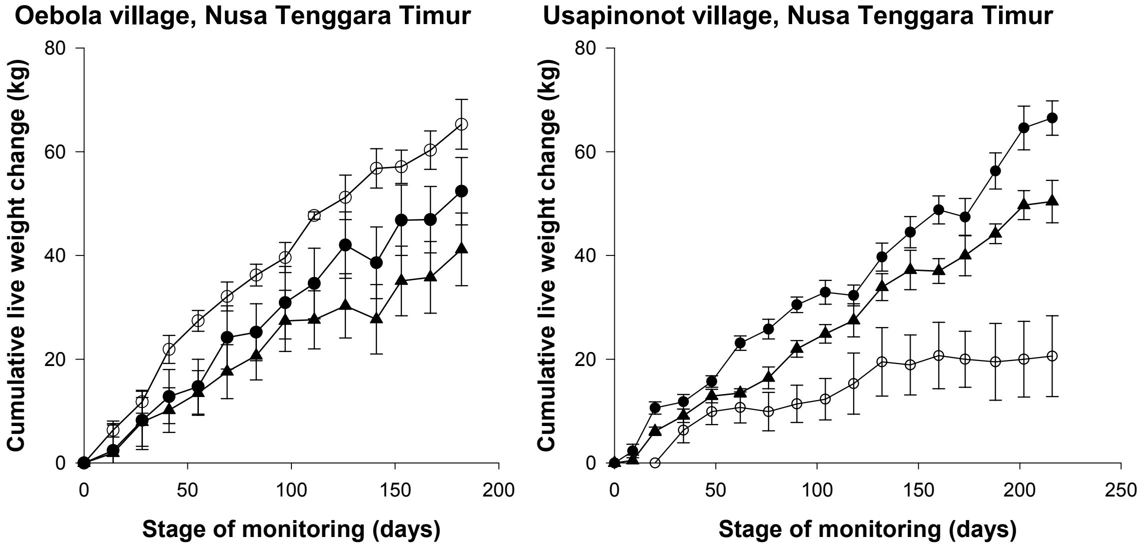


Figure 14. Cumulative live weight change of control (O) and early weaned Bali calves, preferentially fed leucaena (●) and forage legumes (▲) from 6 to 12 months of age in Oebola village and 6 to 15 months of age in Usapinonot village, Nusa Tenggara Timur.

Table 12. Estimated profit of feeding strategy for early weaned Bali cattle, from 6 to 12 months of age, in villages in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah

Site	**Estimated profit after approximately 6 months of feeding (rupiah/head/d)**		
	Control	Treatment 1	Treatment 2
Jawa Timur[2]	3,827	10,404	N/A[1]
Nusa Tenggara Barat[3]	3,810	6,905	N/A
Nusa Tenggara Timur – Oebola[4,5]	6,471	4,767	4,904
Nusa Tenggara Timur – Usapinonot[4,5,6]	1,098	5,730	4,445
Sulawesi Tengah[7]	7,533	11,128	N/A

[1]N/A, not applicable as only one treatment was implemented in these villages.
[2]Treatment 1 was leucaena fed at approximately 10 g DM/kg W/d.
[3]Treatment 1 was sesbania fed at approximately 10 g DM/kg W/d.
[4]Treatment 1 was leucaena fed at approximately 15 g DM/kg W/d.
[5]Treatment 2 was forage legumes (Clitoria ternatea, Centrosema pascuorum, Stylosanthes hamata and Lab lab purpureus) fed at approximately 15 g DM/kg W/d.
[6]Study was conducted from 6 to 14 months of age.
[7]Treatment 1 was rice bran and copra meal mixed in equal proportions as fed and fed at approximately 10 g DM/kg W/d.

Field days were held at each site upon completion of the study, with visiting farmers, not directly involved in the study, control farmers and intervention farmers invited to attend; local extension officers and government officials also attended in most cases. Farmers were surveyed at the completion of the field day (Table 13). General information to describe the participating farmers and their cattle herds are presented in Appendix 11.6; Figure 22.

Table 13. Number of small-holder farmers attending village demonstration field days at Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah (number of villages is in brackets)

Farmer	Jawa Timur	Nusa Tenggara Barat	Nusa Tenggara Timur	Sulawesi Tengah
Visiting	79 (3)	27 (17)	4 (2)	55 (7)
Control	19 (1)	5 (3)	6 (2)	16 (1)
Treatment	16 (1)	9 (1)	11 (2)	17 (1)
Total	114	41	21	88

There was little difference in the age of farmers between sites or the farmer's role in the study; however farmers in NTB had more experience in raising cattle than farmers in the other areas (Appendix 11.6; Figure 22). A greater proportion of farmers in NTB were owners and managers of cattle, compared with the other areas, while herd size was greatest in NTT and smallest in NTB. Control and treatment farmers were more likely to already practice weaning, thought it better to wean at a younger age and were more likely to adopt the early weaning and preferential feeding strategies (Appendix 11.6; Figures 23 and 24). The reasons given for weaning varied between sites, with farmers in Sulteng indicating that weaning had benefits on cow body condition and reproduction, farmers in NTT indicated that weaning would increase calf growth while farmers in Jatim indicated weaning was to increase calf growth or to sell the calf. Of those farmers not likely to adopt the preferential feeding strategy of targeted supplementation, the constraints given included were that they were managers only, cattle were not a priority and feeds, land and seed were expensive or unavailable (Appendix 11.6; Figure 24). It is interesting to note that over 90% of the small-holder farmers surveyed at NTB said the reason that they had no adopted a preferential supplementation strategy of early weaned calves was that they were unaware of the benefits and they had not received any guidance to implement this type of strategy in the past. The majority of these small-holder farmers are involved in the scale-up of the IVMS (SMAR 2006 096) of which the preferential supplementation strategy will be an introduced component as that project proceeds.

7.3 Develop the capacity, particularly of junior staff, in the conduct of farmer relevant nutritional research

The project developed the capacity of staff to conduct farmer relevant nutritional research.

- Scientists previously trained in Australia were engaged in the project to sustain their development. These scientists have become involved in a range of other ACIAR initiatives, undertaken postgraduate study, received promotion within their organisations or moved on to senior management roles within other organisations. It is anticipated that these senior scientists will have the potential to direct future research initiatives to increase livestock production and cash-flow of small-holder farmers across eastern Indonesia.
- Junior scientists were appointed to manage the day to day activities at each site. The success of this approach was variable. Some sites appointed junior scientists who were young and less experienced but their knowledge and skills developed rapidly under the guidance of the senior scientist and Australian scientists. However, some sites preferred to appoint a more experienced scientist to manage the project to ensure that activities were conducted to a high standard. In some cases junior scientists were not available. While the appointment of more experienced scientists did ensure project activities were conducted appropriately, it meant that a great opportunity to develop a young, less experienced scientist was missed. It is recommended that specific prerequisites be in place for the appointment of junior scientists in future projects.

- Project team members from all sites were presented with opportunities to develop their knowledge and skills through attendance at a range of seminars, conferences, workshops and meetings. These are detailed in section 8.2.1.
- Over 50 undergraduate students were involved in the on-station experiments conducted within the project as part of their Honours program and submitted a thesis based on these studies. Students gained experience in the conduct of feeding, digestibility and live weight gain studies and laboratory work, as well as the applied relevance of on-station activities to the crop-livestock systems in eastern Indonesia. This provided the next generation of livestock scientists with an opportunity to receive training in ruminant nutrition research from experienced Indonesian and Australia researchers. Thirty five of these students prepared an abstract in English and were awarded a Non-award certificate from the University of Queensland. These abstracts were compiled into a booklet which was distributed to the partner organisations, the collaborating universities and ACIAR.
- Mr Tanda Panjaitan successfully completed a PhD at the University of Queensland during which he underwent training in all aspects of ruminant nutrition research. It is expected that this training will greatly enhance the capacity of BPTP-NTB to conduct farmer relevant ruminant nutrition research in the future.
- Prof. Marsetyo was awarded a John Dillon Fellowship and attended the research management and leadership training program in Australia during February and March 2009.

7.4 Investigate strategies to increase microbial protein production in Brahman cattle in Australia

Microbial protein production, as influenced by digestible organic matter intake (DOMI) and the EMCP, supplies approximately 72% of metabolisable protein to ruminants and up to 100% of metabolisable protein from low CP, low digestibility forages (Poppi and McLennan, 1995). An increase in microbial protein supply results in an increase in live weight gain (Poppi and McLennan, 1995). The research activities conducted in Australia first set out to establish baseline information on MCP production and the EMCP of a range of forages typical to northern Australia. Strategies to increase the EMCP through targeted supplementation were then investigated.

Experiment 1

Tropical pastures, such as speargrass and Mitchell grass, commonly grazed by cattle across northern Australia are often low in digestibility and crude protein for extended periods of the year. Cattle fed low quality speargrass (25.7 g CP/kg DM; 709 g NDF/kg DM) and Mitchell grass (29.7 g CP/kg DM; 692 g NDF/kg DM) in experiment 1 had lower feed intake, longer retention times in the rumen and lower rumen ammonia nitrogen concentrations, than cattle fed medium quality pangola grass (75.5 g CP/kg DM; 691 g NDF/kg DM) or high quality ryegrass (199.8 g CP/kg DM; 584 g NDF/kg DM) hays. These differences in intake and retention time (Table 14) were associated with differences in MCP production, where steers fed ryegrass hay had the highest MCP production, followed by steers fed pangola, Mitchell and speargrass hays, with a similar trend determined for the EMCP (Figure 15). The EMCP values determined for tropical forages here were in agreement with other studies and were well below the minimum value of 130 g MCP/kg DOM suggested for forage based diets (CSIRO, 2007). The results indicate that the low RDP content of tropical forages limit the EMCP (Figure 15) and suggest that strategies to supply additional RDP and decrease the retention time may enhance the EMCP of cattle grazing crude protein deficient pastures.

Table 14. Intake, digestibility, retention time, concentration of rumen ammonia nitrogen and microbial protein production (MCP) and the efficiency of MCP of steers fed speargrass, Mitchell grass, pangola grass and ryegrass hays *ad libitum*

Parameter	Speargrass	Mitchell grass	Pangola grass	Ryegrass	SEM[1]
Dry matter intake(g/d)	1908[a]	4083[b]	6367[c]	7243[d]	0.6
Dry matter intake (g/kg W/d)	5.5[a]	10.1[b]	15.6[c]	17.6[d]	1.4
Dry matter digestibility (%)	46.5[ab]	40.7[a]	54.6[b]	69.7[c]	3.8
Digestible organic matter intake (g/kg W/d)	2.4[a]	4.5[b]	7.9[c]	11.4[d]	0.6
Retention time of liquid in the rumen (h)[2]	33.7[a]	31.7[a]	13.7[b]	10.2[b]	2.9
Retention time of solid in the rumen (h)[3]	57.5[a]	41.6[ab]	28.9[b]	13.2[c]	4.9
Rumen ammonia nitrogen (mg/L)	48.5[ab]	31.3[a]	57.1[b]	191.0[c]	10.7
Microbial protein production (g/d)	80.4[a]	172.0[b]	328.1[c]	626.7[d]	31.3
Microbial protein production (g/kg W/d)	0.2[a]	0.4[b]	0.8[c]	1.5[d]	0.07
Efficiency of MCP (g MCP/kg DOM)[4]	77.7[a]	78.6[a]	102.3[b]	135.0[c]	6.77

[1]Standard error of the mean; means with different alphabetical superscripts across a row are significantly different (P<0.05).
[2]Retention time of Cr-EDTA, liquid phase marker.
[3]Retention time of YbCl3.6H2O, solid phase marker.
[4]Outlier values were not included in analysis.

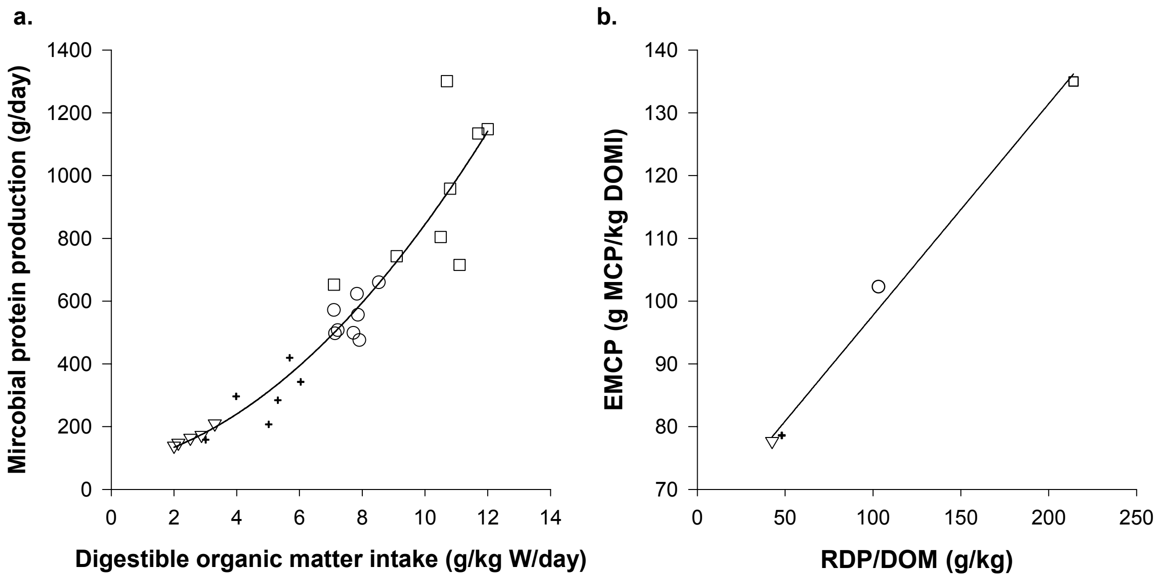


Figure 15. Relationship between microbial protein (MCP) production and digestible organic matter intake (DOMI) (a.) and the efficiency of MCP production (EMCP) and rumen degradable protein (RDP) in steers consuming speargrass (▽), Mitchell grass (+), pangola grass (O) and ryegrass (□) hays.

Experiment 2

It was demonstrated in experiment 1 that the digestion rate of tropical pastures (low in CP and high in NDF) was low, potentially restricting feed intake. Rate of digestion may be improved through the provision of non-protein nitrogen to the rumen microbes, however the rumen microbes have other specific requirements (e.g. peptides, amino acids, vitamins, nucleic acids, fermentable ME) which are not supplied by non-protein nitrogen alone. In the present experiment, the rate of digestion was increased when steers fed a low quality speargrass hay were supplemented with urea, amino acids, casein, cottonseed meal, yeast or algae. Despite the different composition of these nitrogen sources, there was no difference in the rate of digestion between the types of supplement used. It is concluded that when CP of the diet and rumen ammonia nitrogen concentration are low, nitrogen is the primary limiting nutrient and the addition of nitrogen will improve the rate of digestion, regardless of the source of nitrogen.

Experiments 3 and 4

It was demonstrated in experiment 2 that the rate of digestion of animals fed a low quality tropical hay did not differ between different sources of nitrogen supplied to provide 170g RDP/kg DOM. However, MCP production was not measured, so it is unknown if the source of nitrogen influenced MCP production. Branched chain fatty acids, fermentation products from true protein degradation, and phenylalanine are essential nutrients for the growth of fibre degrading rumen bacteria and may be the primary limiting nutrient to microbial growth on high fibre diets. Bowen (2003) demonstrated that high levels of EMCP were achieved only when high levels of RDP were supplied (290 g RDP/kg DOM) and suggested that these high levels of inclusion had not been adequately investigated. It was hypothesised that supplying branched chain fatty acids, in the form of branched chain amino acids (BCAA) may increase MCP production and the EMCP of cattle consuming low quality tropical forages and the response may differ between cattle fed low and moderate quality tropical forages.

Experiments 3 and 4 determined that intake, retention time, rate of digestion, rumen ammonia nitrogen and total volatile fatty acid concentration were similar between steers supplemented with increasing levels of US or USAA, regardless of the quality of the basal tropical forage fed. Supplementation with USAA resulted in an increased proportion of branched chain fatty acids in the rumen compared with supplementation with US alone, for both low and medium quality tropical forages, as expected. It may be concluded that the provision of increasing amounts of BCAA plus phenylalanine to cattle, when RDP supply was adequate, even at high levels result in no additional response in MCP production and EMCP over and above that obtained from increasing RDP through an inorganic N source alone.

Experiment 5

It was demonstrated in experiments 3 and 4 that supplementation with BCAA’s provided no additional response in MCP over non-protein nitrogen sources alone, over the level of intakes used. The results suggested that factors (peptides and nucleic acids) present in protein sources may be beneficial to the rumen microbe population, above that of branched chain amino acids in an adequate rumen ammonia environment. Spirulina is a single cell source of protein which contains a range of novel nutrients and growth factors which may also be required by the rumen microbe population. Increasing levels of Spirulina supplementation increased MCP and the EMCP (Figure 16), increased digesta load and intake, without a substitution effect (Figure 17) and decreased the retention time of liquid and particle fractions in the rumen (Figure 18), over the range of intake levels used in the present study. At high levels of Spirulina supplementation, MCP and the EMCP were in the order of the maximal rates reported in the feeding standards. All responses to Spirulina supplementation were greater than responses determined for non-protein nitrogen supplementation in the present study.

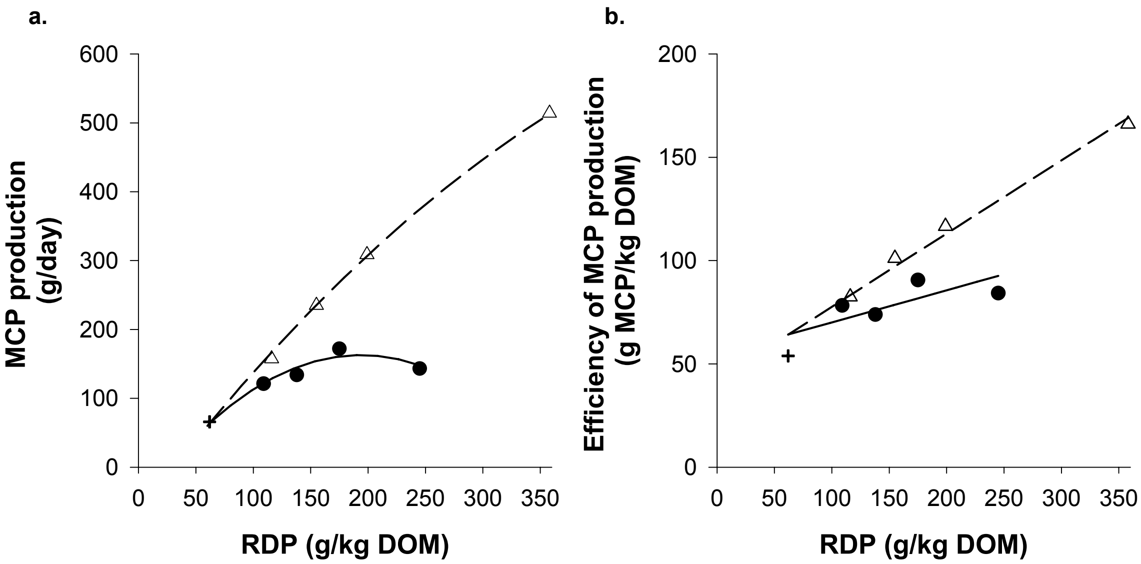


Figure 16. The response of microbial protein (MCP) production (a.) and the efficiency of MCP (EMCP) (b.) of steers fed Mitchell grass hay (+, control) supplemented with increasing levels of rumen degradable protein (RDP) supplied in the form of urea plus ammonium sulphate (●; MCP = -53 + 2.2x – 0.006x^2; EMCP = 55 + 0.16x) and Spirulina (∆; MCP = -66 + 2.2x – 0.002x^2; EMCP = 42 + 0.35x).

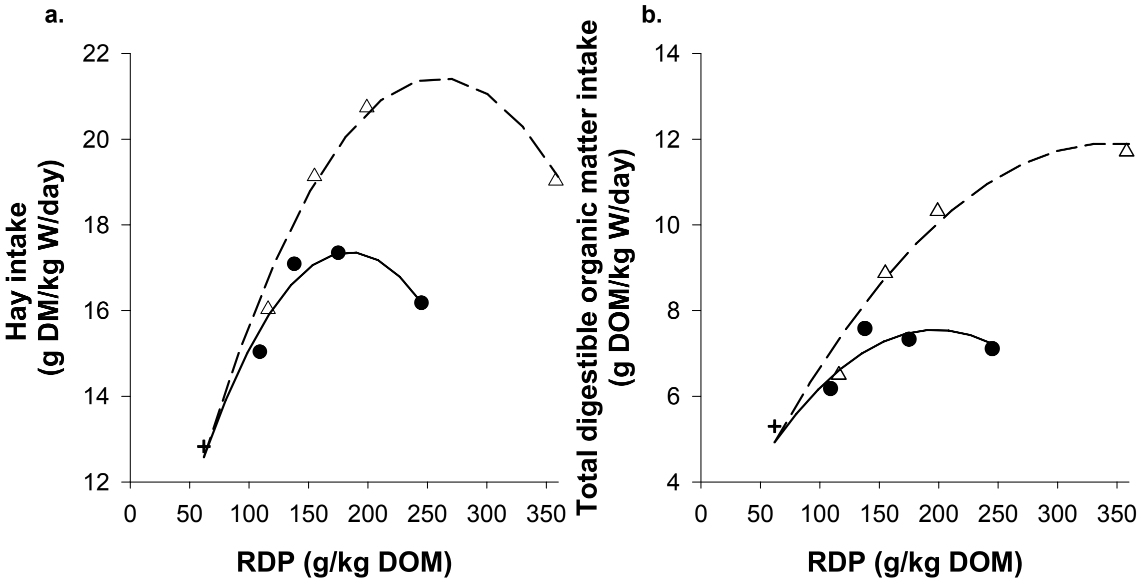


Figure 17. The effect of rumen degradable protein (RDP) on hay intake (a.) and total digestible organic matter intake (DOMI; b.) of steers fed Mitchell grass hay (+, control) supplemented with increasing levels of rumen degradable protein (RDP) supplied in the form of urea plus ammonium sulphate (●; Hay intake = 6.5 + 0.12x – 0.0003x^2; DOMI = 1.97 + 0.057x – 0.00014x^2) and Spirulina (∆; Hay intake = 6.5 + 0.12x – 0.0002x^2; DOMI = 1.54 + 0.06x – 0.00008x^2).

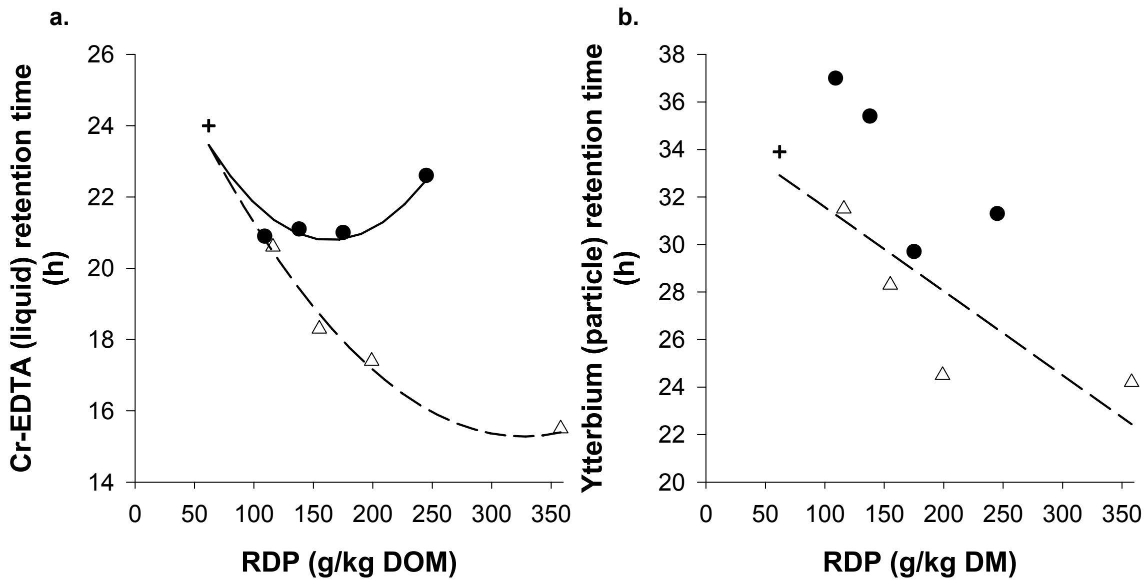


Figure 18. The effect of rumen degradable protein (RDP) on the retention time (RT) of a liquid marker (Cr-EDTA; a.) and a particle marker (Ytterbium; b.) in the rumen of steers fed Mitchell grass hay (+, control) supplemented with increasing levels of urea plus ammonium sulphate (•; Cr-EDTA RT = 28 - 0.08x + 0.0003x^2; Ytterbium RT = Not significant) and Spirulina (Δ; Cr-EDTA RT = 28 - 0.08x + 0.0001x^2; Ytterbium RT = 35 - 0.04x).

Experiment 6

It was demonstrated in experiment 5 that Spirulina supplementation increased intake, decreased the retention time of digesta in the rumen and increased MCP and the EMCP of steers fed low quality Mitchell grass hay. If Spirulina supplementation is to be widely adopted a practical method of administration is required. One possible method of administration is via the drinking water. However, the effects of Spirulina on water intake were unknown, as was the amount of Spirulina which would by-pass the rumen if supplied in the drinking water. The results indicated that the inclusion of Spirulina in the drinking water was acceptable to cattle and had no negative effects on water or hay intake for either short or long periods. The steers showed a strong preference for water containing Spirulina to water alone when given free access to both solutions (Panjaitan, 2009). Approximately 20% of imbibed water bypassed the rumen and this was not influenced by the concentration of Spirulina in the drinking water (Panjaitan, 2009).

General discussion

The results of experiment 1 indicate that cattle fed tropical forages have EMCP values below the minimum value given in the feeding standards due to low RDP content which was less than 94 g RDP/kg DOM. This was below that required for an EMCP of 130 g MCP/kg DOM. This is in agreement with the feeding standards which state that the EMCP is dependent on RDP supply. Supplying sufficient RDP from any source removed a limitation of microbial growth, regardless of the source. However, variation in EMCP still existed even when the quantity of RDP was adequate. Simple NPN supplements failed to increase the EMCP to the highest level in the feeding standards. Branched-chain amino acid supplements increased BCFA but did not affect EMCP. Spirulina supplementation at high levels of RDP increased EMCP to the highest level in the feeding standards. The increase in EMCP in cattle supplemented with Spirulina may be due to its composition which provides a mix of nutrients (peptides, AA, nucleic acids, fatty acids, vitamin and minerals) which was absent in the NPN source and AA supplements. In addition, long retention is a typical characteristic of tropical forages which also restrict the EMCP. Spirulina supplementation decreased the retention time of water and particle markers in the rumen of cattle consuming low tropical forages, however the mechanism for this remains unknown. It is concluded that Spirulina supplementation resulted in the highest

EMCP within the experiments conducted within this project and this, or other single cell algae species, may be novel supplements for increasing the EMCP of cattle consuming low quality forages in Australia and Indonesia. Cattle had a strong preference for Spirulina in the drinking water and this, and feed and water intake, were unaffected by the concentration in the water. Therefore Spirulina could potentially be grown in the drinking water on-farm, or in village, and safely consumed by cattle. The benefits of supply of supplements in the drinking water are that all animals will consume the supplement, as opposed to dry supplements of which a proportion of animals may not consume.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The large amount of data generated in the studies conducted in Indonesia is scientifically unique. This is the only study, of which we are aware, that uses similar protocols, targeting a similar class of animal to generate live weight gain relationships to such a wide range of feeding strategies, for Bali cattle. The data generated will be used in the generation of growth and nutrition models specific to Bali cattle and will also confirm and dismiss some previously held beliefs in regard to the nutrition and management of young growing Bali cattle. It is expected that the large data set will form a framework for making future recommendations regarding feeding and growth of Bali calves and basic information upon which other research opportunities may be built.

Scientists and technicians have introduced quality control programs in the conduct of pen studies and laboratory work. This has included an appreciation of biological and technical variation in the design of experiments, a data review process and the introduction of a ring-test between laboratories involved in the project. These changes have extended to other scientists and technicians, not directly involved in the ACIAR project, who have adopted the experimental design and protocols introduced.

The present project has developed an openness of discussion and debate, while maintaining respect, between partner organisation scientists at annual project meetings and via email and other forms of communication, regarding research issues, methodology, results and ideas. This has resulted in project scientists sharing information, experiences, ideas and resources and joint publications prepared between sites, which previously never had the opportunity to interact. This is also occurring between projects, where team members from LPS 2004 023 are acting as mentors for team members in SMAR 2007 013. Other team members were actively involved in other ACIAR projects, such as SMAR 2006 096, SMAR 2006 061 and SMAR 2006 003.

The results from the Australian component studies investigating MCP production of cattle fed tropical pastures has provided a basic understanding of supplementation strategies to enhance MCP production in cattle upon which future research activities are been built. Samples collected from all the experiments described in this report are being analysed to determine the response of the rumen microbial population to supplementation strategies under Meat and Livestock Australia funding. The information generated in this project from the Spirulina experiments has formed the basis of future research activities been conducted by PhD students at the University of Queensland.

8.2 Capacity impacts – now and in 5 years

8.2.1 Staff capacity

All staff have been given the opportunity to develop their skills and experience by attendance at a range of conferences and seminars, training workshops and meetings and through postgraduate study.

Conferences / Seminars

- 2006. Australian Society of Animal Production, Perth, Australia. Panjaitan, Quigley and Poppi (University of Queensland). (ACIAR and MLA funded).
- 2006. International Seminar on Tropical Animal Production. Yogyakarta, Indonesia. Priyanti (ICARD). (ACIAR funded).

- 2007. International Symposium on Energy and Protein Metabolism. Vichy, France. Quigley (University of Queensland). (Australian Academy of Sciences funded).
- 2007. International Seminar on Nutrition of Herbivores. Beijing, China. Marsetyo (University of Tadulako) and Poppi (University of Queensland). (ACIAR and UQ funded, respectively).
- 2008. Asian-Australasian Association of Animal Production. Hanoi, Vietnam. Panjaitan (BPTP NTB). (ACIAR funded).
- 2008. Australian Society of Animal Production. Brisbane, Australia. Quigley, Isherwood, and Poppi (University of Queensland). (ACIAR and MLA funded).
- 2008. International Seminar on Bali Cattle Production. Kupang, Indonesia. Dahlanuddin (University of Mataram). (Indonesian committee funded).
- 2008. Pengembangan Sapi Potong Menuju Percepatan Pencapaian Swasembada Daging Sapi Nasional. Palu, Indonesia. Panjaitan (BPTP-NTB), Dahlanuddin (University of Mataram), Marsetyo and Damry (University of Tadulako), and Anggraeny and Mariyono (BCRI, Grati). (Indonesian committee funded; local organisation funded).

Training / Workshops

- Experimental design and protocol development workshop. Mataram, Indonesia. 2006. Dahlanuddin, Marsetyo, McLennan, Mullik, Pamungkas, Poppi, Priyanti, Quigley, Sole, Yunuarianto. (ACIAR funded).
- Enhancing social and community dimensions of agricultural, fisheries and forestry research projects workshop. Denpasar, Indonesia. 2006. Marsetyo, Dahlanuddin and Esnawan Budisantoso. (ACIAR funded).
- Enhancing social and community dimensions of agricultural, fisheries and forestry research projects workshop. Bogor, Indonesia. 2006. Dicky Pamungkas. (ACIAR funded).
- Communicating science workshop (I and II). Jakarta, Indonesia. 2006. Marsetyo, Dicky Pamungkas and Esnawan Budisantoso. (ACIAR funded).
- Enhancing social and community dimensions of agricultural, fisheries and forestry research projects workshop. Mataram, Indonesia. 2007. Damry and Oscar Yunuarianto. (ACIAR funded).
- Communicating science workshop. Jakarta, Indonesia. 2007. Dahlanuddin and Damry. (ACIAR funded).
- Statistical analysis and experimental design workshop. Makassar, Indonesia. 2007. Marsetyo, Dicky Pamungkas, Oscar Yunuarianto and Paskalis Fernadez. (ACIAR funded).
- Research and development project management and commercialisation program. Makassar, Indonesia. 2007. Ati Rubiati (BPTP NTT).
- Laboratory analysis of soil and forage samples workshop. Naibonat, Indonesia. 2007. Sriyana (BCRI, Grati), Sri Sulastri (University of Mataram), Sitti Marwiah (University of Tadulako), Piter Ly (University of Nusa Cendana), Meha Malakadu (BPTP-NTT), Yohanis Leki Seran (BPTP-NTT), Sophia Ratnawaty (BPTP-NTT), Aloysia Doa (BPTP-NTT), Sumarti (BPTP-NTT) and Esnawan Budisantoso (BPTP-NTT). ATSE Crawford Fund funded.
- Managers Development Program. Canberra / Melbourne, Australia. 2007. Dahlanuddin (University of Mataram). (ACIAR funded).

- Program linkage ACIAR-SMAR on Beef Cattle Management. Pasuruan, Indonesia. 2008. Ati Rubiati and Hendrik Marawali (BPTP-NTT). (ACIAR funded).
- PhD - John Allwright Fellowship. Brisbane, Australia. 2004-2008. Tanda Panjaitan (BPTP NTB). (ACIAR funded).
- PhD. Yogyakarta, Indonesia. Commenced 2007. Dicky Pamungkas (BCRI, Grati).
- John Dillon Fellowship. Melbourne / Wagga Wagga / Canberra / Brisbane / Armidale, Australia. 2009. Marsetyo (University of Tadulako). (ACIAR funded).

The greatest capacity development of staff (scientists, technicians and students) has come from the regular interaction between Indonesian and Australian counterparts. The involvement of Australian scientists in all stages of the experimental activities of the project has demonstrated the need for a ‘hands-on’ approach to conducting research. This effect has been reciprocal as the Australian scientists gained a greater understanding of the issues that arise with implementing a research program in sometimes difficult conditions, as well as the social and political issues in conducting and extending research findings with the complex crop-livestock systems of eastern Indonesia; the capacity of the Australian scientists to conduct intensive research activities in Indonesia has also been developed. This resulted in Indonesian and Australian scientists learning from each other.

Involvement of senior scientists, previously trained in Australia, in the project has provided continued support for them and the development of their careers. This has been through attendance at training workshops, conferences and seminars, providing opportunities for publications, recognition and promotion at a local level and to conduct interesting but farmer relevant work that probably would not have been likely to be funded at a local level. This continued support has resulted in all of the senior scientists using the knowledge and skills acquired in the current project in achieving awards and qualification, recognition and developing roles outside of the project. These qualifications and roles include

- PhD awarded (Priyanti, Bogor Agricultural University; Panjaitan, University of Queensland)
- PhD commenced (Pamungkas, PhD, Gadjah Mada University)
- promotions within their organisations (Marsetyo, appointed Professor, University of Tadulako)
- project leaders and increased level of involvement in other ACIAR projects (Dahlanuddin, Marsetyo, Budisantoso)
- employment in other organisations (Budisantoso, ANTARA)
- increased local projects.

The appointment of a ‘junior scientist’ at each site and the involvement of honours students in the project contributed to the development of capacity of the next generation of researchers to conduct farmer relevant research. Those honours students which submitted an abstract of their thesis, in English, to the University of Queensland, received a certificate acknowledging their contribution to the project. It is hoped that this certificate will assist these graduates to find employment upon completion of their studies. The continued capacity development of junior scientists will require continued engagement, either through ongoing involvement with ACIAR projects or opportunities for further training, in the form of postgraduate study programs.

The training of Mr Tanda Panjaitan (John Allwright Fellow) during his PhD has greatly enhanced his capacity to conduct livestock research in Indonesia. He has developed skills in experimental design and statistical analysis, critical thinking, questioning and interpretation of data, a range of scientific methodologies and scientific writing. He will return to his host organisation as the senior ruminant scientist and will manage and potentially shape the direction of livestock research in his institution.

The capacity development undertaken in the current project has been extended to other activities, external to the current project. Further, the knowledge and skills acquired by staff have permeated throughout the partner organisations, with staff not directly involved in the project taking up ideas and information generated in the current project for their own activities.

8.2.2 Infrastructure capacity

All sites have used project funds to develop their infrastructure in some way. At most sites this has involved upgrades of animal research facilities, including the animal pens and feed and water troughs. Other sites have purchased laboratory related equipment such as freezers and drying ovens, and laboratory, pen and animal balances, while others have purchased note-book computers for data entry in the field, or digital cameras for video and photographic recording of project activities. These infrastructure improvements will allow high standard research activities to be conducted in the future.

8.2.3 Institution capacity

The improved capacity of staff and infrastructure has not only had a direct impact on the institutional capacity to conduct research. The involvement of partner organisations in the project has also been of benefit where such international collaboration can assist them in their own national recognition and classification and improve their national ranking score, which provides greater opportunities for funding and development in the future. The reputation of all partner organisations to provide service to cattle development programs at a regional level has been enhanced. The project has enriched teaching materials, facilities and opportunities which are now based on local findings and activities rather than theoretical information derived from text books.

The project involved many institutions within Indonesia which encouraged national synergism where scientists from those institutions work together to investigate issues to improve Bali cattle production. This synergism resulted in efficient utilization of resources and also avoided duplication of research activities.

The publication and presentation of project results nationally and internationally has provided project members with the potential to develop networks and linkages with other Indonesian and international organisations. This has provided benefits, especially to support and improve the scientific career, which in general also improves the performance of the institution.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

The current project is unlikely to have any direct economic impacts aside from the improved cash-flow of farmers involved in the village implementation studies. Adoption of early weaning and increased growth rates of weaned calves were reported to increase annual household cash-flow (AS2 2000 103). This economic analysis within this report compared between feeding strategies examined on-station and implemented and evaluated in villages. In general, the inclusion of tree legumes in the diet of weaned Bali calves will result in increased annual household cash-flow compared with the prevailing feeding strategies. The financial impact of early weaning on cow reproduction and the potential to increase herd size were not considered in the current project.

The average number of Bali cattle owned by small-holders in Indonesia is approximately 2 cows per household. By enhancing the productivity of Bali cattle through feeding and management systems (early weaning and preferential feeding) to achieve one calf per cow per year, each household will potentially have two calves for sale per year. The profit per household of raising two weaned Bali calves from 6 to 12 months of age under the recommended feeding strategy will be 3,828,672, 2,665,800, 2,475,144 and 4,028,336, rupiah/year in Jatim, NTB, NTT (Usapinonot) and Sulteng, respectively. This figure is equivalent to 15-25% of the minimum regional wages paid by the Government of Indonesia, excluding tax. To further add value to Bali cattle farming at the household level an increase in the number of cows owned by each household, from 2 to 4 cows, would be required. This will also empower farmers as small producers in agribusiness and facilitate better access to production factors and economic returns.

8.3.2 Social impacts

At this stage it is not possible to ascertain any wider social impacts of the project than with those farmers directly involved. The greatest impact on farmers, from any possible nutritional management strategy introduced in villages, is through reduced labour inputs and increased cash-flow. Any feeding strategy which reduces a farmer's time, or the time of wives and children, spent cutting and carrying forages will increase its chances of adoption. It will either allow time for other activities, including potential income generating activities, or it will allow time to raise more cattle for the same labour input. For example, some farmers have adopted the feeding of gliricidia as it reduces the time required to cut and carry feeds, due to ease of cutting and proximity to kandang, compared to grass; this decision is made aside from the benefit of increased live weight gain.

It is anticipated that adoption of early weaning and management strategies to increase the growth rates of calves will potentially have a large social impact. Early weaning and preferential feeding will result in improved reproductive output and increased growth rates. The ensuing financial benefits will impact society through increased cash flow available for education, home improvements, religious celebrations and festivals, special occasions and further investments in farming and livestock enterprises. However, there will also be a psychological impact, which may not be as apparent. A sense of pride and a feeling of enthusiasm amongst small-holder farmers will develop when the majority of cows are producing a calf each year, at a concentrated point in time, and the calves are growing well. The more efficient use of feed resources, greater growth rates of calves and larger number of calves at a similar age and live weight allows farmers to have more flexibility in marketing cattle, allowing them to sell under more favourable conditions.

A potential impediment to the scale-up of the IVMS is a negative perception by farmers on weaning and feeding high proportions of tree legumes in the diets of young cattle. Farmers who visited on-station or in village activities within the current project now realise that Bali calves can be weaned at 6 months of age and successfully grown well if provided with appropriate feeds and that feeding high levels of tree legumes will have no adverse affects on the wellbeing of their cattle. Further demonstration and extension of this will facilitate the adoption of the early weaning and tree legume feeding component of the IVMS scale-up activities.

The weighing of cattle in villages has been reported to boost enthusiasm amongst cattle producers. Most farmers have never seen cattle weighed before and are extremely interested to guess and confirm the weight of their animals. In some villages, all cattle are brought for weighing not just those directly involved in the monitoring. This has also provided farmers with an appreciation of the effects of season, nutrition and draught on weight gain of animals and the returns they receive per kg live weight when they sell their animals.

8.3.3 Environmental impacts

This project was not expected to have any significant environmental impacts. Any environmental impacts which do arise are likely to be relevant at the household level only. Adoption of the early weaning and preferential feeding of the calf may reduce the risk of overgrazing of high quality feed resources. Collection and composting of faeces to be used as an organic fertiliser on crops will reduce the reliance on synthetic fertilisers, which may be environmentally and economically unsustainable, and may reduce the risk of faecal contamination of food and water resources for human consumption. Early weaning and preferential feeding of the calf will require hygienic conditions, this may minimise potential disease reservoirs in the kandang and near to the house as a result of the improved sanitisation.

Various algae species are currently being investigated for their potential use for biofuel production and as carbon-sinks for industry. The potential use of algal by-products as a feed resource for ruminants adds value to the existing environmental benefits of these uses of algae species.

8.4 Communication and dissemination activities

Given the geographical distribution of the project team, updates of activities at each site were compiled and circulated to all partners each month. This kept all project team members informed of activities and progress at each site and often acted as a means of stimulating discussion between partner organisations. While Australian team members visited Indonesia regularly, cross site visits and communication was encouraged between Indonesian project team members; this resulted in the sharing of ideas and resources between organisations which may not have previously had the opportunity to interact.

Project workshops

Project planning workshop. December 2005. University of Mataram. NTB.

Protocol development workshop. February 2006. University of Mataram. NTB.

Project planning and review workshop. December 2006. BCRI, Grati. Jawa Timur.

Project planning and review workshop, joint meeting for LPS 2004 023 and SMAR 2007 013. December 2007. University of Mataram. NTB.

Farmer field days

Extension of on-station results, Experiment 1, May 2006. University of Tadulako. Sulawesi Tengah.

Extension of on-station results, Experiment 2, August 2006. University of Tadulako. Sulawesi Tengah.

Extension of on-station results, Experiment 3, November 2006. University of Tadulako. Sulawesi Tengah.

Farmer field day, extension of village monitoring study, July 2007. Malonas village, Donggala district, Sulawesi Tengah.

Extension of on-station results, Experiment 1, June 2006. BCRI, Grati. Jawa Timur.

Extension of on-station results, Experiment 2, October 2006. BCRI Grati. Jawa Timur.

Extension of on-station results, Experiment 3, April 2007. BCRI, Grati. Jawa Timur.

Farmer field day, extension of village monitoring study, April 2008. Sukolilo village, Prigen district, Jawa Timur.

Extension of on-station results, Experiment 1, May 2006. University of Mataram, NTB.

Extension of on-station results, Experiment 2, November 2006. University of Mataram, NTB.

Extension of on-station results, Experiment 4, April 2008. University of Mataram, NTB.

Farmer field day, extension of village monitoring study, December 2008. Tandek village, Central Lombok, NTB.

Extension of on-station results, Experiment 2, September 2007. BPTP-NTT, NTT.

Extension of on-station results, Experiment 2, November 2007. BPTP-NTT, NTT.

Extension of on-station results, Experiment 3, April 2008. BPTP-NTT, NTT.

Farmer field day, extension of village monitoring study, December 2008. Usapinonot village, Timor Tenggara Utara district, NTT.

Newsletter articles

Quigley, S. 2008. Increasing growth rate of weaned Bali calves. SMAR 2006 096, Project Newsletter, Vol 3.

Reports

LPS 2004 023. ACIAR Annual report. 2005-2006.

LPS 2004 023. ACIAR Annual report. 2006-2007.

LPS 2004 023. ACIAR Annual report. 2007-2008.

Laporan Akhir, Hasil Penelitian Kerjasama. 2008. Strategi peningkatan laju pertumbuhan sapi Bali lepas sapih (Internal report on project completion for ICARD).

Presentations

LPS 2004 023 Project overview, ACIAR LPS project leaders meeting, Brisbane, August, 2007.

9 Conclusions and recommendations

9.1 Conclusions

Bali calves can be successfully weaned at 6 months of age and will grow well if fed a diet high in crude protein (above approximately 160 g CP/kg DM). On-station studies demonstrated that the potential growth rate of 6 to 12 month old Bali calves is approximately 0.65 kg/d, which is typically only achieved with feed stuffs that are not likely to be used by farmers. However, simple feeding strategies are available to farmers which can potentially increase growth rates of Bali calves from 0.1 - 0.2 kg/d, under prevailing feeding scenarios, to over 0.4 kg/d. These strategies include the provision of high protein feeds such as leucaena, sesbania or copra meal. Even at low levels of inclusion (10 g DM/kg W/d) these supplements will result in financially beneficial increases in live weight gain, on a rupiah/head/d basis. While early weaning will increase reproductive efficiency within the herd, strategic supplementation will provide small-holders with more flexibility in their cattle marketing strategies and better utilisation of scarce high quality feed resources. These strategies can be successfully implemented by small-holders within the complex village crop-livestock systems which exist in eastern Indonesia. Small-holder farmers who participated and visited on-station and in village demonstration activities indicated that their involvement changed their perceptions of calf management and would consider adopting a preferential supplementation strategy of early weaned calves due to its ease of implementation, increased calf growth rates and opportunities for increased profits.

The project successfully integrated research groups across eastern Indonesia and Australia and developed an ethos of openness and sharing of ideas and resources. The engagement of scientists previously trained in Australia not only continued their development but also allowed them to share their experiences from this training with other team members who didn't have similar opportunities. The junior scientists gained valuable experience in farmer relevant nutrition research. The practice of good science (hypothesis development, appropriate experimental design and methodology, high attention to detail, interpretation and presentation of results) ensured integrity in the experiments conducted within the project and this has been transferred to other experiments conducted by researchers, not involved in the present project. The involvement of such a large number of undergraduate students in the project was rewarding and exciting for the future of ruminant nutrition research in Indonesia.

From the studies conducted in Australia it was demonstrated that ruminants fed low quality, tropical forages had lower MCP and EMCP compared to ruminants fed high quality forages. It was concluded that RDP was the primary factor limiting EMCP, irrespective of the source of nitrogen. High EMCP was associated with a short retention time of water in the rumen and high feed intake. Once RDP is no longer limiting EMCP, a source of RDP rich in true protein, nucleic acids, fatty acids, vitamins and minerals, such as Spirulina algae, enabled higher levels of EMCP to be achieved.

9.2 Recommendations and future opportunities

It is recommended that the strategic supplementation of early weaned Bali cattle with leucaena and sesbania or with high CP by-products such as copra meal, is disseminated across eastern Indonesia. There is an opportunity for this feeding strategy to be introduced as a component of the scale-up initiatives currently in progress in NTB and Sulsel. A component of the scale-up activities could involve training farmers in feeding early weaned calves a fixed level of an available source of high protein supplement each morning, prior to their typical animal feeding practices. Simple means of ensuring the right amount of supplement could be distributed amongst villages (e.g. baskets, buckets). It is recommended that extension materials are developed from these findings and are distributed amongst local extension officers to facilitate the uptake of the preferential supplementation strategy at all sites. It is recommended that future research activities include this extension or training component as an exit strategy at the end of the project. For example, within the current project feeding strategies to increase growth of weaned Bali calves were successfully established in villages. However, without ongoing support and training it is unknown what proportion of engaged farmers continued to adopt, or what proportion of visiting farmers adopted, the practices and their reasons for, or constraints to, adoption. There was no process for ensuring on-going support for farmers implementing the respective feeding systems.

This project indicates that tree legumes are the most profitable feeds available to increase the growth of weaned Bali calves. It is recommended that plantings of leucaena and sesbania are established in areas that currently do not have access to tree legumes. Further information on seasonal biomass production would allow farmers to better manage their feed supply throughout the year.

There are still several areas of work which require investigation in regard to growth of the early weaned Bali calf. These include responses to increasing levels of protein and / or energy supplements and the influence of early life nutrition on subsequent growth rates, mature weights and reproductive output.

There are a range of new forages being established across eastern Indonesia, with no comprehensive studies conducted on the suitability for Bali cattle. Typically this requires the establishment and production of large quantities of biomass to be available at the start of an experiment. This has proved difficult to achieve when attempted within the current project, where feed quality has often been compromised in an attempt to produce sufficient biomass for experiments. There is a need to establish nursery's for the production of seed and propagation materials of new forages, rather than relying on imports. It is recommended that experiments evaluating forage legumes and introduced grasses, reported here, be repeated once appropriate systems for establishing, harvesting, conserving and feeding have been established before recommendations on their subsequent potential as a livestock feed resource is extended.

To further improve the efficiency of feed resource utilisation and to support the Indonesian government's policy for increased domestic beef production, it is recommended that the focus of future research activities be moved to low input feeding strategies to maintain reproductive efficiency in the Bali cow. This would include the use of untreated, low quality crop residues, typically unused or burnt, as a basal feed for cows coupled with strategic supplementation at specific stages of the reproductive cycle. This could potentially utilise an underutilised feed resource to maintain or increase production, improve the efficiency of feed resource utilisation, maintain or decrease labour inputs and increase faeces production (subsequently used for fertiliser and biogas production). Higher quality feed resources could then be directed towards the early weaned calf. The researchable issues are will reproductive output be maintained on low quality crop residues, when is strategic supplementation required and what supplements are the most appropriate?

Small-holder farmers appear to place relatively less importance on nutrition than other aspects of their cattle production system. It is recommended that local extension packages are developed and delivered to small-holder farmers detailing the importance of nutrition and nutritional management strategies for different cattle classes. Further, given the relative lack of interest in nutrition by small-holders, it is suggested that any nutritional strategies to be implemented, validated or scaled-up across villages be packaged within other management strategies (as done with the IVMS) or be integrated with some new form of technology to initiate small-holder interest.

The research group that was established in this project has the potential to direct the future of beef cattle research across eastern Indonesia in the coming years. The group are well trained in basic ruminant nutrition but can also readily apply this theory to practical situations. They work extremely well together despite the diversity of sites and organisations. It is recommended that attempts be made to keep this group of research organisations together in some form in future projects.

It is recommended that initiatives be developed to retain undergraduates and junior scientists in the field of livestock research. Too many undergraduates, in particular, move into other areas of employment upon graduation. This is a huge loss of talented, hard working individuals who could contribute to the development of livestock industries in Indonesia over the next thirty years. When considering the appointment of junior scientists to projects in the future, some guidelines need to be established, regarding age and qualifications.

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10.2 List of publications produced by project

Scientific papers and seminar and conference proceedings

- Dahlanuddin, Puspadi, K., Quigley, S.P. and Corfield, J.P. In Press. Herd management and feeding strategies to increase calf crop and post-weaning growth rate of Bali cattle in eastern Indonesia. *International seminar on Bali cattle production*.
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Book chapters

- Poppi D.P, Panjaitan, T., Quigley, S.P. and Fordyce, G. (submitted to ACIAR). Case Study: Developing an integrated production system for Bali cattle in the eastern islands of Indonesia. ACIAR book chapter.

11 Appendixes

11.1 Project team members

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11.2 Common and scientific names of feeds used in studies conducted in Indonesia

Table 15. Common and scientific names of all feeds used in studies conducted in Indonesia and abbreviations used in this report

Common name	Scientific name	Abbreviation
Centrosema	*Centrosema pascuorum*	CENTRO
Stylosanthes	*Stylosanthes hamata*	STYLO
Butterfly pea	*Clitoria ternatea*	CT
Desmodium[1]	*Desmodium spp.*	DES
Mulato	*Brachiaria mulato*	BM
King grass	*Pennisetum spp*	KG
Rice bran	*Oryza sativa bran*	RB
Copra meal	*Cocos nucifera meal*	CM
Sesbania	*Sesbania gradiflora*	SES
Gliricidia	*Gliricidia sepium*	GLIR
Leucaena	*Leucaena leucocephala*	LEUC
Moringa	*Moringa oliefera*	MOR
Native grass[2]	N/A	NG
Maize (corn) stover	*Zea mays*	CS
Elephant grass	*Pennisetum purpureum*	EG
Maize (corn) grain	*Zea mays*	MG
Soybean meal	*Glycine max meal*	SBM
Prima feed[3]	N/A	PRIMA
Mungbean stover	*Phaseolus aureus*	MB
Palm pith	*Corypha spp.*	PP

[1]*Local Desmodium spp. found in Nusa Tenggara Timur.*
[2]*Term describes mixture of locally available fresh grasses and forbes typical of feeds used by small-holder farmers in cut and carry systems across eastern Indonesia.*
[3]*Commercially available feed manufactured from a range of agro-industrial by-products.*

11.3 Collated live weight gain data from previous studies conducted in Indonesia

Table 16. Live weight gain response of Bali cattle to various feeding strategies, collated from a range of studies conducted in Indonesia[1]

ADG[2] (kg/d)	LW[3] (kg)	Treatment[4]	Region[5]	Reference
0.02	185	Cane tops (70%) + soybean straw (30%)	East Java	Wardhani (1990)
0.02	185	Cane tops (55%) + soybean straw (45%)	East Java	Wardhani (1990)
0.03	185	Cane tops (100%)	East Java	Wardhani (1990)
0.03	185	Cane tops (75%) + soybean straw (25%)	East Java	Wardhani (1990)
0.04	204	Native grass (NG)	South Sulawesi	Paat and Winugroho (1990)
0.05-0.1	170	Dry season NG	South Sulawesi	Bahar and Rachmat (2003)
0.06	204	NG + 1 kg rice bran	South Sulawesi	Paat and Winugroho (1990)
0.10	115	NG	South Sulawesi	Abduh *et al*. (1992a)
0.10	228	Elephant grass (EG)	Bali	Lanna *et al*. (1994)
0.10	228	Stylosanthes	Bali	Lanna *et al*. (1994)
0.12	138	Grass + concentrate	South Sulawesi	Rangkuti *et al*. (1973)
0.12	150	Grass only	East Java	Musofie *et al*. (1981)
0.12	204	NG + 2 kg rice bran	South Sulawesi	Paat and Winugroho (1990)
0.12	102	EG + gliricidia + leucaena + calliandra	Lombok	Dahlanuddin (2002)
0.13	143	Grass only	South Sulawesi	Rangkuti *et al*. (1973)
0.13	280	Cane tops	East Java	Soemarmi *et al*. (1985)
0.13	167	NG	South Sulawesi	Amril *et al*. (1990)
0.13	199	Rice straw	South Sulawesi	Sariubang *et al*. (2000)
0.14	108	Integrated with estate plant (dry season)	Bali	Puger *et al*. (1990)
0.14	115	NG + rice bran + urea	South Sulawesi	Abduh *et al*. (1992a)
0.14-0.17	175	Grass only	Bali	Nitis *et al*. (1988)
0.17-0.30	210	Grass, banana stem, coconut leaf	Bali	Rika *et al*. (1981)
0.18-0.39	220	Mixture grass +legume pasture	Bali	Rika *et al*. (1981)
0.19	108	Integrated with crop (dry season)	Bali	Puger *et al*. (1990)
0.2-0.4	170	Wet season NG	South Sulawesi	Bahar and Rachmat (2003)
0.20	228	EG + Stylosanthes (1:1)	Bali	Lanna *et al*. (1994)
0.20	92	EG	East Java	Ma'sum (1978)
0.22-0.27	15	Unweaned calves grazing unimproved tropical pastures	Northern Territory	Kirby (1979)
0.24	170	Cane tops + 0.25 kg Leuceana	East Java	Musofie *et al*. (1983)
0.29	170	Cane tops	East Java	Musofie *et al*. (1983)
0.30-0.33	15	Unweaned calves grazing under coconut	Sabah	Copland (1974)
0.30	92	Cane tops	East Java	Ma'sum (1978)
0.30	170	Cane tops + 0.50 kg Leucaena	East Java	Musofie *et al*. (1983)
0.31	167	NG + 1.8%W concentrate	South Sulawesi	Amril *et al*. (1990)
0.31	108	Integrated with estate plant (wet season)	Bali	Puger *et al*. (1990)
0.31	176	EG	Bali	Oka (2002)
0.32	115	NG	South Sulawesi	Abduh *et al*. (1992b)

0.32	122	Grass (70%) + gliricidia (30%)	Bali	Mastika (2002)
0.33	108	Integrated with crop (wet season)	Bali	Puger *et al*. (1990)
0.35-0.36	121	NG + rice bran or UMB	Lombok	Dahlanuddin (2002)
0.36	172	NG	South Sulawesi	Sumbung *et al*. (1978)
0.36	150	Grass + 0.5% W concentrate	East Java	Musofie *et al*. (1981)
0.38	199	Rice straw + 0.5% Probiotic fermentation	South Sulawesi	Sariubang *et al*. (2000)
0.39	182	EG (10% W) + 2 kg concentrate with 45% kosambi seed	West Timor	Katipana (2001)
0.39	122	Grass (50%) + gliricidia (30%) + hisbiscus (20%)	Bali	Mastika (2002)
0.41	170	Leucaena *ad libitum*	East Java	Musofie *et al*. (1983)
0.41	270	Grass + 2 kg rice bran	Bali	Parwati *et al*. (1999)
0.42	111	NG	South Sulawesi	Paat *et al*. (1992)
0.42	176	EG (40%) + concentrate (60%)	Bali	Oka (2002)
0.43	167	Ammoniated rice straw +1.8%W concentrate	South Sulawesi	Amril *et al*. (1990)
0.44	122	Grass (70%) + gliricidia (15%) + UMB (15%)	Bali	Mastika (2002)
0.45	122	Grass (50%) + gliricidia (20%) + hisbiscus (15%) + UMB (15%)	Bali	Mastika (2002)
0.49	158	NG + gliricidia (3 kg/head)	South Sulawesi	Sariubang *et al*. (1992)
0.51	150	Grass +1% W concentrate	East Java	Musofie *et al*. (1981)
0.51	111	NG + gliricidia	South Sulawesi	Paat *et al*. (1992)
0.51	184	King grass (50%) + sesbania (37.5%) + putak (12.5%)	West Timor	Bamualim (1995)
0.51	182	EG (10% W) + 2 kg concentrate (without tamarind seed, kosambi seed and palm pith meal)	West Timor	Katipana (2001)
0.52	270	Grass + 2 kg rice bran + 20 g starbio	Bali	Parwati *et al*. (1999)
0.53	150	EG + 4 kg rice bran	Bali	Mastika *et al*. (2000)
0.57	115	NG + gliricidia (0.75% W)	South Sulawesi	Abduh *et al*. (1992b)
0.57	111	NG + concentrate	South Sulawesi	Paat *et al*. (1992)
0.58	182	EG (10% W) + 2 kg concentrate with palm pit meal	West Timor	Katipana (2001)
0.59-0.66	200	EG + wheat pollard + maize grain	West Java	Moran (1985)
0.60	231	Grass + copra meal	Lombok	Martojo (1988)
0.69	280	EG	East Java	Soemarmi *et al*. (1985)
0.70	170	Fresh sagu, rice bran, corn bran, copra meal and by-product of fish	Central Sulawesi	Siregar and Talib (1992)
0.71	182	EG (10% W) + 2 kg concentrate with 45% tamarind seed	West Timor	Katipana (2001)
0.76	120	EG (40%) + concentrate (60%)	Bali	Mastika *et al*. (1996)
0.76	122	Grass (40%) + concentrate (60%)	Bali	Mastika (2002)
0.82	280	Cane tops	East Java	Soemarmi *et al*. (1985)
0.85	155	EG + 4 kg concentrate	Bali	Mastika (2001)

[1]A review of some of these studies was presented at the "4th International Seminar on Tropical Animal Production", Gadjah Mada University, Yogyakarta, 2006, and published in the seminar proceedings.
[2]Average daily live weight gain.
[3]Live weight of cattle used in study.
[4]Summary of feeding management of cattle.
[5]Region where study was conducted.

11.4 Economic analysis of on-station feeding studies conducted at four sites across eastern Indonesia

Table 17. Profit above feed cost of feeding strategies to improve growth of weaned Bali calves in on-station experiments conducted in Jawa Timur[1]

Parameter	Experiment			
	Experiment 1			
	EG[2]	EG+ leucaena	Leucaena	Native grass
Feed intake (kg/hd/d)[3]	7.3	2.79 + 6.27	6.27	7.58
Feed price (Rp/kg)[4]	150	150 + 200	200	200
Experimental period (d)	77	77	77	77
ADG (kg/d)[5]	0.102	0.192	0.336	0.122
Cattle price (Rp/kg W)[6]	30,000	30,000	30,000	30,000
Total feed cost (Rp/hd/period)[7]	84,315	99,561	96,558	116,732
Total revenue (Rp/hd/period)	235,620	443,520	776,160	281,820
Profit (Rp/hd/period)	151,305	343,959	679,602	165,088
Profit (Rp/hd/d)[8]	1,965	4,467	8,826	2,144
R/C[9]	2.79	4.45	8.04	2.41
	Experiment 2			
	9.2% CP[2] + EG	16.7% CP + EG	18.8% CP + EG	24.5% CP + EG
Feed intake (kg/hd/d)	2.58 + 1.81	2.87 + 1.36	2.88 + 1.81	2.88 + 1.36
Feed price (Rp/kg)	3785 + 150	4121 + 150	4457 + 150	4808 + 150
Experimental period (d)	70	70	70	70
ADG (kg/d)	0.306	0.556	0.646	0.591
Cattle price (Rp/kg W)	30,000	30,000	30,000	30,000
Total feed cost (Rp/hd/period)	702,576	842,189	917,536	983,194
Total revenue (Rp/hd/period)	642,600	1,167,600	1,356,600	1,241,100
Profit (Rp/hd/period)	-59,976	325,411	439,064	257,906
Profit (Rp/hd/d)	-857	4,649	6,272	3,684
R/C	0.91	1.39	1.48	1.26
	Experiment 3			
	100% Prima feed + 0% Leucaena	65% Prima feed + 35% Leucaena	35% Prima feed + 65% Leucaena	0% Prima feed + 100% Leucaena
Feed intake (kg/hd/d)	2.29	1.14 + 2.05	0.8 + 4.10	6.83
Feed price (Rp/kg)	825	825 + 200	200 + 825	200
Experimental period (d)	56	56	56	56
ADG (kg/d)	-0.039	0.161	0.191	0.243
Cattle price (Rp/kg W)	30,000	30,000	30,000	30,000
Total feed cost (Rp/hd/period)	105,798	75,735	82,830	76,450
Total revenue (Rp/hd/period)	-65,520	270,480	320,880	408,240
Profit (Rp/hd/period)	-171,318	194,745	238,050	331,789
Profit (Rp/hd/d)	-3,059	3,478	4,251	5,925
R/C	- 0.62	3.57	3.87	5.34

[1]*Feeding strategies have been described in detail in section 5.1.2 of this report.*
[2]*Elephant grass (EG); crude protein content (CP).*
[3]*Feed intake is on an as fed basis.*
[4]*Rupiah/kg (Rp/kg) on an as fed basis.*
[5]*Average daily live weight gain (ADG).*
[6]*Rupiah per kg animal live weight for a Bali calf aged 12 months and approximately 100 kg in live weight.*
[7]*Over experimental period.*

[8]*Profit per day based on profit over experimental period.*
[9]*Revenue over cost.*

Table 18. Profit above feed cost of feeding strategies to improve growth of weaned Bali calves in on-station experiments conducted in Nusa Tenggara Barat[1]

Parameter	Experiment			
	Experiment 1			
	NG[2]	NG + Sesbania	Sesbania	Sesbania + RB[2]
Feed intake (kg/hd/d)[3]	10.99	7.85 + 2.67	9.78	9.33 + 0.66
Feed price (Rp/kg)[4]	200	200 + 300	300	300 + 1500
Experimental period (d)	56	56	56	56
ADG (kg/d)[5]	0.025	0.071	0.341	0.401
Cattle price (Rp/kg W)[6]	35,000	35,000	35,000	35,000
Total feed cost (Rp/hd/period)[7]	123,088	132,776	164,304	212,184
Total revenue (Rp/hd/period)	49,000	139,160	668,360	785,960
Profit (Rp/hd/period)	-74,088	6,384	504,056	573,776
Profit (Rp/hd/d)[8]	-1,323	114	9,001	10,246
R/C[9]	0.40	1.05	4.07	3.70
	Experiment 2			
	Gliricidia + sesbania	Leucaena	Moringa	Sesbania
Feed intake (kg/hd/d)	1.16 + 0.7	3.73	2.62	2.84
Feed price (Rp/kg)	1600 + 1600	1600	1600	1600
Experimental period (d)	70	70	70	70
ADG (kg/d)	0.001	0.471	0.221	0.429
Cattle price (Rp/kg W)	35,000	35,000	35,000	35,000
Total feed cost (Rp/hd/period)	208,320	417,760	293,440	318,080
Total revenue (Rp/hd/period)	2,450	1,153,950	541,450	1,051,050
Profit (Rp/hd/period)	-205,870	736,190	248,010	732,970
Profit (Rp/hd/d)	-2,941	10,517	3,543	10,471
R/C	0.01	2.76	1.85	3.30
	Experiment 3			
	Mulato[2]	Centro[2]	King grass	Stylo[2]
Feed intake (kg/hd/d)	9.37	2.55	9.1	1.97
Feed price (Rp/kg)	200	1600	200	1600
Experimental period (d)	56	56	56	56
ADG (kg/d)	0.098	0.213	0.016	0.091
Cattle price (Rp/kg W)	35,000	35,000	35,000	35,000
Total feed cost (Rp/hd/period)	104,944	228480	101,920	176,512
Total revenue (Rp/hd/period)	192,080	417,480	31,360	178,360
Profit (Rp/hd/period)	87,136	189,000	-70,560	1,848
Profit (Rp/hd/d)	1,556	3,375	-1,260	33
R/C	1.83	1.83	0.31	1.01
	Experiment 4			
	Mulato	Mulato + RB	Mulato + Sesbania	Mulato + Stylo
Feed intake (kg/hd/d)	12.9	8.39 + 1.15	7.1 + 5.63	5.81 + 2.92
Feed price (Rp/kg)	200	200 + 1600	200 + 300	200 + 300
Experimental period (d)	35	35	35	35
ADG (kg/d)	0.069	0.251	0.169	- 0.066

Cattle price (Rp/kg W)	35,000	35,000	35,000	35,000
Total feed cost (Rp/hd/period)	90,300	119,105	108,815	66,220
Total revenue (Rp/hd/period)	84,525	307,475	207,025	-80,850
Profit (Rp/hd/period)	-5,775	188,370	98,210	-147,070
Profit (Rp/hd/d)	-165	5,382	2,806	-4,202
R/C	0.94	2.58	1.90	-1.22

[1]Feeding strategies have been described in detail in section 5.1.2 of this report.
[2]Native grass (NG); Rice bran (RB); Brachiaria mulato (Mulato); Centrosema pascuorum (Centro); Stylosanthes hamata (Stylo).
[3]Feed intake is on an as fed basis.
[4]Rupiah/kg (Rp/kg) on an as fed basis.
[5]Average daily live weight gain (ADG).
[6]Rupiah per kg animal live weight for a Bali calf aged 12 months and approximately 100 kg in live weight.
[7]Over experimental period.
[8]Profit per day based on profit over experimental period.
[9]Revenue over cost.

Table 19. Profit above feed cost of feeding strategies to improve growth of weaned Bali calves in on-station experiments (2, 3 and 4) conducted at Lili Research Station in Nusa Tenggara Timur[1]

Parameter	Experiment			
	Experiment 2			
	Centro[2]	Clitoria[2]	Desmodium[2]	Leucaena[2]
Feed intake (kg/hd/d)[3]	2.22	1.84	1.89	6.47
Feed price (Rp/kg)[4]	1075	1075	250	250
Experimental period (d)	49	49	49	49
ADG (kg/d)[5]	0.182	0.159	0.100	0.422
Cattle price (Rp/kg W)[6]	24,000	24,000	24,000	24,000
Total feed cost (Rp/hd/period)[7]	116,939	96,922	23,153	79,258
Total revenue (Rp/hd/period)	214,032	186,984	186,984	496,272
Profit (Rp/hd/period)	97,094	90,062	163,832	417,015
Profit (Rp/hd/d)[8]	1,982	1,838	3,446	8,511
R/C[9]	1.83	1.93	8.08	6.26
	Experiment 3			
	Corn stover	MBS[2]	MBS + Leucaena	MBS + RB[2]
Feed intake (kg/hd/d)	1.85	2.33	1.51 + 2.51	1.77 + 0.75
Feed price (Rp/kg)	250	250	250 + 250	250 + 1500
Experimental period (d)	28	28	28	28
ADG (kg/d)	0.021	0.304	0.35	0.243
Cattle price (Rp/kg W)	24,000	24,000	24,000	24,000
Total feed cost (Rp/hd/period)	12,950	16,310	28,140	43,890
Total revenue (Rp/hd/period)	14,112	204,288	235,200	163,296
Profit (Rp/hd/period)	1,162	187,978	207,060	119,406
Profit (Rp/hd/d)	42	6,714	7,395	4,265
R/C	1.09	12.53	8.36	3.72
	Experiment 4			
	Leucaena (drench)	Leucaena (no drench)	Leucaena + MG[2]	Leucaena + RB
Feed intake (kg/hd/d)	8.74	8.4	6.59 + 1.26	7.3 + 3.48
Feed price (Rp/kg)	250	250	250 + 1500	250 + 1500
Experimental period (d)	56	56	56	56
ADG (kg/d)	0.425	0.413	0.614	0.555

Cattle price (Rp/kg W)	24,000	24,000	24,000	24,000
Total feed cost (Rp/hd/period)	122,360	117,600	198,100	394,520
Total revenue (Rp/hd/period)	571,200	555,072	825,216	745,920
Profit (Rp/hd/period)	448,840	437,472	627,116	351,400
Profit (Rp/hd/d)	8,015	7,812	11,199	6,275
R/C	4.67	4.72	4.17	1.89

[1]Feeding strategies have been described in detail in section 5.1.2 of this report.
[2]Centrosema pascuorum (Centro); Clitoria ternatea (Clitoria); Mung bean stover (MBS); Rice bran (RB); Maize grain (MG).
[3]Feed intake is on an as fed basis.
[4]Rupiah/kg (Rp/kg) on an as fed basis.
[5]Average daily live weight gain (ADG).
[6]Rupiah per kg animal live weight for a Bali calf aged 12 months and approximately 100 kg in live weight.
[7]Over experimental period.
[8]Profit per day based on profit over experimental period.
[9]Revenue over cost.

Table 20. Profit above feed cost of feeding strategies to improve growth of weaned Bali calves in on-station experiments conducted in Sulawesi Tengah[1]

Parameter	Experiment		
	Experiment 1		
	Native grass	Native grass + RB[2]	Native grass + (RB/CM[2])
Feed intake (kg/hd/d)[3]	7.17	6.26 + 1.07	6.08 + 0.91
Feed price (Rp/kg)[4]	250	250 + 500	250 + 700
Experimental period (d)	56	56	56
ADG (kg/d)[5]	0.104	0.225	0.292
Cattle price (Rp/kg W)[6]	30,000	30,000	30,000
Total feed cost (Rp/hd/period)[7]	100,380	117,600	120,792
Total revenue (Rp/hd/period)	174,720	378,000	490,560
Profit (Rp/hd/period)	74,340	260,400	369,768
Profit (Rp/hd/d)[8]	1,328	4,650	6,603
R/C[9]	1.74	3.21	4.06
	Experiment 2		
	EGH[2]	EGH + gliricidia	Gliricidia
Feed intake (kg/hd/d)	3.86	3.24 + 3.52	9.41
Feed price (Rp/kg)	200	200 + 150	150
Experimental period (d)	56	56	56
ADG (kg/d)	0.174	0.280	0.269
Cattle price (Rp/kg W)	30,000	30,000	30,000
Total feed cost (Rp/hd/period)	43,232	65,856	79,044
Total revenue (Rp/hd/period)	292,320	470,400	451,920
Profit (Rp/hd/period)	249,088	404,544	372,876
Profit (Rp/hd/d)	4,448	7,224	6,659
R/C	6.76	7.14	5.72
	Experiment 3		
	CS[2]	CS + gliricidia	Corn stover + (RB/CM)
Feed intake (kg/hd/d)	4.03	3.09 + 3.5	3.37 + 1.18
Feed price (Rp/kg)	200	200 + 150	200 + 700
Experimental period (d)	56	56	56
ADG (kg/d)	0.232	0.311	0.402
Cattle price (Rp/kg W)	30,000	30,000	30,000

Total feed cost (Rp/hd/period)	45,136	64,008	84,000
Total revenue (Rp/hd/period)	389,760	522,480	675,360
Profit (Rp/hd/period)	344,624	458,472	591,360
Profit (Rp/hd/d)	6,154	8,187	10,560
R/C	8.64	8.16	8.04

[1]*Feeding strategies have been described in detail in section 5.1.2 of this report.*
[2]*Rice bran (RB); copra meal (CM); elephant grass hay (EGH); corn stover (CS).*
[3]*Feed intake is on an as fed basis.*
[4]*Rupiah/kg (Rp/kg) on an as fed basis.*
[5]*Average daily live weight gain (ADG).*
[6]*Rupiah per kg animal live weight for a Bali calf aged 12 months and approximately 100 kg in live weight.*
[7]*Over experimental period.*
[8]*Profit per day based on profit over experimental period.*
[9]*Revenue over cost.*

Table 21. Profit above feed cost of feeding strategies to improve growth of weaned Bali calves in on-farm studies conducted in villages in Jawa Timur, Nusa Tenggara Barat and Sulawesi Tengah[1]

Parameter	Site / treatment	
	Jawa Timur	
	Control	Control + leucaena[2]
Estimated feed intake (kg/head/d, as fed)	10.29	(6.76 + 5.6)
Feed price (Rupiah/kg, as fed)	150	(150 + 200)
Study period (d)	184	184
Average daily live weight gain (kg/d)	0.179	0.418
Cattle price (Rupiah/kg live weight)	30,000	30,000
Total feed cost (Rupiah/head/period)	284,004	393,024
Total revenue (Rupiah/head/period)	988,080	2,307,360
Profit (Rupiah/head/period)	704,076	1,914,336
Profit (Rupiah/head/d)	3,827	10,404
R/C[3]	3.48	5.87
	Nusa Tenggara Barat	
	Control	Control + sesbania[4]
Estimated feed intake (kg/head/d, as fed)	15	(10 + 7)
Feed price (Rupiah/kg, as fed)	250	(250 + 350)
Study period (d)	180	180
Average daily live weight gain (kg/d)	0.216	0.353
Cattle price (Rupiah/kg live weight)	35,000	35,000
Total feed cost (Rupiah/head/period)	675,000	891,000
Total revenue (Rupiah/head/period)	1,360,800	2,223,900
Profit (Rupiah/head/period)	685,800	1,332,900
Profit (Rupiah/head/d)	3,810	7,405
R/C	2.02	2.50
	Sulawesi Tengah	
	Control	Control + RB/CM[5]
Estimated feed intake (kg/head/d, as fed)	7.58	6.43 + 1.15
Feed price (Rupiah/kg, as fed)	150	150 + 650
Study period (d)	181	181
Average daily live weight gain (kg/d)	0.289	0.428
Cattle price (Rupiah/kg live weight)	30,000	30,000
Total feed cost (Rupiah/head/period)	205,797	309,872

Total revenue (Rupiah/head/period)	1,569,270	2,324,040
Profit (Rupiah/head/period)	1,363,473	2,014,168
Profit (Rupiah/head/d)	7,533	11,128
R/C	7.63	7.50

[1]Studies were conducted with Bali calves, approximately 6 months of age at commencement, over approximately 6 months.
[2]Leucaena was offered at approximately 10 g DM/kg W/d.
[3]R/C is revenue over cost.
[4]Sesbania was offered at approximately 10 g DM/kg W/d.
[5]Rice bran mixed with copra meal in equal proportions and offered at approximately 10 g DM/kg W/d.

Table 22. Profit above feed cost of feeding strategies to improve growth of weaned Bali calves in on-farm studies conducted in Oebola and Usapinonot villages in Nusa Tenggara Timor[1]

Parameter	Site / treatment		
	Oebola		
	Control	Control + leucaena[2]	Control + forage legume[3]
Estimated feed intake (kg/head/d, as fed)	8.58	3.8 + 4.78	3.8 + 2.12
Feed price (Rupiah/kg, as fed)	250	250 + 250	250 + 250
Study period (d)	182	182	182
Average daily live weight gain (kg/d)	0.359	0.288	0.266
Cattle price (Rupiah/kg live weight)	24,000	24,000	24,000
Total feed cost (Rupiah/head/period)	390,390	390,390	269,360
Total revenue (Rupiah/head/period)	1,568,112	1,257,984	1,161,888
Profit (Rupiah/head/period)	1,177,722	867,594	892,528
Profit (Rupiah/head/d)	6,471	4,767	4,904
R/C4	4.02	3.22	4.31
	Usapinonot		
	Control	Control + leucaena	Control + forage legume
Estimated feed intake (kg/head/d, as fed)	6.65	2.95 + 3.7	2.95 + 1.64
Feed price (Rupiah/kg, as fed)	250	250 + 250	250 + 250
Study period (d)	196	216	216
Average daily live weight gain (kg/d)	0.115	0.308	0.233
Cattle price (Rupiah/kg live weight)	24,000	24,000	24,000
Total feed cost (Rupiah/head/period)	325,850	359 100	247,860
Total revenue (Rupiah/head/period)	540,960	1,596,672	1,207,872
Profit (Rupiah/head/period)	215,110	1,237,572	960,012
Profit (Rupiah/head/d)	1,098	5,730	4,445
R/C	1.66	4.45	4.87

[1]Studies were conducted with Bali calves, approximately 6 months of age at commencement, over approximately 6 months in Oebola and 8 months in Usapinonot.
[2]Leucaena was offered at approximately 15 g DM/kg W/d.
[3]Forage legume was offered at approximately 15 g DM/kg W/d.
[4]R/C is revenue over cost.

11.5 Descriptive information of farmers, their existing management practices and their perceptions of weaning and feeding during visits to on-station demonstration days at four sites across eastern Indonesia

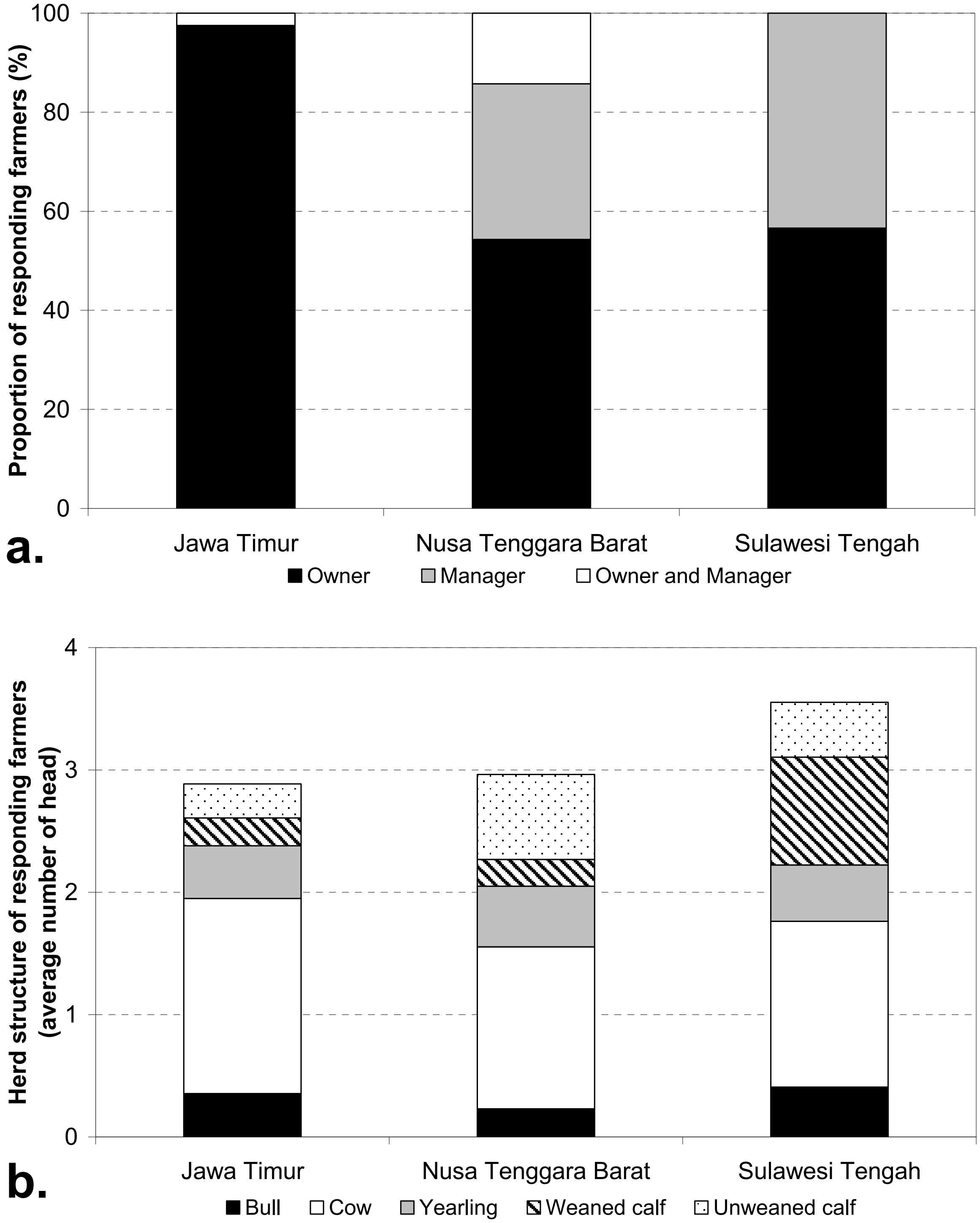

Figure 19. Ownership status (a.) and typical herd size and structure (b.) of small-holder farmers who participated in on-station demonstrations at three sites across eastern Indonesia (data from Nusa Tenggara Timur is excluded). Survey data is from individual farmers and is combined across experiments conducted within each site.

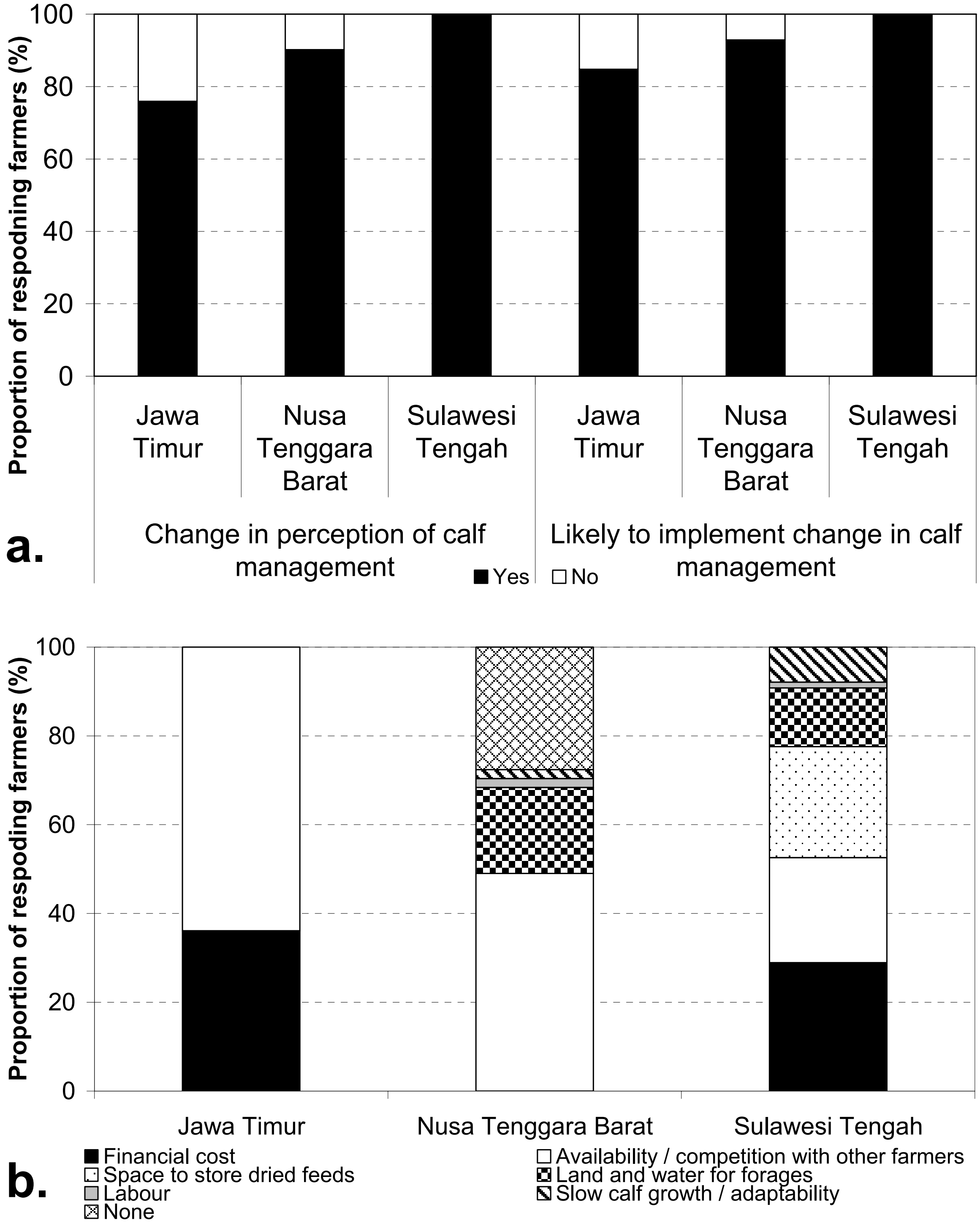

Figure 20. Change in perceptions on calf management and likelihood of adoption of new calf management strategies (a.) and major constraints to adoption of various feeding strategies (b.) as identified by small-holder farmers who participated in on-station demonstrations at four sites across eastern Indonesia (data from Nusa Tenggara Timur is excluded). Survey data is from individual farmers and is combined across experiments conducted within each site.

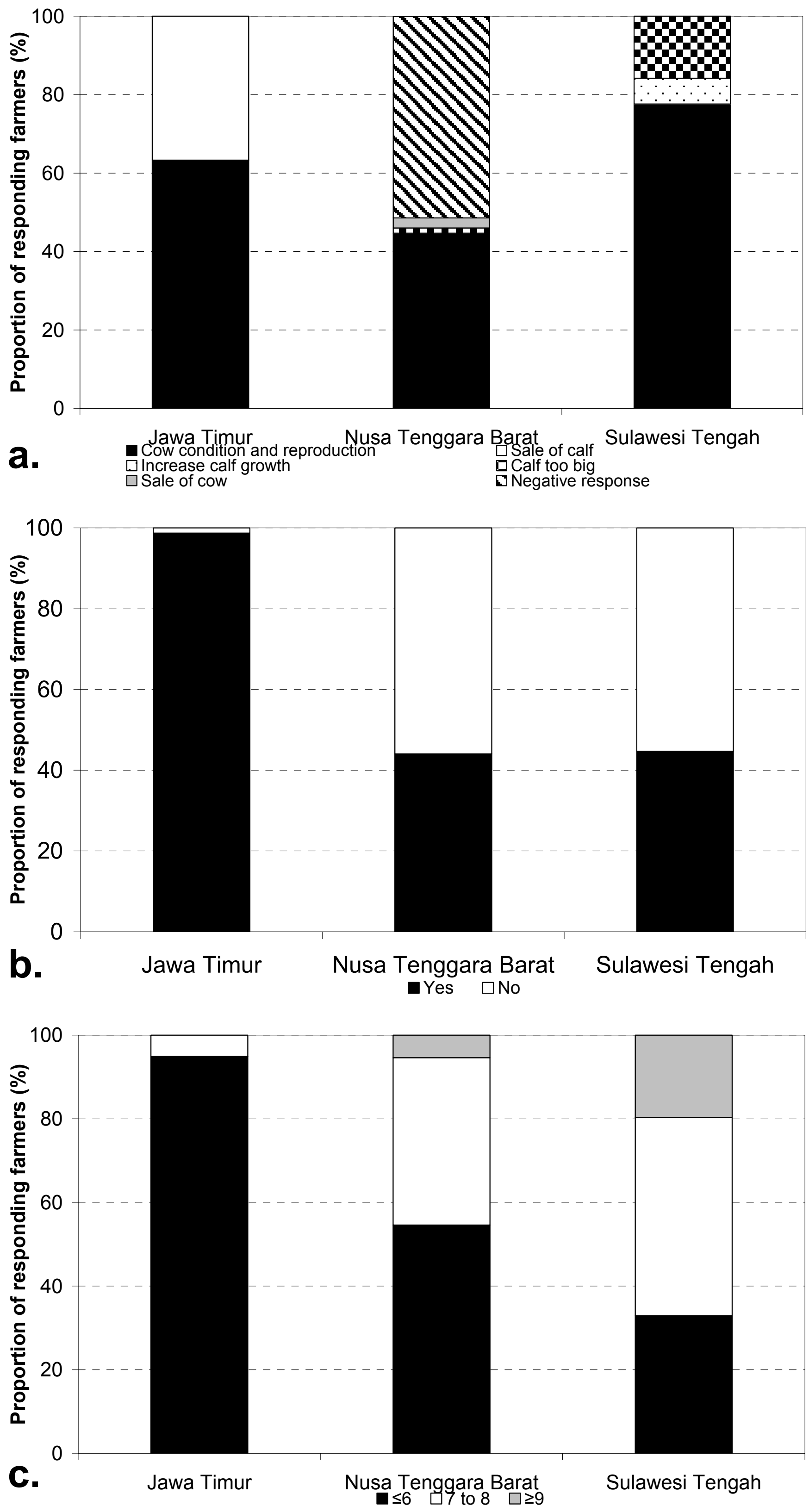

Figure 21. Major reasons for weaning (a.), proportion practice weaning (b.) and best age to wean (c.) as identified by small-holder farmers who participated in on-station demonstrations (data from Nusa Tenggara Timur is excluded). Survey data is from individual farmers and is combined across experiments conducted within each site.

11.6 Descriptive information of farmers, their existing management practices and their perceptions of weaning and feeding during visits to on-farm demonstration days at four sites across eastern Indonesia

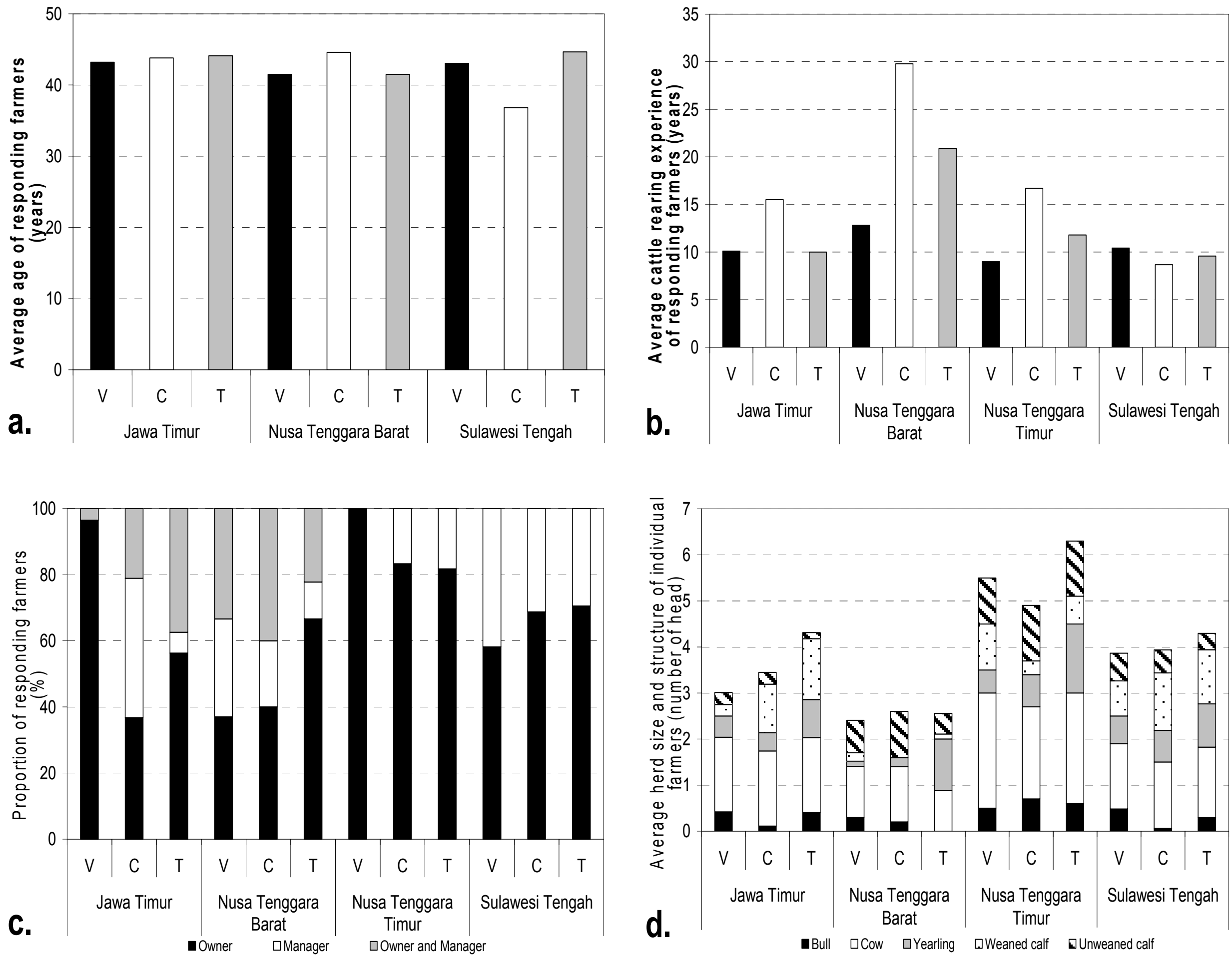

Figure 22. Age (a.), experience rearing cattle (b.), ownership status (c.) and herd structure (d.) of visiting (V), control (C) and treatment (T) farmers who participated in village demonstration field days held in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah.

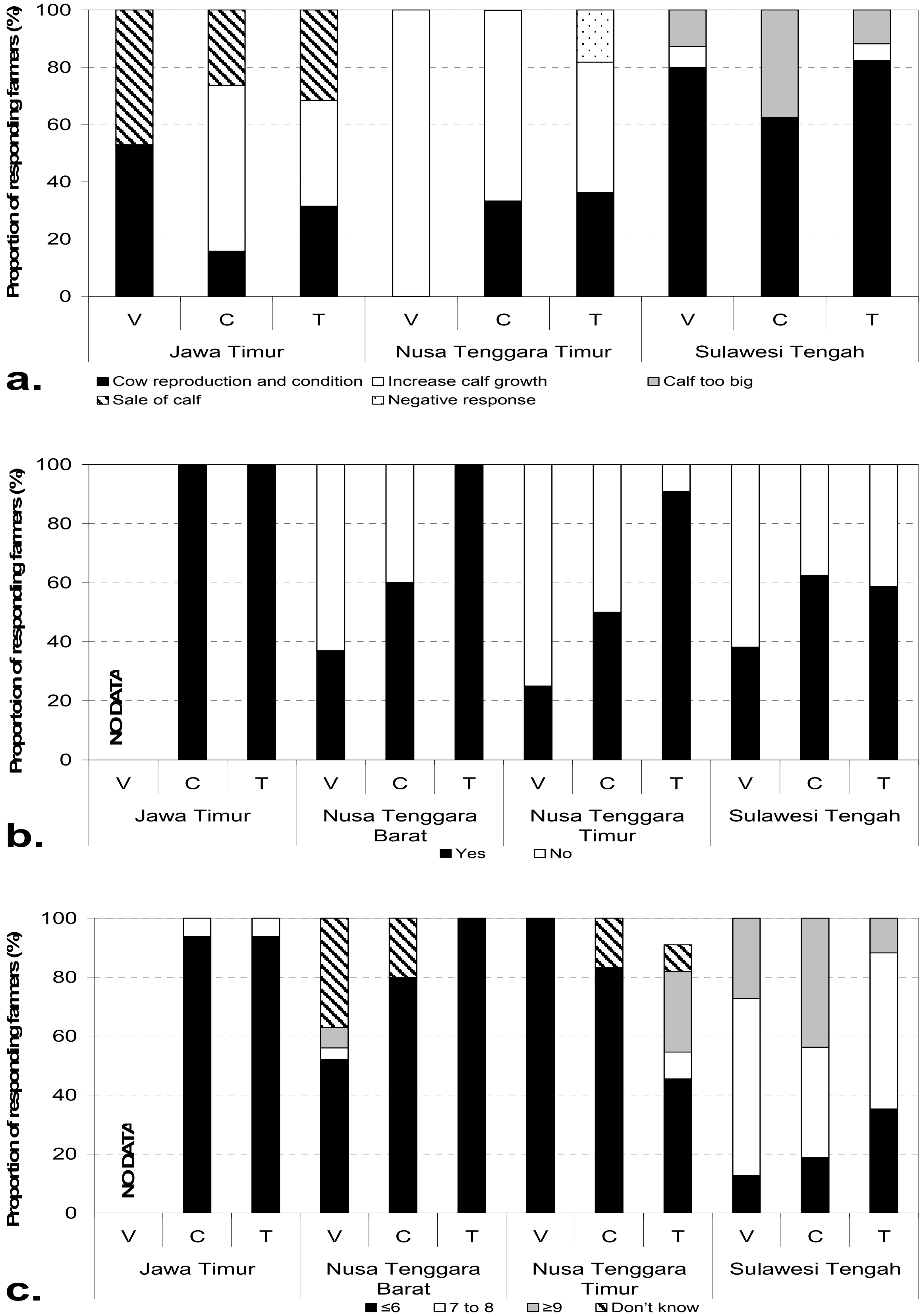

Figure 23. Major reasons for weaning (a.), proportion practice weaning (b.) and best age to wean (c.) as identified by visiting (V), control (C), and treatment (T) small-holder farmers who participated in village demonstration field days held in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah.

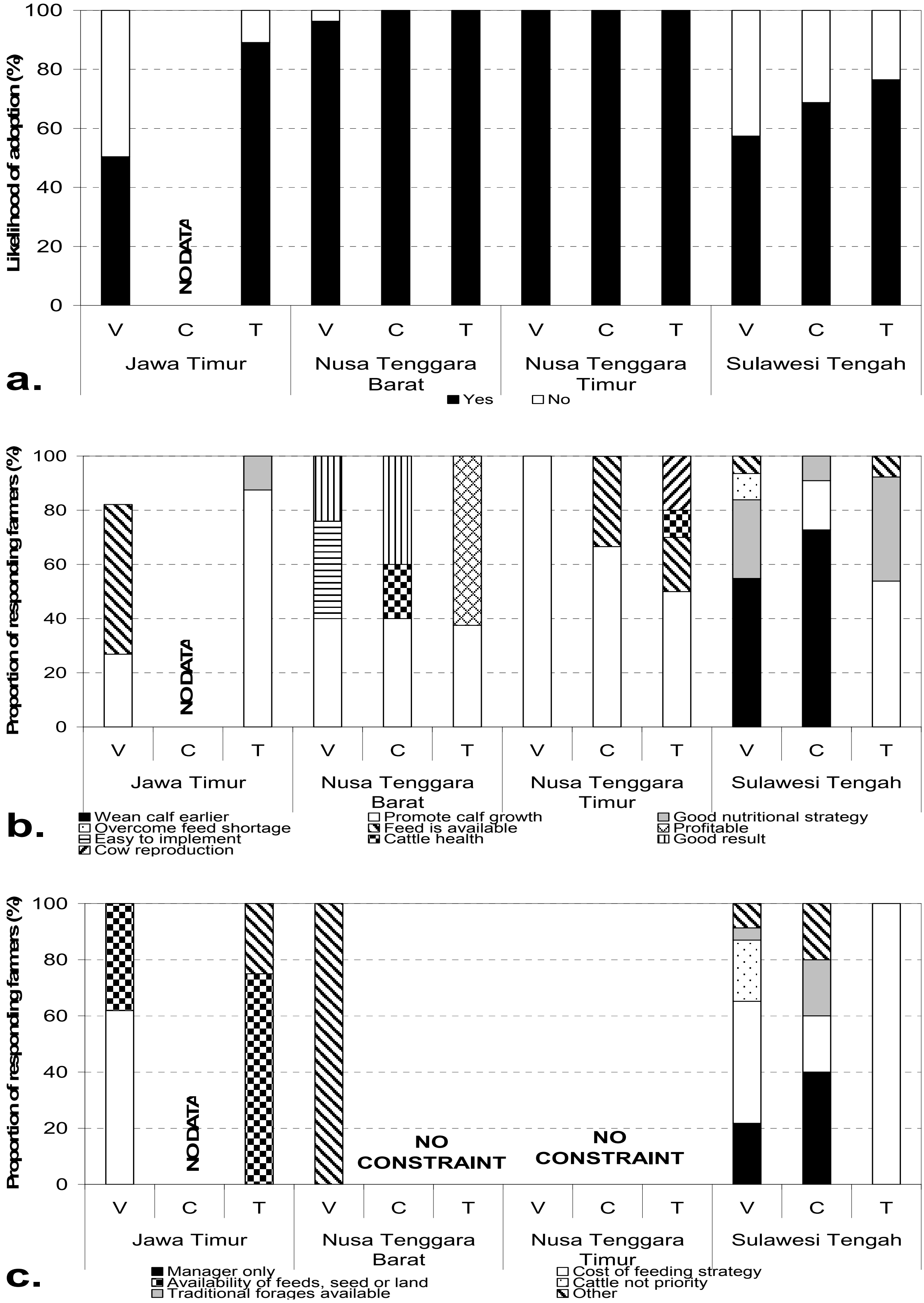

Figure 24. Likelihood of adoption of demonstration feeding strategies (a.), reasons for adoption (b.) and constraints to adoption (c.) by visiting (V), control (C) and treatment (T) farmers who participated in village demonstration field days held in Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur and Sulawesi Tengah.