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Contents

List of tables

List of figures

Abbreviations

BCS	Body condition score (1-5 scale)
BTBP	Assessment Institute for Agricultural Technology , Indonesia
CAHW	Community Animal Health Worker
CDZ	Central Dry Zone
Dahat Pan	ACIAR Project AH/2011/054 Improving livelihoods of small−scale livestock producers in the central dry zone through research on animal production and health in Myanmar
DLD	Department of Livestock Development, Thailand
DM	Dry Matter
DOF	Department of Fisheries
DVO	District Veterinary Officer
FAO	Food and Agriculture Organisation of the United Nations
FMD	Foot and mouth disease
GHG	Green house gas
HGP	Hormone growth promotants
JICA	Japan International Cooperation Agency
LBVD	Livestock Breeding and Veterinary Department, Myanmar
LIFT	Livelihood and Food Security Trust Fund, Myanmar
MoALI	Ministry of Agriculture, Livestock and Irrigation, Myanmar
NGO	Non government organisation
MLF	Myanmar Livestock Federation
OIE	World Organisation for Animal Health
OM	Organic matter
TIPS	Technical implementation packages provided to the LBVD-FAO project
TVO	Township veterinary office
USAID	United States Agency for International Development
UoM	University of Melbourne, Australia
UNE	University of New England, Australia
UQ	University of Queensland, Australia
UVS	University of Veterinary Science, Myanmar

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2 Executive summary

The ACIAR project AH/2011/054, also known as Dahat Pan, was part of the DFAT-funded ACIAR Myanmar Program 'Improving Food Security and Farmer Livelihoods in Myanmar'. The project, 2012-17, was managed by the University of Queensland in collaboration with the University of Melbourne in Australia and the Livestock Breeding and Veterinary Departments (LBVD) and the University of Veterinary Science (UVS) in Myanmar.

Dahat Pan found that significant improvements could be made to livestock production, reproduction and health in the Central Dry Zone (CDZ). These baseline data provide an important reference point for evaluating current and future livestock work in the CDZ.

Newcastle disease vaccinations, protecting chicks from predation using bamboo coops and providing supplementary feed to chicks in creep feeders reduced mortality rates from 47% without the interventions to 14% during and after the interventions. Modelling showed that over a 3-year period income from village chicken could be doubled to 133,000 Myanmar Kyat, when the interventions were used. Flock sizes increased as mortalities reduced but the feed resource is limited in a scavenging environment. Semi-intensive village chicken rearing was established as an alternative business for village chicken farmers with the potential to establish greater flock sizes under supplementary feeding and thereby generating higher income for village chicken farmers.

Three grasses and tree legumes were identified as the best options for farmers to use. Grass yields were five times greater, grew earlier after the first rain and grew longer into the dry season than traditional forage such as sorghum.

Small ruminants often suffered from 'ill thrift'—poor growth and health caused by a combination of poor nutrition and disease. All farmers owning goats and sheep in the two villages provided supplementary feed, improving survival and growth of young goats and sheep. Strategic drenching of small ruminants for worms improved their productivity. Enormous wastage occurs between birth and the potential saleable ages of young kids and goats and is a major area of lost opportunity for farmers and the country's small ruminant value chains. Targeted provision of higher-quality feeds to young small ruminants ('creep feeding') reduced average mortality of young animals from 44% to 0%. Large ruminants exhibited poor reproduction and growth. Undernutrition of cows was reflected in poor body condition scores (BCS; average BCS 2.0 on a 1-5 scale) and reproductive performance. The average calf birth rate varied between sites from one calf per cow every 1.7-2.7 years. There were internal parasites in both young and mature cattle (27-73%), with unexpectedly high worm egg counts observed in 25% of breeding cows. The overall estimated prevalence of haemoparasites was 43% (36–51%). The opportunity to develop more productive cow-calf and fattening systems was huge given the shift away from draught to mechanisation in cropping systems but this depended on developing a better nutritional base with basic animal husbandry procedures. Farmers evaluated supplementary feeding which improved the growth of young cattle. Longitudinal monitoring of cattle and small ruminants identified very low reproduction rates and growth rates which directed the above interventions but also identified other interventions for future work.

A Regional Learning Alliance was formed to facilitate sharing information across projects, government and non-government organisations (NGOs) working with livestock in the CDZ. Additionally, the formation of the Regional Learning Alliance led to particular collaboration with two of the projects. The LBVD-FAO project UNJP/MYA/022/OPS approached the Dahat Pan project to provide input to the development of Technical Implementation Packages (TIPs) covering cattle, small ruminants, forage and village chicken production. LBVD-FAO will use this information, through developing extension messages and adopting technologies with up to 177,000 livestock-rearing households engaged in their project activities. The USAID project AID-486-11-00010 being implemented by a consortium including the Italian

NGO CESVI received training from the Dahat Pan project on castration and creep feeding in goats; this led to 641 households across their project carrying out these activities.

Engagement with key private sector collaborators, in particular the Myanmar Livestock Federation (MLF) resulted in their involvement in the village chicken and forage activities. This included the production of the chick starter diet, and establishment of forages for initiation of seed production in Myanmar and distribution to farmers.

A “village chicken extension package” that comprises of a variety of extension methods and tools was compiled. Extension workshops were conducted in a total of 117 villages outside the project area, involving 3,385 village chicken farmers.

The project increased the knowledge and skills of researchers at the Livestock Breeding and Veterinary Department (LBVD), University of Veterinary Science (UVS) and latterly Yezin Agriculture University (YAU) with the most tangible evidence being the number and quality of master’s students from UVS (25 students) involved in the project. Most were young professionals from LBVD and this will have an impact on both individual and institutional capacity. Two other individuals received a John Allwright Fellowship for PhDs in Australia, one individual received a John Dillon Fellowship and another received a Crawford Fund fellowship. Mentor farmers and Community Animal Health Workers (CAHW) now have the skills to support longer-term village chicken, ruminant and forage production. They have shared their experience and knowledge at workshops and field days held by the project.

3 Background

This project was part of the multidisciplinary research program 'Improving Food Security and Farmer Livelihoods in Myanmar' which was funded by DFAT. The program, consisted of 5 related projects designed to improve food security and livelihoods for smallholders in the Central Dry Zone (CDZ) and the Ayeyarwady Delta of Myanmar.

The Central Dry Zone is one of the poorest regions in Myanmar (JICA, 2010). It covers 14% of the total land area of Myanmar and supports a population of 10 million people whose livelihood depends mostly upon agriculture. Administratively, it consists of a large part of the Magway Division, the lower part of the Sagaing Division and the western part of the Mandalay Division. The vast majority of farmers in the CDZ depend on dry land agriculture, and most are either smallholders or landless. 65% of farms in the Magway Division are smaller than 5 acres, and barely able to support rural families. JICA (2010) concluded that, in this area, only those households that have access to at least 8-10 acres of agricultural land are able to sustain their livelihood from agriculture alone. Others depend on supplementary off-farm income to support their families. JICA (2010) estimated that 40-50% of the rural population in the CDZ are landless and many households earn most of their income from farm labour. Many landless households keep village poultry around their home and some keep small sheep and goat herds which they graze along roads, fields and other common property; thus there are both smallholder and landless livestock producers.

The CDZ is an important agricultural production area in Myanmar (JICA, 2010). More than 60% of Myanmar's total production of wheat, sorghum, oil seed plants (such as sesame, groundnut and sunflower), peas, onions, cotton and maize are produced in the three divisions of Magway, Sagaing and Mandalay. The rainy season extends from May to October with annual rainfall varying from 700-1000 mm. Low annual rainfall and high rainfall variability, both between and within years, results in a high risk of crop failure. For that reason farming systems are highly diversified and livestock play a very important role, both as a source of cash income and for livelihood security. Any improvements which increase animal productivity, increase the value of animals or reduce risk of loss of animals would have a significant impact on livelihoods of poor rural households in the CDZ.

For Myanmar, the CDZ is also an important livestock producing area, particularly for sheep, goats and cattle. The combined livestock population of the Magway, Sagaing and Mandalay Divisions (covering 34% of the total land area of the country) is approximately 50% of the total cattle, 79% of the total sheep and goat, 33% of the total pig, 23% of the total buffalo and 31% of the total chicken population in Myanmar (JICA, 2010).

During the ACIAR scoping mission in October 2011 the Government, through the Director General of the Livestock Breeding and Veterinary Department (LBVD), stated that improving smallholder livestock production was a high priority to improve food security and livelihoods of poor rural families. In consultations with LBVD, the University of Veterinary Science (UVS) and other local stakeholders, two key issues for livestock development in the CDZ were raised consistently: the importance of ruminants and the lack of feed available for increasing livestock production. Improving livestock productivity to increase food security and raise income of small scale producers is directly in line with Australian Government policy outlined in AusAID's Interim Statement on Myanmar, December 2010 and with the Millennium Development Goal 1: Eradicating Extreme Hunger and Poverty.

A detailed analysis of the potential of different animal species to improve livelihoods of small-scale livestock producers in the CDZ (ACIAR, 2011) led to the selection of village chickens, small ruminants (sheep and goats) and indigenous cattle as target species for this project. The following three paragraphs describe the identified research priorities for the three target species.

Village chicken production is an important livelihood activity for most poor households. Mean flock size is approximately 30 birds and they are usually allowed to free-scavenge around the house (Henning et al., 2007). They are kept for home consumption and for occasional sale to local people. The ACIAR funded project 'Control of Newcastle disease and identification of major constraints in village chicken production systems in Myanmar', 2004-2008, identified high chick mortality and deaths from Newcastle disease as the two main constraints to village chicken production in the Yangon Division (Henning et al., 2007). An intervention study by the ACIAR project showed that promoting I-2 Newcastle disease vaccinations, protection of chicks from predation using bamboo coops and supplementary feeding of chicks with commercial chick-starter feed were able to overcome these constraints and resulted in a significant increase in the number of birds sold by farmers (Henning et al., 2009). There is an opportunity to adapt and extend these recommendations to farmers in the CDZ.

Sheep and goats are raised for meat and are well suited to the dry climate of the CDZ. They are popular as shown by a doubling of the number of small ruminants since 2003 (FAO, 2011). Small ruminants are raised by landless households or farmers who own only small areas of land (JICA, 2010). Producers keep flocks at their house at night, often in enclosures or in a simple pen, and supervise grazing of the flock during the day. Animals are grazed on communal feed resources along roads, in fallow fields and on common property grazing lands. There is no supplementary feeding. Most sheep/goat meat and animals are traded domestically; however, some animals are exported to Malaysia and China (FAO, 2011). Low productivity, animal health problems and high mortality rates of kids were identified as research areas for interventions.

Indigenous cattle are used extensively by farmers in the CDZ for draught power, sale of calves and for milk production. Most farmers keep a pair of male cattle for draught and many have one or two cows. Cows are kept to produce calves and 2.5-3.3 litres of milk per day (JICA, 2010) for home consumption and sale to local tea shops and consumers. Old cattle are sold for meat. While local consumption of beef is lower than that for other meats for traditional reasons there is strong demand for beef cattle for export to China, Thailand and Malaysia. It is likely that over the next 10 years the importance of draught cattle will decline as mechanisation of agriculture takes place. If farmers in the CDZ follow the development path of farmers in rain-fed areas of other Southeast Asian countries then many of them will replace their male draught cattle with cows to produce calves rather than stop raising cattle. This provides an opportunity to substantially increase the number of calves for sale but will also put considerable stresses on the environment. Sound cattle production management and health practices will be critical in ensuring a successful transition and maximising returns to smallholders. A lack of feed and the high cost of purchasing feeds were identified as major constraints by many stakeholders during the inception mission. In addition, farmers indicated a calving interval of 18 months or more, which provides opportunities for improvement. There are opportunities to increase productivity of indigenous cow-calf systems and milk production by improving fodder supply, feeding systems and reproductive management, and fattening cattle prior to sale to improve sale value.

4 Objectives

The overall aim of the project was *to improve the livelihoods of small-scale livestock producers in the central dry zone by enhancing management, nutrition and health of small ruminants, indigenous cattle and village chickens*.

Objective 1: Understand the technical constraints and opportunities for small-scale livestock development in the Central Dry Zone.

Activities:

- Collate and review available information on livestock production, health and marketing in the CDZ
- Select two research sites that represent common small-scale livestock production systems in the CDZ
- Analyse (using participatory methods) livestock related problems, needs and opportunities at project sites
- Conduct stakeholder meetings and household surveys to provide baseline data on livestock production, marketing and livelihoods of small-scale livestock producers at project sites (in collaboration with Component 5 of the ACIAR Myanmar R&D Program)
- Conduct a study on available feed resources for ruminant production to better understand the opportunities for fodder production

Objective 2: Develop and adapt improved animal production and health practices, linked to local and regional market value chains, for small ruminants, indigenous cattle and village chickens.

Activities:

- Review the market chain analyses undertaken by other projects in Myanmar and in other components of the ACIAR Myanmar program.
- Adaptation of recommendations for village chicken interventions in Yangon Division to the CDZ
- Monitor small ruminant production and health on smallholder farms, and introduce interventions designed to improve animal productivity and returns to producers
- Monitor indigenous cattle production and health on smallholder farms, and introduce interventions designed to improve animal productivity and returns to producers. These interventions will include vaccination, chemical treatment and biosecurity practices.
- Conduct laboratory and on-station animal production and health studies in country and in Australia to support on farm research at project sites
- Evaluate best-bet forage varieties for suitability for smallholder farms in the CDZ
- Extend promising interventions to farmers at all project sites and monitor uptake and outcomes

Objective 3: Strengthen the capacity of project partners and farmers to develop, evaluate and out-scale improved livestock technologies and practices for small-scale livestock producers.

Activities:

- Conduct project workshops to plan activities and review results and progress
- Establish effective implementation arrangements at project sites
- Facilitate linkages between local scientists involved in the project with researchers in neighbouring countries

- Supervise students involved in project research and publish project results jointly with UVS and LBVD scientists and students
- Involve farmers in the Research Site Steering Committees to ensure that they are part of identifying the research questions and approach and also involve farmers in the choice of technology to trial with their enterprise (eg forage species)

Objective 4: Create pathways to sustainable impacts and the scaling out of technologies and practices.

Activities:

- Form and facilitate a ‘Regional Alliance for Livestock Development in the CDZ’ in collaboration with LIFT
- Facilitate cross visits to project sites and organise 'training of trainers' on best practice animal production and health for staff of Regional Alliance partners and government agencies
- Link with other agriculture and livestock initiatives to ensure that project activities complement other research and development initiatives and results are widely publicised.
- Establish a formal linkage with the OIE FMD program and contribute to their scaling out program where appropriate and of direct relevance to our village systems.

5 Methodology

Project activities commenced with a start up workshop to bring together key partners to discuss the objectives, activities and outputs of the project, agree on implementation arrangements and responsibilities, and develop a detailed work plan for the first year of operations. Subsequent annual project workshops were held to review progress, discuss implementation issues and agree on annual work plans. A final project workshop was held to bring together the results of the project and provide an avenue for summarising and publicising project outcomes.

The project conducted farmer participatory research at two research sites in the CDZ with supportive laboratory and on-station research at LBVD and UVS in Myanmar, and at UQ and UoM in Australia. The research sites were selected on the basis that they represented typical landless and smallholder village chicken, small ruminant and indigenous cattle production systems in the CDZ. Other selection criteria included: availability of interested and motivated District Veterinary Officers and other local partners; all year accessibility by road; and a supportive local government. At each research site the project worked with at least 100 households.

At each site the project formed a site team and this team was responsible for implementation of all project activities and collaboration with local government and other stakeholders. The site team consisted of District Veterinary Officers (DVO), Township Veterinary Office (TVO) staff, Community Animal Health Workers (CAHWS) and a junior scientist employed directly by the project and tasked with supporting the implementation of research activities. In addition, an informal local steering committee was formed with key stakeholders involved in livestock development. The project facilitated linkages among project partners and the two research sites through coordination meetings, training workshops, cross visits and mentoring to create an effective learning environment and build capacity of project partners.

For each research activity, such as a survey, a research team consisting of one scientist from Myanmar and one scientist from Australia was assigned to be responsible for designing, implementation, analysis and reporting of the activity. The research team involved students and staff members in the research activity, and the responsibility for the activity rested with the assigned research team.

The following provides an outline of the methodology for each of the four objectives. Activities were discussed and planned, and resources allocated, at annual review and planning meetings of the project partners.

Objective 1:

Two project sites were designated as the research sites for small ruminant and cattle longitudinal research (Kyauk Aoe village, Meiktila township and Ya Thar village, Myingian township). Village chicken research was conducted at the same project site in the Meiktila township (Kyauk Aoe village), and in the Myingian township Hpet Yin village was included rather than Ya Thar village. The villages were broadly representative of the agroecology and farming systems of the Central Dry Zone, according to previously published descriptions of the region (Henning et al., 2006; Maclean, 2011), local experts and team members' previous experience. Key village and livestock farming characteristics of both villages were within the interquartile ranges of descriptors obtained in a survey covering 84% of villages in the two townships (local administrative areas) covered by the study (Table 1).

Table 1 Overview of villages and Households (HH) in the Meiktila and Myingian townships of the Central Dry Zone

	Meikhtila	Myingian
Number of villages	376	182
Number of villages surveyed	237	37
Percentage of villages with irrigation	40%	40%
Mean N (range) HH per village	102 (11-476)	231 (37-900)
Mean percentage (range) landless HH per village	35% (0-92%)	34% (6-92%)
Mean percentage (range) cattle HH per village	68% (6-100%)	61% (2-100%)
Mean percentage (range) sheep/goat HH per village	10% (0-87%)	3% (0-19%)
Mean percentage (range) chicken HH per village	77% (5-100%)	42% (1-100%)

At each site, the site team formed and facilitated a livestock producer / farmer interest group to work together to identify and evaluate interventions designed to improve animal productivity and returns to producers. The project conducted a participatory diagnosis of livestock related problems, needs and opportunities, and discussed options for research to address priority issues with the producer group. The information was verified and quantified through household surveys, providing baseline data on livestock production, marketing and livelihoods of small-scale livestock producers. Key participatory rural appraisals and surveys that were held included:

- A participatory rural appraisal study on available feed resources to better understand the opportunities for introduction of fodder production (held in Kyauk Aoe and Ya Thar, separate meetings held for cattle and small ruminant farmers)
- Township-wide surveys on livestock ownership, husbandry and health
- Household surveys of participating small ruminant cattle farmers (held in Kyauk Aoe and Ya Thar)
- Health and blood borne parasite surveys of cattle farmers (held in Kyauk Aoe and Ya Thar, as well four other villages)
- Socio-economic study with participating farmers and farmers not participating in the project (held in Kyauk Aoe and Ya Thar)
- A survey with village chicken farmers in the project villages on village chicken production, health and marketing (held in Kyauk Aoe and Hpet Yin)
- Two surveys with village chicken farmers in the project villages on perceptions of village chicken farmers on disease prevention and biosecurity (held in Kyauk Aoe and Hpet Yin)
- Focus group discussions with village chicken farmers in the project villages on village chicken production, health and marketing (held in Kyauk Aoe and Hpet Yin)

Objective 2:

For village chicken the project built on recommendations of the previous ACIAR project and adapted its recommendations for the Yangon Division to the CDZ. Adapted recommendations were introduced to the farmer group and its effect monitored and evaluated. The basic concept for improving survival rates is to reduce high attritions rates in newly hatched birds and then keep birds alive through the grower stage until the sale. Thus three simple interventions were introduced: 1) improved chick rearing, 2) vaccination against Newcastle Disease and 3) improved biosecurity and improved poultry management.

The intervention study was conducted over 12 months between November 2014 and December 2015 involving 100 households in Hpet Yin (92% of all village chicken HH at the time) and 74 households in Kyauk Aoe (95% of all village chicken HH at the time). Farmers

recorded losses, sales, consumption and purchases in monthly intervals. Intervention equipment and starter feed was produced locally using local materials and ingredients.

After the intervention study, equipment and starter feed was sold to village chicken farmers within the project villages through designated sellers, who received a small profit. A supply chain for intervention equipment and starter feed was established in the project villages. Model farmers provided training to other farmers in the project villages and in other township villages during extension workshops. Full details are provided in Appendix 11.2.

For small ruminants and indigenous cattle, the project monitored animal production and health of a number of animals from January 2014 to December 2016. In Ya Thar 185 goats were enrolled and 194 cattle in January 2014. In Kyauk Aoe 223 sheep and goats, and 157 cattle were enrolled. Animals were enrolled in the monitoring program and their liveweight and reproductive performance recorded every 1-2 months. Other information monitored included animal sales, births, deaths and animal health problems through regular observation and discussion with farmers (Table 2). This data provided a baseline of the current productivity of livestock.

Table 2 Key parameters of longitudinal monitoring of ruminants

Parameter	Small ruminants	Cattle
Body condition score (BCS)	X	X
Lactation status		X
Liveweight	X	X
Hip height	X	X
Girth		X
Births	X	X
Sales	X	X
Mortalities	X	X
Health problems (syndromes)	X	X
Worm egg counts	X	X

By year 2, the project had identified some priority interventions with a high chance of significantly improving animal productivity and these were introduced to the farmer groups for evaluation. These included locally produced chick starter diets based on local ingredients, supplementary feeding and weaning of calves, supplementary feeding kids/ lambs and targeted drenching regimes. Promising interventions identified were extended to the broader village community and their adoption and impact monitored. Farmer participatory research was supported with laboratory and on-station research in country and in Australia. This research provided a scientific basis for on-farm results and improved opportunities for publishing key research results. Laboratory support for forage, feed and animal nutrition research was provided by UVS. The project allocated funding to support laboratory analysis.

In Australia, an experiment to investigate the effect of different growth paths manipulated by levels of supplementation during the first dry season for early and normally weaned heifers and the long-term effects on growth and reproductive performance was carried out. In the first dry season animals were fed different supplement levels (copra meal and corn grain) in pens and thereafter were moved onto pasture and grazed as a group for 2 years until mated. One hundred and thirty-five Brahman crossbred heifers were selected and formed two groups, early-weaned (EW; 118 ± 6 kg LW) and normally-weaned (NW; 183 ± 6 kg LW).

Growth of steers to maturity, with a genotype common to northern Australia, has not been studied especially with respect to weight and skeletal dimensions. Similarly the two main breed types in Myanmar (Pyar Zein and Shwe Ni) have not had their growth path characterised and only descriptive parameters noted, in a thesis, “Phenotypic characterization, within and between breed diversity, breeding and management practices of

Shwe Ni and Pyar Zein". The ACIAR study was undertaken to provide information of the growth path of Brahman cross steers in northern Australia and as HGPs are used in the industry to define their specific role in weight and skeletal changes in these cattle.

Thirty-six (36) weaner *Bos indicus* steers approximately 180 kg liveweight were given a high quality pelleted diet and their liveweight and hip height monitored to maturity. Growth curves were fitted to the Brody growth equation. They were allocated into three groups; Control, C+Compudoes-100 (E2) and C+Synovex Plus (TE2) where these are commercial hormonal growth implants. Full details are provided in Appendix 11.8.

Feed has been identified as a major limitation for ruminant production in the CDZ and there are good examples of smallholder fodder production in nearby countries. The most successful forage varieties in these countries were introduced and evaluated in the CDZ. Small plots of best-bet forages were evaluated at UVS (evaluation and multiplication) and the two project sites in the CDZ. These had the dual purpose of evaluating productivity and suitability of the various forage varieties, and producing planting material. Forage planting material was produced for evaluation of feed interventions and for distribution to farmers for on-farm evaluation. Forage research involved a strong collaboration with Thailand researchers where forages and fodder production has been successful. Full details are provided in Appendix 11.3.

***Objective 3*:**

Training was based on strengthening capacity needs of project partners and built on existing knowledge and skills. LBVD and UVS scientists gained new knowledge in forage agronomy, fodder production, animal nutrition, reproduction and animal health, and new research skills in formal experimentation and farmer participatory research. This was achieved through active involvement of partner scientists in all aspects of research, mentoring by Australian scientists, participation in workshops and scientific meetings, joint publications, and collaboration with scientists in nearby countries and other ACIAR projects. For all research activities, the project paired at least one country scientist and at least one Australian scientist to be responsible for particular research studies. Students were involved in a significant amount of the research and were jointly supervised by country and Australian scientists. In particular, the project developed a Dahat Pan Masters Scholarship program with the UVS to provide opportunities for students to complete field research during their Master of Veterinary Science degree. This involved supporting students in research design, implementation and analysis of results. Additionally, support for PhD students was actively sought and promoted. At site level, project partners were actively involved in all activities such as facilitating farmer groups, implementing farmer participatory research, conducting household surveys, analysing livestock production and health issues and disease surveillance. The project kept records of all formal training.

The project facilitated linkages between scientists involved in the project in Myanmar with researchers involved in similar research in neighbouring countries, particularly those involved in related ACIAR projects. This was in the form of study visits, participation in scientific meetings and workshops in the region, and for scientists from other countries to provide inputs into the project in Myanmar. For example, scientists from Thailand provided training in forages and forage evaluation. The project provided several opportunities for participation in international meetings, including the Asia Australasian Animal Production Conference (AAAP), 2014 in Indonesia, International Grasslands Congress, India, International Conference on Sustainable Animal Agriculture for Developing Countries, Thailand and TropAg Conference, Australia (November 2017). The project provided opportunities for research for post-graduate students enrolled at UVS and scholarship opportunities for postgraduate studies at Australian Universities. The project identified research for joint publication with country scientists.

Objective 4:

The project, in collaboration with LIFT, formed and facilitated a 'Regional Alliance for Livestock Development in the CDZ'. This Regional Alliance provided a forum to enable project researchers and extension workers from a range of NGO development projects to discuss livestock development issues. It provided the project with an avenue for sharing its research results and for NGO extension workers to access technical knowledge. In collaboration with LIFT, the project facilitated a meeting with interested NGOs to discuss the formation and implementation of a Regional Alliance. The project then facilitated yearly workshops which provided an opportunity for all participants from NGOs and government agencies to share their experiences with implementing livestock interventions in their projects, to learn from each other and create an informal network of livestock researchers and extension workers in the CDZ. The project organised cross visits to project sites to strengthen the capacity of NGOs to implement recommended interventions.

The regional alliance facilitated close collaborations between the Dahat Pan project and other projects working with livestock farmers in the CDZ. Collaboration occurred with two projects; LBVD-FAO project UNJP/MYA/022/OPS *'Improving Farmer Livelihoods in the Dry Zone through Improved Livestock Health, Productivity and Marketing'* and the USAID project AID-486-11-00010 *Shae Thot 'The Way Forward'* being implemented by a consortium including the Italian NGO CESVI. These projects were given technical training and direct research outputs for use in developing and implementing their own activities.

The Dahat Pan project also engaged with the Myanmar Livestock Federation (MLF) in scaling out project results through forage production and production of the chicken starter feed. A "village chicken extension package" that comprised of a variety of extension methods and tools was compiled. It provided a number of different educational tools that can be easily used by other organisations to conduct training of farmers on improved village chicken production.

6 Achievements against activities and outputs/milestones

Objective 1: Understand the technical constraints and opportunities for small-scale livestock development in the Central Dry Zone

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
1.1	Collate and review available information on livestock production, health and marketing in the CDZ	Project report	Y 1, m6	Complete. December 2017
	Information from a number of sources was included in production system descriptions in the final report appendices, including information on households owning multiple livestock species. Site selection was based on a partial analysis of this information. In addition information has been collected more broadly across the CDZ by PhD candidate, Tu Tu Zaw Win.			
1.2	Select two research sites that represent common small-scale livestock production systems in the CDZ	Sites selected and selection accepted by partners	Y 1, m3	Complete. November 2013
	Two sites were selected for ruminant and forage production, Ya Thar village in Myingian Township and Kyauk Aoe village in Meikhtila Township. Two sites were selected for village chicken interventions (Kyauk Aoe and, Hpet Yin (Myingian). Sites were selected based on a survey of 'the majority' of villages in the townships and a principal component analysis to validate the representativeness of the villages.			
1.3	Participatory analysis of livestock related problems, needs and opportunities at project sites	Project report describing the results of the participatory analysis	Y 1, m6	Complete. March 2014
	Farmer interest groups were interviewed regarding their cropping and livestock systems, labour and credit availability, breeding management and marketing for cattle and small ruminants in both Kyauk Aoe and Ya Thar. During the PRA we created village maps and charts highlighting seasonal animal husbandry, cropping, and disease/outbreak patterns. Farmers interested in village chicken production were interviewed in Hpet Yin and Kyauk Aoe using PRA methods to identify constraints to village chicken health and husbandry. A project report was not completed although the results were used to develop the longitudinal studies.			
1.4	Conduct stakeholder meetings and household surveys to provide baseline data on livestock production, marketing and livelihoods of small-scale livestock producers at project sites	Project report describing the results of meetings and HH survey	Y 1, m9	Complete. December 2017
	Household surveys have been completed by participating small ruminant (12) and cattle (38) farmers. Detailed farm enterprise surveys have been completed with participating forage farmers (8), and it is intended that this paper will be submitted for publication. Surveys to identify constraints to village chicken production and health were completed by 170 households. Results are included in the appendices. *Township-wide surveys on livestock ownership, husbandry and health were conducted in October-November 2014. It was part of the work that the PhD JAF candidate, Tu Tu Zaw Win has undertaken and was accepted for publication.*			
1.5	Conduct a study on available feed resources for ruminant production to better understand the opportunities for fodder production	Project report	Y 1, m12	Complete. July 2015

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	A paper was presented (Soe Min Thein, AAAP conference) on analysis of available feed resources and the livestock management system based on the PRA in Ya Thar and Kyauk Aoe villages. Key findings were that although there is an overall shortage of feed year-round, the two main periods of feed scarcity are in the late dry to early wet season, and in the late wet to early dry season. There are opportunities for the introduction of forage and fodder crops, tailored to the needs of cattle and goat/sheep producers. Longitudinal investigation of grazing nutritional resources was included in the Masters thesis of Ei Mon Nyein (project supported student at UVS), 'Body Condition Score and liveweight changes of Native Cows in the Dry and Wet Season at Dryzone Area in Myanmar'.			
1.6	Conduct a survey of the animal health constraints to understand the opportunities for animal disease control	Project report	Y 1, m12	Complete. December 2017
	A cattle health survey was completed in 3 villages in the Meiktila and Myingian townships respectively. A blood borne parasite sero-survey was also completed in the same villages. Longitudinal syndromic surveillance was carried out for small ruminant and cattle health in the study villages (2.5 years). Longitudinal monitoring of gastrointestinal parasitism has been conducted for over 12 months in both sheep and cattle via repeated faecal sampling and worm egg counts (WEC). WEC results in both cattle and small ruminants, suggest strategic anthelmintic treatment may efficiently reduce parasite burdens. *Multiple surveys were conducted on village chicken activities, including a survey on constraints to village chicken production (174 HH) to inform an intervention study and surveys on biosecurity practices conducted by village chicken farmers before and after the intervention study (140 HH). Results are included in the appendices.* *Surveys on livestock health and production and marketing and trading practices were conducted across 38 villages involving more than 600 multispecies livestock farmers.*			

Objective 2: Develop and adapt improved animal production and health practices, linked to local and regional market value chains, for small ruminants, indigenous cattle and village chickens

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
2.1	Adaptation of recommendations for village chicken interventions in Yangon Division to the CDZ	Livestock producer interest groups formed at project sites	Y 1, m5	Complete. December 2013
	Preliminary chicken producer interest groups were established in December 2013. Approximately 50% of all village chicken farmers were members of the village chicken interest groups. Regular trainings were conducted in both study villages on methods to improve village chicken production and on symptoms, treatments and prevention of village chicken diseases.			
		Study tour to sites of the previous ACIAR project in the Yangon Division completed	Y 1, m12	Incomplete
	Study tour was not deemed valuable after visit of Yangon site by Dr J. Meers and this did not proceed			
		'Best practice' chicken health and production introduced at project sites	Y 2, m1	Complete. November 2014
	Interventions in village chicken households November 2014- November 2015.Newcastle Disease vaccination and improved chick management was implemented in 85% of households in Hpet Yin (94 households,1040 birds) and in 75 % of households in Kyauk Aoe (56 households, 688 birds). Regular vaccinations were conducted in three-monthly intervals and additional chick starter feed was supplied to village chicken farmers when new batches of chicks were born. Follow up-meetings were conducted with farmers to monitor the progress. Impact of the interventions was recorded monthly by farmers into farmer recording sheets and this data was compiled by the leader of the village chicken interest groups and by the Junior Scientists.			
		Adoption of interventions and results monitored	Y 2, m6 Y 3, m6 Y4, m6	Complete. January 2016

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	Monitoring success, December 2015: A survey was conducted to monitor the results from the intervention study. In this follow-up survey outcomes of intervention study (sale of birds and eggs, flock size and consumption of birds and eggs) were summarized. *Monitoring behaviour change, December 2015: A follow-up survey on perceptions of disease prevention and biosecurity of village chicken farmers was conducted after the completion of the intervention study to investigate if farmers' attitudes had changed after they had experienced ND vaccination, improved biosecurity and improved chicken rearing on their farms.* *Sustainable adoption, January 2016: Sale of starter feed and intervention materials was conducted by feed dealers in Hpet Yin and Kyauk Aoe. Feed dealers received incentives for the sale of these items and farmers purchased these items at subsidized prices. Free three-monthly ND vaccinations were provided for 12-months, then payment was required. Sales, consumption and disease constraints were monitored in households that received ND vaccination and purchased intervention equipment.*			
		Study on chick starter diets locally produced and based on locally available ingredients completed and options for its use evaluated by producer groups at project sites	Y 2, m12	Complete. January 2016
	Village chicken starter feed was selected and analysed for nutritional value, it is produced locally in Myingian by Win Naing Phone (Myanmar Livestock Federation).Refer to information above on 'best practice' chicken health as chick starter diets were evaluated by producer groups concurrently with the use of Newcastle Disease vaccinations and coops.			
2.2	Monitor small ruminant production and health on smallholder farms, and introduce interventions designed to improve animal productivity and returns to producers	Livestock producer interest group formed	Y 1, m5	Complete. January 2014
	A goat-farmer interest group was formed in Ya Tha, consisting of 6 households, 3 having herd sizes of 30–35 goats, and 3 having herd sizes of 80–85 goats. All members of the group were landless, as is typical of goat farmers in the village. *A sheep- and goat-farmer interest group was formed in Kyauk Aoe, consisting of 6 households, 2 of which raise sheep, and 4 of which raise goats. All members of the group were land owners, as is typical of the village.*			
		150 sheep / goats enrolled (i.e. 6-12 smallholder and landless producers) and monitoring system set up and operational	Y 1, m6	Complete. January 2014
	Monitoring schedule, procedures, data bases and recording sheets were prepared. 185 goats in Ya Tha and 223 sheep and goats in Kyauk Aoe were initially enrolled. Junior scientists received training in the maintenance of these records with continual support from Australian researchers during this process. Data was checked monthly and queries were checked at the next monitoring event.			
		Animal production and health monitored over 3 years and cumulative results and analysis available Establish links to international regional projects on disease surveillance, control measures and cross-border constraints	Y1, m12 Y2, m12 Y3, m 12 Y4, m 6	Monitoring complete. December 2016.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	Final measurements were made in December 2016 to complete the 3 year data set. Results for production, reproduction and health parameters were compiled and presented to project team members at each annual project meeting. Parameters monitored included weight, body condition score (BCS), births, deaths, sales, health problems and treatments. *International links were established with FAO (ECTAD based in Yangon and FAO-LBVD project based in Nyaung U), and OIE (LBVD project staff participated in regional meetings of disease control surveillance where approved by Myanmar government).*			
		Interventions introduced to producer group and adoption and results monitored	Y2, m6 Y3, Y4	Complete. June 2017
	Dry and wet season anthelmintic trials were carried out in 2016 to measure differences in production and health of adult small ruminants treated with a short-acting, broad-spectrum anthelmintic compared to untreated control animals from the same household and/or village. The results indicated a decrease in the worm burden and higher weight gains of treated animals. *A dry season anthelmintic trial was carried out from December 2016- March 2017 to measure the difference in production and health of young small ruminants.* *From July 2016 supplementary feeding of young animals was offered to all interested small ruminant farmers in both villages after a trial period earlier in the year. Farmers were supported with equipment and were required to supply simple records of births, deaths, and sales to participate. All farmers across the two villages (44) elected to participate.* *Feedback surveys were carried out in September 2016 with farmers who were creep feeding their young small ruminants to be able to identify whether they perceived benefits and would continue creep feeding without project support.* *Based on the positive results from 2016 a supplementary feeding trial to compare alternative feeds for creep feeding was carried out from March-June 2017.*			
2.3	Monitor indigenous cattle production and health on smallholder farms, and introduce interventions designed to improve animal productivity and returns to producers	Livestock producer interest group formed	Y1,m5	Complete. January 2014
	A cattle-farmer interest group was formed at Kyauk Aoe, consisting of 42 representative households. A similar group was established at Ya Thar, consisting of 92 representative households. *A subsection of the farmer interest groups met at different times throughout the project to discuss current feeding management of cattle, introduction of supplementary feeding and weaning.*			
		150 cows + recent off-spring enrolled, monitoring system set up and operational	Y1, m6	Complete. January 2014
	Monitoring schedule, procedures, data bases and recording sheets prepared.157 cattle at Kyauk Aoe and 194 cattle at Ya Tha were initially enrolled. Junior scientists received training in the maintenance of these records with continual support from Australian researchers during this process. Data was checked monthly and queries were checked at the next monitoring event.			
		Animal production and health monitored over 3 years and cumulative results and analysis available Establish links to international regional projects on disease surveillance, control measures and cross-border constraints	Y1, m12 Y2, m12 Y3, m12 Y4, m6	Monitoring complete. March 2017

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	Final measurements were made in March 2017 to complete the 3 year data set. Results for production, reproduction and health parameters were compiled and presented to project team members at each annual project meeting. Parameters monitored included weight, body condition score (BCS), hip height, girth, births, deaths, sales, health problems and treatments. *International links include with FAO, OIE (LBVD project staff participated in regional meetings of disease control surveillance where approved by Myanmar government), and Asia Beef Network (an initiative of the University of Queensland, HELVETAS Vietnam, funded by ACIAR).*			
		Interventions introduced to producer group and adoption and results monitored	Y2, m6 Y3, Y4	Complete. June 2017
	March 15- June 15: A trial to investigate the efficacy of strategic nutrient supplementation of calves during the dry season to improve calf and cow performance at the study site in the Myingian township was established. The trial successfully indicated improved growth rates of the calves receiving supplementary feed. *March 15: An anthelmintic trial to measure differences in production and health between cattle treated with a short-acting, broad-spectrum anthelmintic compared to untreated control animals from the same household and/or village was conducted. The trial was performed early in the project and was unsuccessful due to poor protocol compliance: animals tended to be under-dosed because of a lack of team training in the size of the injection guns used and a hesitation on the part of researchers to treat pregnant animals with anthelmintics; the same animals tended to receive control supplements instead. Nonetheless, this demonstrated the critical importance of training collaborators, including experienced animal health staff, in new field research techniques, and the need for good animal handling and veterinary skills in the research team.* *October 15- June 16: A trial to investigate the efficacy of weaning calves from cows to improve cow performance was trialled. Calves were not successfully separated from the cow in all cases which has influenced the results.* *March 16- June 16: Farmers were supported in both villages to supplementary feed their calves; 13 calves in Kyauk Aoe and 21 in Ya Thar. Farmers have reported that calves grew faster and were healthier and that they were happy with the response.* *August 2016: Farmers who had been providing supplementary feed to their calves during the dry season were supported to wean the calves to improve cow performance. Supplementary feeding and weaning were strategically timed based on when calves are most commonly born and when there are shortages of feed.* *February 2017: Feedback surveys were carried out with farmers who had provided supplementary feed and weaned their calves to identify whether they perceived benefits and would continue without project support.* *March 2017 to June 2017: A trial was undertaken to compare the efficacy of two different rations used for supplementary feeding of calves during the dry season to improve calf and cow performance at the study site in the Myingian township.* *March 2017 to June 2017: A calf anthelmintic trial was carried out to measure differences in production and health of calves treated with a short-acting, broad-spectrum anthelmintic compared to untreated control animals of the same age and from the same village.*			
2.4	Laboratory and on-station animal production and health research in country and in Australia to support on farm research at project sites	Research data providing a scientific basis for on farm results and opportunity to publish research results	Y2, Y3, Y4	Complete. December 2017

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	A trial of semi-intensive village chicken production was conducted at UVS as part of a UVS master project. In this trial weight gain and production parameters of Imbimwa and Sittagaung and Hlebyaung chickens were compared in a semi-intensive environment. A second trial conducted as part of a UVS master project was the comparison of antibody development following Newcastle disease vaccination between Imbimwa, Sittagaung and Hlebyaung using HI and ELISA test methods. Antimicrobial resistance has been investigated from chicken-fish, commercial broiler and layer farms through analysis of 400 samples at UVS. *Blood borne parasite survey in cattle to investigate the prevalence of tick-borne pathogens in the Central Dry Zone. 360 blood samples were collected and analysed at UVS and have been further analysed at UoM. Faecal samples from ruminants were analysed at the LBVD Mandalay laboratory and UVS for WECs.* *Dry matter yield on station and at UVS has been used for the forage evaluation. In addition, the nutritive value of the species has been compared at UVS. The forage research facilities at UVS have been expanded and irrigation installed. At YAU a forage research facility has been established with plans for improvement to the area. This has facilitated research work by a total of 8 post graduate students.* *Two long-term (2-year) experiments on growth and skeletal frame size were completed at two sites in Australia. There has been no long-term effect of early weaning on heifer reproduction and frame size but reproduction rate in the second wet season was much lower (68 vs 30% respectively) purely as a function of liveweight at mating. In a second experiment there was an effect of testosterone implants on mature skeletal frame size (reduced) but no effect of oestrogen-based implants. Maximal skeletal elongation rates have now been determined for* Bos indicus *steers over the whole growth curve, providing a basis for comparing treatments in the field at any stage of the growth curve to maturity. Two PhD students (one a JAF) were involved in the work. These results link to growth and skeletal frame size being done in Myanmar with cattle.*			
2.5	Evaluate best-bet forage varieties for suitability for smallholder farms in the CDZ	Forage evaluation experiment established at UVS and results summarised in annual reports	Y1, m9 Y2 Y3 Y4	Complete. Established May 2014
	A range of forage species with likely adaptation to the environment and farming systems of the CDZ was identified through a process of extensive consultation. Single row grass and legume evaluation experiments were established and evaluated at the UVS campus in 2014 and 2015. Sequential harvesting of biomass undertaken at ~45 day intervals to simulate a cut and carry feeding system was used to compare species. In the following years specific research questions were investigated at the forage research facilities in the form of Master's theses. Research topics were: 'Comparison on the digestibility of introduced grasses, Napier grass and Sorghum through in vitro and in situ method', 'Effects of cutting intervals on yields and nutritive values of Sorghum and two introduced grasses' and 'The effects on fertiliser application on yields and nutritive values on sorghum and introduced grasses grown in the dry season'. In total 5 Masters students have utilised the forage experiments at UVS to complete their research. Herbaceous legumes have now been established on weed mat for the collection of seed.			
		Forage evaluations established at project sites and results summarised in annual reports	Y2,m3 Y3 Y4	Complete. Established May 2014
	A range of forage species with likely adaptation to the environment and farming systems of the CDZ was identified through a process of extensive consultation. Single row grass and legume evaluation experiments were established and evaluated at Kyauk Aoe and Ya Thar villages in 2014. *In 2015 larger replicated forage experiments (3 x 3 m plots) were established at Ya Thar and Kyauk Aoe to evaluate a sub-set of species (6 grass and 6 herbaceous legumes and 3 browse legumes) considered to have potential in the CDZ based on the single row evaluation in 2014. These experiments were evaluated at ~60 day intervals depending on the season. The final grass and herbaceous legume measurements were completed in January 2017 and the final tree legume measurement was completed in June 2017.*			

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
		Participatory evaluation of forages with farmers established and results summarised in Annual Reports	Y2, m1 Y3 Y4	Complete. Established 2015
	In 2014 there were minimal results from farmer managed experiments as a result of lower than average rainfall causing reluctance to plant seed and seed planted too deeply. In 2015/16 eight farmers in Ya Tha and Kyauk Aoe established areas of grass (Cayman, Mulatto II, Mombassa) ranging in size from 200-500m^2.Five areas were successfully grown through to harvest with the biomass fed to their cattle. UVS support for forage production research and extension resulted in 14 farmers growing 15100 m^2 of grass in the 2 villages in 2016/17. Fifty one farmers in Ya Thar and 24 in Kyauk Aoe planted >1000 seedlings in the 2 villages.			
		Promising forages extended to other farmers at project sites and adoption monitored and results summarised in annual report	Y3, m1 Y3, Y4	Complete. June 2017
	Scaling out in the 2016/17 season was facilitated by irrigation of production areas from the previous year (3) during the dry season to provide planting material (along with imported seed). Tree legume nurseries were established in the 2 villages in May 2016 to supply seedlings. In May 2015 tree legume nurseries were established at UVS. Collaboration with the New Zealand Dairy Excellence Project to purchase vegetative material for planting for 3 farmers in Kyauk Aoe village also facilitated the extension to other farmers. *In addition to the forages established in Ya Thar and Kyauk Aoe there were 10 farmers from the Natogyi township who established 1000 m^2 (0.25 acres) of grass for the feeding of draught and dairy cattle. Browse legumes are now being grown in two townships with seven farmers establishing 300 plants. Two commercial farmers established a total of 1.2 ha (3 acres) of grass and 400 browse legumes for seed increase and forage production. One commercial farmer is from the Myingain MLF and was a long term supporter of the project.* *Ongoing support and monitoring has been provided to these farmers by Soe Min Thein (UVS) since 2016.*			
2.6	Extend promising interventions to farmers at all project sites and monitor uptake and outcomes	Promising interventions evaluated by at least 50 producers per site	Y3, Y4	Complete. June 2017
	174 farmers evaluated village chicken interventions, finding that survival of village chicken was significantly improved at the project sites. Extension workshops were conducted in a total of 117 villages outside the project area, involving 3,385 village chicken farmers across the CDZ. *44 small ruminant farmers (all farmers owning small ruminants at the project sites) provided supplementary feed in creep feeders for young animals.* *62 cattle farmers across the two villages have evaluated supplementary feeding and some have experimented with weaning of calves.* *14 farmers are growing 15100 m^2 of forage grasses across the 2 villages. 51 farmers in Ya Thar and 24 in Kyauk Aoe planted >1000 tree seedlings in the 2 villages.*			

Objective 3: Strengthen the capacity of project partners and farmers to develop, evaluate and out-scale improved livestock technologies and practices for small-scale livestock producers

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
3.1	Conduct project workshops to plan activities and review results and progress	Start-up workshop held and agreed year 1 work plan developed	Y1, m3	Complete. September 2013
	A project inception meeting was held 2–4 September 2013 at UVS, Yezin. At this meeting project teams (Cattle/Small ruminants/ Forages/ Village chickens) and workplans were established.			
		Annual project workshops held and agreed work plans developed	Y2, m3 Y3, m3 Y4, m3	Complete. October 2016
	The annual meeting for 2014 was held in October in Meiktila with a field visit to the research site in the Myngian township included. Progress for 2014 was reviewed through strengths, weaknesses, opportunities, threats (SWOT) analysis and other techniques. Work plans for 2015 were discussed. *The project annual meeting was held in December 2015 in Mandalay, with a field visit to the New Zealand Dairy Excellence Project. Work plans for 2016 were developed.* *The project annual meeting was held in October 2016 in Nyaung U, with a field visit to the research site in the Myingian township included. Work plans for 2017 were developed.*			
		Final project workshop held and final project outputs reported	Y4, m10	Complete. August 2017
	It was held from July 31- August 1, 2017 in Nyaung U. Project reviewers and senior government staff attended the meeting.			
3.2	Establish effective implementation arrangement at project sites	Key stakeholders at project sites identified, project objectives and implementation arrangements discussed with local government and other key stakeholders	Y1, m5	Complete. January 2014
	After project sites were proposed, meetings were held with each village chairman, then with the township veterinary office and township administration in Meikhtila and Myingian to confirm agreement for participation. A meeting was held in Mandalay with the regional government to explain project objectives and seek agreement for implementation of the project. *Field work was restricted until September 2015 as a result of administrative and approval difficulties for village visits by foreigners. After this time significant improvement was made and more appropriate time could be spent in the villages during visits.*			
		Project site teams established	Y1, m6	Complete. December 2013
	A junior scientist was appointed at each project site (Myingian and Meiktila), both junior scientists were Bachelor of Science graduates from Meiktila University. Roles for the township veterinary offices, Community Animal Health Workers (CAHWs) and the Myanmar Livestock Federation (MLF) and linkages with LBVD and UVS staff were established. There were some challenges in appropriate supervision and communication regarding activities. Site teams were strengthened by the addition of Soe Min Thein (UVS) to assist in the establishment of forages by farmers.			
		Project steering committees established at sites and 6-monthly meetings held to report progress and results	Y1, m6 Y1,2,3, m12 Y2,3,4, m6	Partially complete
	The objective of forming steering committees at the two project research townships in Myingian and Meiktila was to ensure that the project is recognised and supported by the township authorities and non-government livestock development stakeholders, and contributes to the development goals of the townships. Establishing formal committees proved difficult but agreements were reached with the Township Administrations to convene informal meetings involving the Township Supporting Committee (TSC), the Township Administration, the Myanmar Livestock Federation and any other interested local			

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	stakeholders every 4–6 months to keep them informed of progress. Meetings have been held on an ad hoc basis with difficulty meeting the 6 monthly requirement. Meetings were held most recently in December 2016. In July 2017 extension materials were distributed and discussed with the township administration for each site.			
		Training needs assessment for farmers outlined	Y1, m11	Complete
	The participatory assessments highlighted several areas of training needs for farmers. Interviews with village chicken farmers were conducted during the November 2014 vaccination campaign to explore farmers' perceptions, beliefs and practices towards Newcastle disease and its prevention. *Numerous trainings with farmers have been held (refer to section 7.3).* *One example is farmer to farmer training for village chicken activities, from January 2016: Two 'model village chicken farms' were established in each study village. They were supported with starter feed and intervention material and organised meetings with other farmers to promote interventions. They received extension material (billboards, posters, flyers) for distribution to other village chicken farmers.*			
3.3	Facilitate linkages between local scientists involved in the project with researchers in neighbouring countries	Four in-country scientists have participated in study visits, scientific meetings or workshops in the region	Y1 (2 visits) Y2 (4 visits) Y3 (4 visits) Y4 (2 visits)	Complete. November 2016
	Khin San Mu (UVS) and Zin Min Latt (LBVD) visited the project sites and final project meeting of ACIAR project LPS/2008/038 (Indonesia) for training in project management, feeding systems and scientific techniques in November 2013. *Tanda Panjaitan (BPTP Indonesia) and Ganda Nakamanee and Wattanawan Srisomporn (DLD, Thailand) visited the project sites to train and mentor Myanmar scientists in cattle management and forage evaluations in February and May 2014, respectively.* *This led to ongoing supervision and collaboration with Ganda Nakamanee from DLD in Thailand continuing to visit to train and mentor partner scientists, with a further 7 visits throughout the project.* *Soe Min Thein from UVS presented at the AAAP conference in Indonesia, attended the ACIAR symposium and had a study tour to ACIAR funded cattle project in Indonesia.* *Four UVS master students presented internationally in November 2015, two on the village chicken health belief model at the Sustainable Animal Agriculture for Developing Countries Conference and two on forage production at the International Grasslands Congress.* *A study tour for the junior scientists employed by the project and one UVS staff member was held in November 2015 in Thailand to learn seed and forage production with the DLD.* *John Dillon Fellowship for research leadership received by Aung Aung, UVS to complete a study visit focussed on research leadership, March 2016* *Seed production training was provided in Thailand in November 2016 for one UVS staff member and one YAU staff member who have undertaken seed increase responsibilities with funding from the Collaborative Research Grant, C2015 299-Developing capacity in forage seed increase and research in Myanmar.* *Crawford Fund International Training Award received by Lwin Naing Oo to complete a study visit to Australia focussed on livestock research and pasture establishment and management, October-December 2017.* *ACIAR travel scholarships received by four Master's students to present at the TropAg Conference in Brisbane, November 2017. A JAF PhD student also attended this meeting.*			
3.4	Supervise students involved in project research and publish project results jointly with UVS and LBVD scientists and students	At least three students enrolled at UVS and these students have completed their degree on project research	Y2, m1 Y4, m10	Complete, July 2016

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	There were three PhD students; two have received JAF scholarships to study at the University of Queensland (UQ), and one completed his Doctorate at the University of Veterinary Science (UVS). *There were a total of 27 Master of Veterinary Science students who were supported throughout their research thesis at UVS. Seventeen master's students have completed their field experiments and received their degree. A further seven Master students commenced research with the project in 2017 and will complete their studies in 2018. A project scholarship was provided, and co-supervision with Myanmar and Australian researchers. Predominantly they were field research projects based in the same villages where the project carried out longitudinal monitoring.* *In addition to Master's student enrolled at UVS, another student completed her studies from the University of Sydney (USyd), and another is studying at Yezin Agricultural University (YAU).*			
		At least three joint research papers submitted for publication in national and international publications	Y4, m12	Incomplete
	Research papers for submission to journals are currently being written, with the intention of approximately 18 papers published. 1 paper has been accepted, and 2 papers have been submitted to international journals. A list is included in Section 10.2.			
3.4	Development of a communication plan	A communication plan will be developed during year 1 of operation	Y1, m11	Complete
	Regular 'skype' meetings were used for communication within the project team in addition to meetings in person. Ad hoc newsletters and project factsheets were developed for communication with a wider audience. Project documents were shared using dropbox. No formal communication plan was documented.			

Objective 4: Create pathways to sustainable impacts and the scaling out of technologies and practices

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
4.1	Form and facilitate a 'Regional Alliance for Livestock Development in the CDZ' in collaboration with LIFT	Agreement to form a Regional Alliance meeting with interested NGOs	Y2, m3	Complete, March 2014
	Agreement was reached with LIFT to establish and facilitate a regional alliance for livestock development. LIFT agreed to organise and facilitate the first meeting in October/November 2014 and the proceeding meetings. This was an important part of the project Impact Pathway which was developed to facilitate planning for impacts within and outside the project.			
		6-monthly workshops of the Regional Alliance held	Y2, m9 Y3,m3+9 Y4,m3+9	Partially complete

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	The first meeting was held in Meiktila on 3 November 2014 and included the following organisations; LIFT, CESVI, FAO, GRET, MFLF, Thadar Consortium, LBVD, UVS. Projects shared their progress to date and we discussed challenges and lessons learnt working in the livestock sector of the CDZ. *The second meeting was held in Yenanchaung on 23-24 June 2015 with 21 participants from International NGOs, NGOs, universities and government departments. This meeting included a field visit to Mae Fah Luang (Thai NGO) to see the work they have done using a goat bank model and growing Ruzi grass.* *The third meeting was held 10-11 May 2016 in Meiktila. There were 20 participants in total; 8 women and 13 men. The organisations represented were LIFT, FAO, MFLF, ADRA, CESVI, UNDP, LBVD, UVS, MLF, OIE. This includes 3 NGOs, 3 donor funds, 1 industry body, 1 university and 1 department.* *The fourth meeting was held in September 2017 and was hosted by FAO in Pokoku with a theme of Community Animal Health Worker (CAHW) training. There were 18 participants from LBVD, UVS, CESVI, LIFT, FAO, CDA, MVC, MLF. This meeting was postponed as a result of LIFT and FAO commitments from the previously scheduled time of November 2016.* *Workshops were not held every six months, however closer collaboration was developed with interested organisation from the Regional Learning Alliance, in particular the LBVD-FAO project, CESVI- Shae Thot project and Myanmar Livestock Federation (MLF).* *At the final meeting held in September 2017, LIFT indicated their willingness to continue to organise meetings on an annual basis.*			
4.2	Facilitate cross visits to project sites and organise 'training of trainers' on best practice animal production and health for staff of Regional Alliance partners and government agencies	At least 3 cross visits facilitated	Y3 Y4	Complete. September 2017
	Cross visits occurred in Yenan Chaung and Meiktila, hosted by the Dahat Pan project, Mae Fah Luang and the New Zealand Dairy Excellence project. A cross visit was also hosted by the Dahat Pan project in July 2017 when field days occurred at the two project study villages. These field days provided farmers, regional alliance members, and government agencies the opportunity to gain information about key successful interventions the project has undertaken with farmers. Additionally a cross visit was held in Pokoku in September 2017, hosted by the LBVD- FAO project. Farmers form all 3 villages attended annual meetings and were asked to comment on activities.			
		At least 3 training courses held in conjunction with Regional Alliance workshops	Y3 Y4	Complete
	May 2016: Training material provided on gender considerations in managing and implementing livestock projects by Khin Hnin Phyu, LIFT. *December 2016, February 2017, and June 2017: Training courses were provided to CESVI (Italian NGO) staff on castration and creep feeding in small ruminants. This has resulted in scale out to 12 Shae Tot/CESVI villages (641 Shae Tot farmers have received training and information on castration).* *September 2017: The regional alliance workshop focused on training of CAHWs.*			
4.3	Link with other agriculture and livestock initiatives to ensure that project activities complement other research and development initiatives and results are widely publicised	Reported project progress in at least one meeting of the FAO Animal Health Priorities Steering Committee (AHPSC) and/or other national working groups and conferences each year	Y1 Y2 Y3 Y4	Partially complete

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Completion status
	Project progress has not been formally presented at national conferences. However we have had regular representation at conferences such as the Myanmar Veterinary Association where post graduate students have presented project results. At the 2016 and 2017 World Food Day the results and extension materials of the project were displayed and promoted by UVS, with a particular focus on the forages that have been used during the project. LBVD project staff participated in national and regional FAO and OIE meetings of disease control surveillance where approved by the Myanmar government. *Other national working groups we have had involvement with include:* • *Participation in the 2014 Livestock Expo hosted by the Myanmar Livestock Federation in January 2014.* • *Participation in a Food Security Working Group meeting in March 2014 with a focus on food security in Myanmar.* • *Regular liaison with LIFT through the process of collaboration in the organisation of the regional alliance.* *Research results were compiled to formulate technical implementation procedures (TIPs) which were requested by the LBVD-FAO project UNJP/MYA/022/OPS 'Improving Farmer Livelihoods in the Dry Zone through Improved Livestock Health, Productivity and Marketing'. These TIPS which cover cattle, small ruminant, forage and poultry production will be incorporated into LBVD-FAO extension materials aimed at reaching their target of 177,000 livestock owning farmers engaged in their project activities.*			
		Participated in annual ACIAR Program Coordination workshops	Y1 Y2 Y3 Y4	Complete. October 2017
	6 project team members participated in the 2013 annual ACIAR Program Coordination workshop *7 project team members participated in the 2014 annual ACIAR program workshop. The project hosted the field visit to our research in the Meiktila township.* *10 project team members participated in the ACIAR annual meeting, December 2015.* *8 project team members participated in the ACIAR annual program meeting, October 2016.* *20 project team members, including farmers, CAHWs and students participated in the showcase at the final ACIAR meeting in October 2017.*			

7 Key results and discussion

7.1 Key results

Objective 1: Understand the technical constraints and opportunities for small-scale livestock development in the Central Dry Zone.

Village chicken

A total of 144 households owning village chicken across both project villages were surveyed. For approximately 52% of the farmers who owned village chickens in the two project villages, income from village chickens was considered to be the major income source (classified as very important and important) (Figure 1).

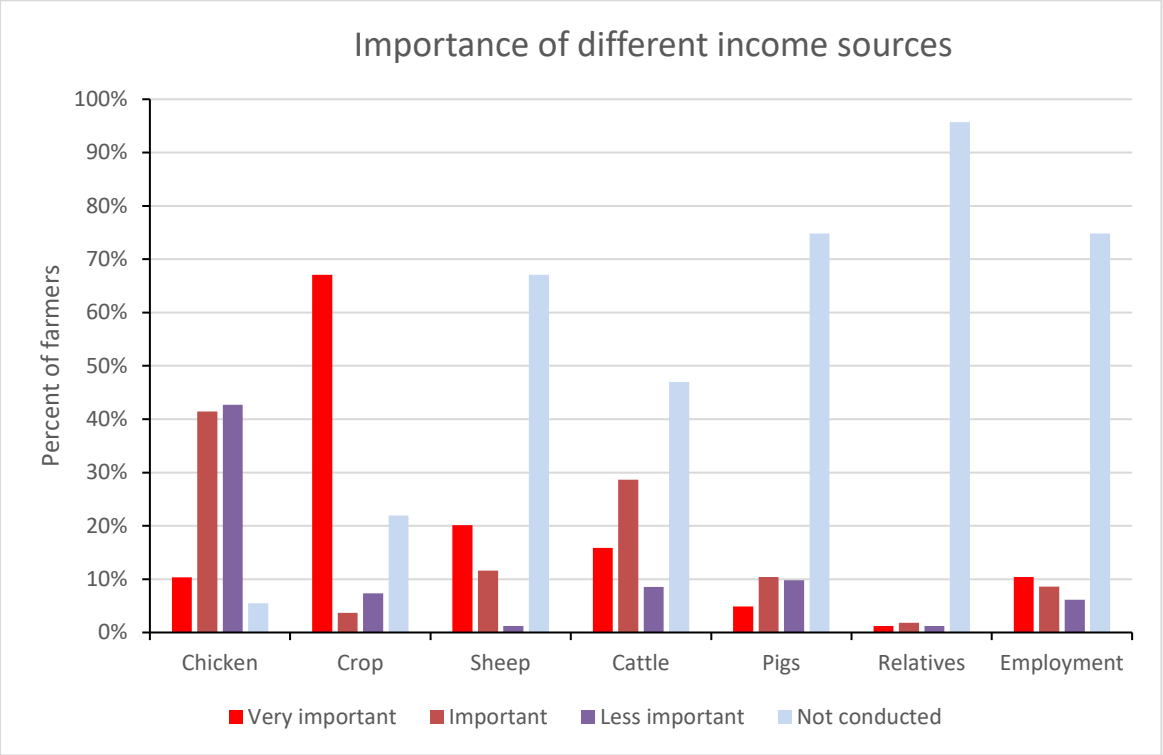

Figure 1 Major sources of income for farmers in the in the Central Dry Zone of Myanmar (N=144 village chicken flocks). Each HH that had one or more of the enterprises was surveyed for importance of enterprise.

The average village chicken flock size in the two project villages was 14 birds, with a median of 11 birds and a maximum of 54 birds kept within a flock. The mean number of birds sold per year was 9.6 (median 7.0), usually when they reached a grower age of 6-7 months. The mean sale price of birds was 4450 Kyat per viss (SD 494 Kyat; 1 viss=1.6kg) (Figure 2).

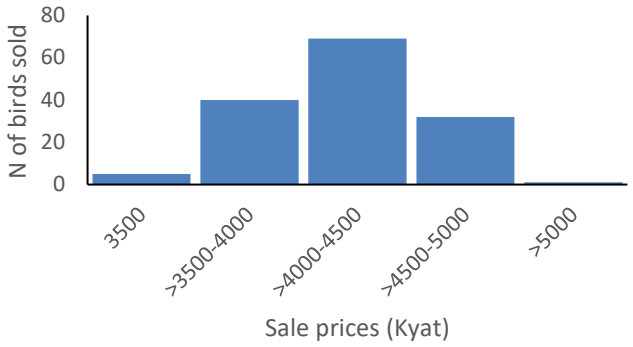

Figure 2 Sales prices of birds in the Central Dry Zone of Myanmar

In flocks without specific health interventions, mortalities were high in the first 6 weeks after hatching. In the CDZ, 57% of chicks died within the first 6 weeks and a further 11% died in the grower age and 5% as adults. Diseases were the major cause of death in all age groups (Table 3).

Table 3 Causes of deaths in village chickens in the Central Dry Zone of Myanmar (N=144 village chicken flocks)

Cause of death	Chicks	Growers	Adults
Disease	31%	49%	70%
Exposure to extreme weather	13%	29%	30%
Predation	27%	9%	0%
Other	27%	2%	0%
Theft	1%	7%	0%
Unknown	1%	4%	0%

Approximately 38% of farmers reported Newcastle (ND) outbreaks within the past 2 years and an additional 11% reported disease outbreaks, but were not sure if these outbreaks represented ND outbreaks. Of those farmers, who experienced ND outbreaks, 84% reported that ND occurs annually in their flocks. The majority of farmers reported ND outbreaks in April (37%) and in July (21%; Figure 3).The average mortality rate during ND outbreaks was 78% (95% CI 70% - 86%). Newcastle disease vaccination was not commonly conducted in the CDZ, none of the households surveyed in the CDZ had their birds vaccinated in the past.

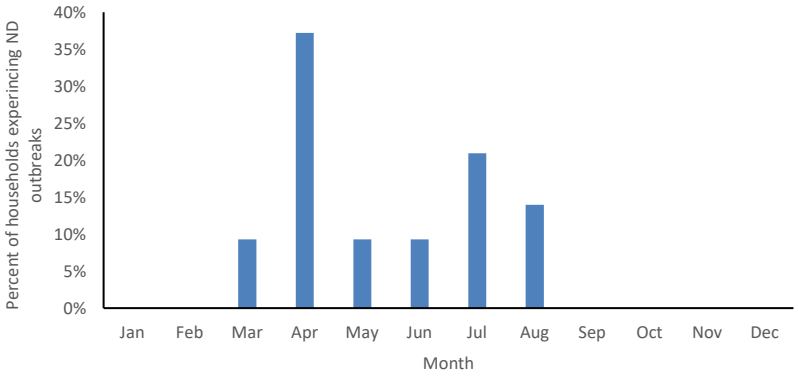

Figure 3 Seasonal pattern of Newcastle disease outbreaks in the in the Central Dry Zone of Myanmar

Based on the outcomes of this survey (and the focus group discussions), two major constraints to village chicken production were identified - high chick mortality and deaths from Newcastle disease. Full details are provided in Appendix 11.2.

Forages

Traditionally, farmers have grazed small ruminants on village common lands while using a combination of grazing and direct feeding for large ruminants. Feeding priority was given to the draught cattle that provide agricultural and transport capability. These animals were fed 'green chop' dual-purpose sorghum (used for forage and seed), native grasses and crop residues during the wet season and a mix of dried and chopped forage sorghum and crop residues during the dry season. While draught cattle are well fed, cows and calves are a lower priority subsisting on a sub-optimal diet provided through grazing communal lands and standing crop residues. In seasons of low or variable rainfall, late dry season feed gaps occurred across all classes of animal.

In both villages, stock classes that were grazed did so in uncultivated areas during the crop growing period, and in the cultivation areas once all crops had been harvested. Feed resources were greatest from December to January, as animals were moved to cultivation areas post-harvest, where crop residues and natural grasses and other feed have been accumulated ungrazed during the preceding months. Availability of grazing then declined sharply during the dry season to reach a low point from March–June. As sowing commenced in about May animals were moved to uncultivated grazing areas but there was little feed available until the start of the wet season when feed supply increased. As rains started to taper off in September–October, feed availability declined until animals were moved to the post-harvest cultivation area where there was more feed available at that time. Animal growth rates were expected to be very limited in the late dry / early wet season (March–June) and to a lesser extent in the late wet/ early dry season as feed diminished in the non-cultivation grazing areas.

Interviews with eight smallholder farmers in Ya Thar and Kyauk Aoe, managing agricultural production areas of between 2 and 15 ha (5.2 and 36 acres), showed that between 10 and 66% of an individual's cropping land was being used to maintain between 1 and 4 draught animals. At these levels of investment, only 3 of the 8 farms produced sufficient forage to meet optimal draught animal energy demand and only 2 to meet protein demand.

The CDZ experiences a tropical monsoonal climate with annual mean temperature range between the mid-twenties and mid-thirties (°C). Rainfall was concentrated in the summer months between May and October with annual rainfall ranging between ~600 and ~1200 mm (interpolated data- https://www.apsim.info/TheStack/The_Stack_Library.kml). While Ya Thar is generally considered to be the better endowed of the 2 CDZ research villages based on historical data, in fact Kyauk Aoe received more rainfall in 2 of the 3 years of engagement (Table 4).

Table 4 Monthly rainfall (mm) at the village of Ya Thar during the period of research from 2014 to 2017) showing the variable annual and seasonal rainfall during this period

Village	Year	Rainfall	
		Annual (mm)	July onwards (growing season) (mm)
Kyauk Aoe	2014	342	294
	2015	880	636
	2016	909	801
	2017	285	15 (until early July)
Ya Thar	2014	618	593
	2015	548	337
	2016	662	555
	2017	295	10 (until early July)

Full details are provided in Appendix 11.3 and 11.16.

Ruminants

A survey of households who participated in the longitudinal monitoring of cattle in Kyauk Aoe and Ya Thar villages found that the major source of income for these farmers was from cropping, particularly pigeon pea, whilst a large number of households in Kyauk Aoe also ha heavily relied on remittances (Figure 4, Figure 5).

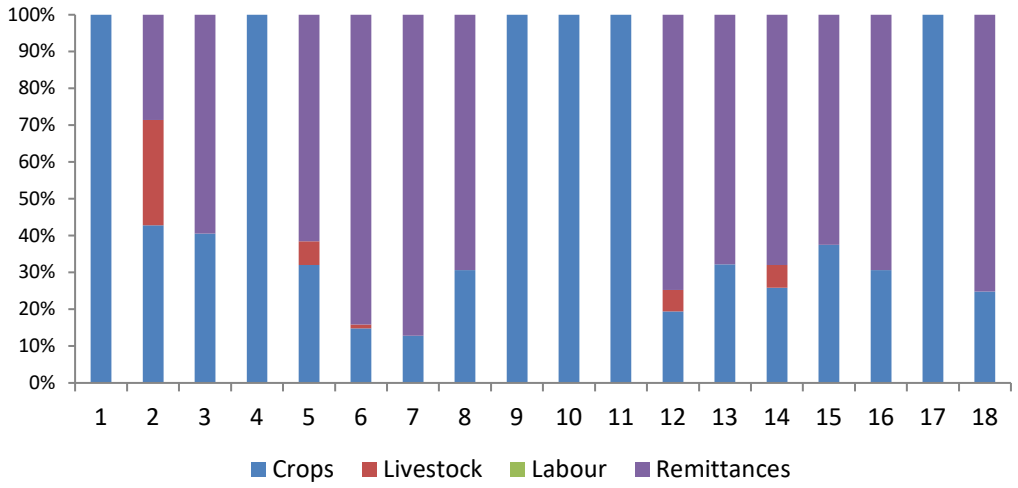

Figure 4 Proportion of individual enterprises contributing to the total household income in KA (Kyauk Aoe village, n= 18)

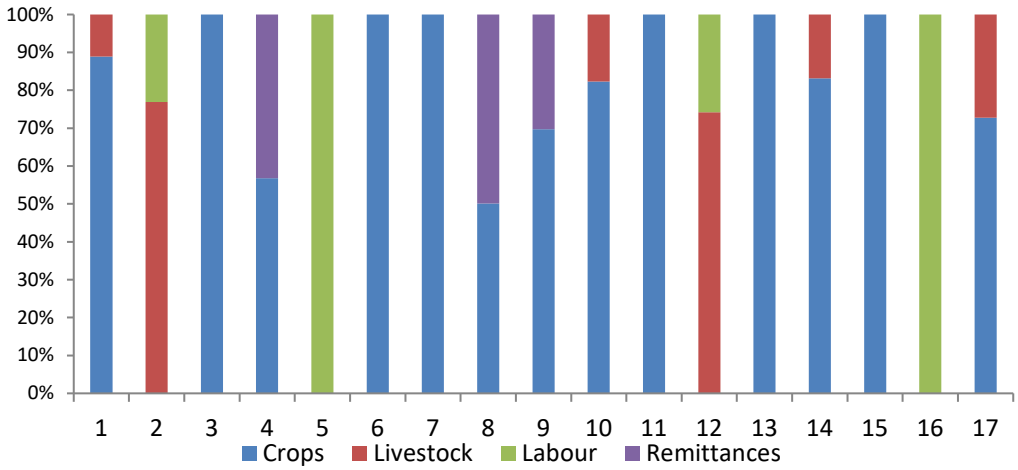

Figure 5 Proportion of individual enterprises contributing to the total household income in YT (Ya Thar village, n= 17)

In contrast, a survey from households who participated in the longitudinal monitoring of small ruminants in Kyauk Aoe and Ya Thar villages found that the major source of income for these farmers was from cropping in Kyauk Aoe, but the major source of income was from livestock (goats) in Ya Thar (Figure 6).

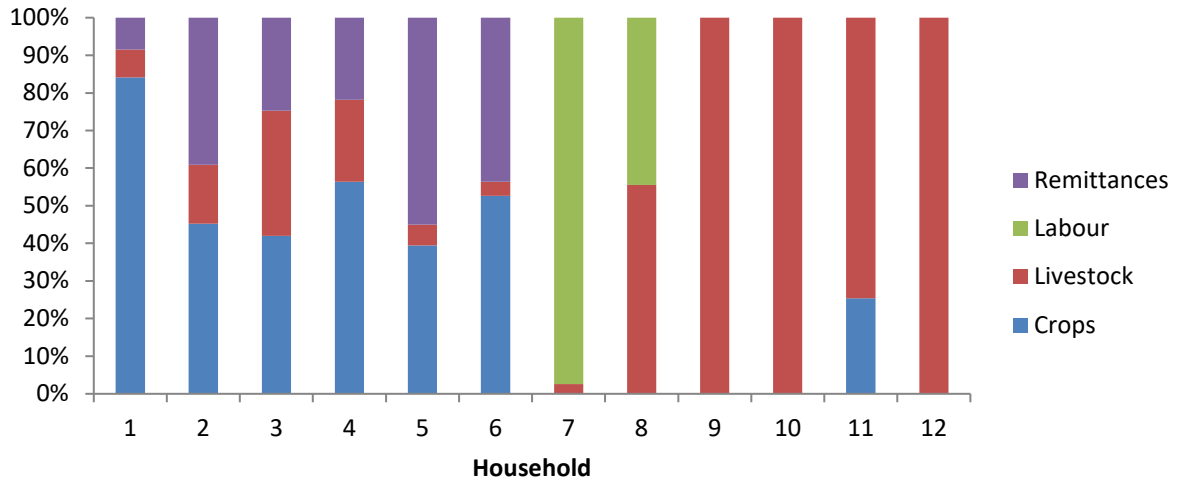

Figure 6 Proportion of individual enterprises contributing to the total household income in KA (Kyauk Aoe village, household n= 1-6) and YT (Ya Thar village, household n= 7-12)

The main reason for keeping cattle was reported to be for draught in both villages. Other reasons for keeping cattle were breeding, sale and other (which was specified as manure for fertiliser). Trading was not reported to be a reason for keeping cattle by any households. Milk was never consumed from cows owned by the household so it was assumed that cattle were not kept for milk production. The main reason for keeping small ruminants was for sale for meat, there were no reports of the fibre or milk being used.

The two villages differed in the proportion of women and youth (≤ 18 years) who were involved in the roles and responsibilities of keeping cattle. Women in Kyauk Aoe were involved in more of the decision making for cattle production, and youth were more involved in the feeding and grazing of cattle. In Kyauk Aoe, women accounted for 56% of the people making the selling and buying decisions, whereas in Ya Thar women accounted for 26% of the people making the selling and buying decisions for cattle. These differences are likely to have been influenced by the higher level of migration which has occurred from Kyauk Aoe compared to Ya Thar. In Kyauk Aoe there were more youth that contributed to the roles and responsibilities of cattle management, compared to Ya Thar. Additionally, there were more youth in Kyauk Aoe who reported that their primary occupation was farmer (14%). This suggests that a labour shortage resulting from migration has changed the roles and responsibilities of household members in keeping cattle.

Women played very prominent roles in keeping small ruminants in village households in the CDZ, usually being responsible for making more decisions about buying and selling, as compared to for cattle. In Kyauk Aoe, roles such as feeding and care at home, taking grazing and selling and buying decisions were shared relatively evenly between men and women (women accounted for 55-60% of the people carrying out the roles). In Ya Thar women performed more of the roles and responsibilities, and accounted for around 65-70% of the people carrying out the roles.

Feeding and management appeared to be different for cattle and small ruminants based on household surveys across the Meiktila and Myingian townships. Patterns of cattle grazing differed between seasons with 74% of cattle herds taken out for grazing in the wet season (June-October) and cool dry season (November-February), whereas only 62% of herds were taken out for grazing in the hot dry season (March-May). Providing concentrate feed to cattle was more common (>50% of households) during the hot dry season and then decreased (<50%) in the other seasons. No seasonal differences were observed for small ruminant grazing, with approximately 98% of small ruminant flocks taken out for grazing in all

seasons. Most cattle farmers used a bull from their own village or another village for breeding, whilst commonly there was no control of breeding for small ruminants. Full details are provided in TuTu Zaw Win et. al., 2018 (see section 10.2 Scientific Publications) and Appendix 11.7 and 11.10.

Objective 2: Develop and adapt improved animal production and health practices, linked to local and regional market value chains, for small ruminants, indigenous cattle and village chickens.

Village chicken

The intervention study was conducted over 12 months between November 2014 and December 2015 involving 100 households in Hpet Yin (92% of all village chicken households at the time) and 74 households in Kyauk Aoe (95% of all village chicken households at the time). The aim of improved chick management was to reduce the attrition rate of young chicks in the first 6 weeks after hatching. Coops were used to confine chicks up to 6 weeks. Creep feeders were used to provide chicks with starter feed under the coop from hatching up to 3 weeks and outside the coop from week 3 to week 6. Chick starter feed was supplied to chicks up to 6 weeks of age. Vaccination against Newcastle Disease (I-2 vaccine) was given four times per year in the months of January, April, July and October. Biosecurity measures were promoted including segregation measures (confinement, controlling contacts with other birds, introduction of healthy birds only), cleaning and decontamination measures (burying of dead birds). Additionally, the provision of water was recommended.

Newcastle disease vaccinations, protecting chicks from predation using bamboo coops and providing supplementary feed to chicks in creep feeders reduced mortality rates from 47% without the interventions to 14% during and after the interventions (174 households). The production effects of the interventions in the CDZ were used to conduct a cost–benefit analysis using a deterministic model to identify the net benefits for households adopting these interventions. The cumulative sum of the net difference of improved village chicken management compared to no interventions over the 3-year period was about 133,000 Kyat, or double the income when no interventions were used (Figure 7).

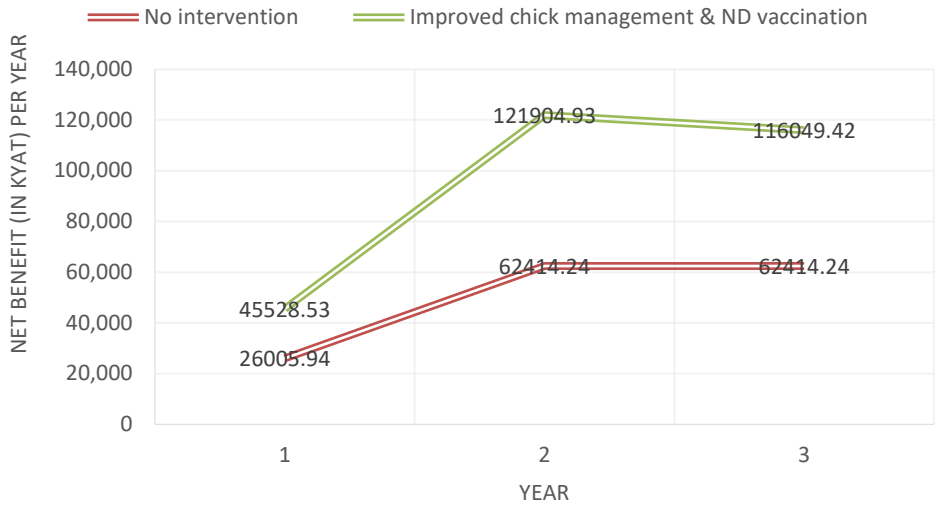

Figure 7 Net benefits from improved chick management and ND vaccination compared to no village chicken interventions over a 3-year period

A survey to describe farmers' behaviours and attitudes towards village chicken bio-security and disease prevention before and after the interventions found that an overwhelming

majority of farmers believed that after the interventions regular vaccination was the method of choice to prevent Newcastle disease. Farmers were more willing to overcome barriers of vaccination, such as catching birds to make them available for vaccination, and showed a willingness to pay for vaccination. However, farmers reduced their efforts in ensuring good biosecurity practices; they were less likely to inform veterinarians about dying birds or bury dead birds after the interventions. Full details are provided in Appendix 11.2.

Forages

Grass and legume evaluation trials

A range of tropical grasses and legumes were introduced to complement existing forage supplies. Three grass species, *Brachiaria spp.* (Cayman), *Brachiaria spp*. (Mulato II) and *Panicum maximum* (Mombasa) achieved yields between 15000 and 21000 kg ha^{-1} DM after establishment. This was around five times the yield of the traditionally grown, annual forage sorghum which produced 3000 kg ha^{-1} DM. *Gliricidia sepium* was the most successful browse legume species. While the time frame for the evaluation of the browse legumes was shorter than optimal, it is likely that these plants will only ever contribute a small but important source of protein for future animal production while pulse residues will continue to be the major feed resource, likely complemented by herbaceous legume species. *Lablab purpureus* was the most successful of this group of plants producing ~7500 kg ha^{-1} DM over 121 days after sowing (DAS).

Grasses

In 2014-15 the biomass yields of individual grasses varied between sites because of seasonal, soil and management differences, although the same species were in the top 10 producers at all three locations. The best performers were Brachiaria and Panicum species (Table 5).

Table 5 2014-15 biomass production (kg ha-1 DM) for the top 10 grasses at Yezin (UVS), Ya Thar and Kyauk Aoe (* indicates species selected for further evaluation)

Grasses	Yezin (UVS)	Kyauk Aoe	Ya Thar
	Seasonal biomass (kg ha^{-1} DM)		
**Brachiaria brizantha* (Toledo)	5721	1382	7018
Brachiaria decumbens (Basilisk)	6438	654	8708
Brachiaria hybrid (BRO2/1794)	2446	527	6724
**Brachiaria hybrid* (Cayman)	4645	1538	8419
**Brachiaria hybrid* (Mulato II)	5158	1930	7611
**Brachiaria ruziziensis* (Ruzi)	4468	2113	11315
P. max x P. infestum (Massai)	2475	1106	7835
**Panicum maximum* (Mombasa)	2557	1819	11490
**Panicum maximum* (Simuang)	2964	874	10195
Urochloa oligotricha (CPI47129)	-	225	3246

A sub-set of the 2014-15 grass species were selected for further evaluation in 2015-16 and 2016-17 at Ya Thar and Kyauk Aoe. Overall production for the 20 months of growth ranged between 18965 kg ha^{-1} DM for *B. ruziziensis* and 29381 kg ha^{-1} DM for *B. brizantha* in Ya Thar *(*Figure 8). At the end of the 2015-16 season, three species were selected for broader farmer demonstration and scaling out. Selection was somewhat pragmatic, while based primarily on yield it also accounted for farmer feeding preferences and the availability of seed on the international market. Those selected were *Brachiaria spp.* (Cayman), *Brachiaria spp*. (Mulato II) and *Panicum maximum* (Mombasa).

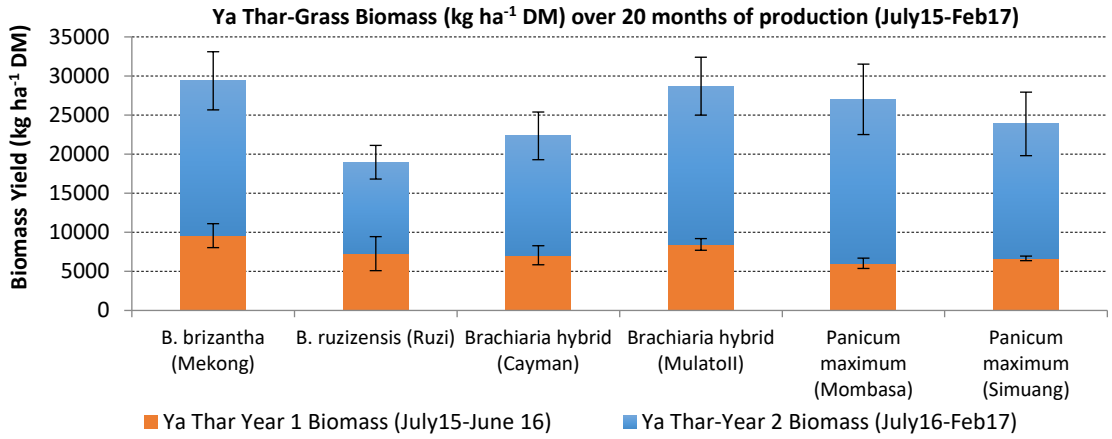

Figure 8 Grass biomass production (kg ha-1 DM) from 6 species at Ya Thar during the 2016-16 and 2016-17 seasons

Herbaceous legumes

Based on yield and on experience in other Asian countries, six herbaceous legume species were selected for further evaluation after the 2014-15 trial (Table 6). While the annual, *Lablab purpureus* did not perform well in these experiments, it was selected for further evaluation based on its international reputation for grazing and cut and carry and as a dual-purpose crop for animal and human consumption.

Table 6 2014-15 biomass production (kg ha-1 DM) for the top 10 herbaceous legumes at Yezin, Ya Thar and Kyauk Aoe (* indicates plants selected for further evaluation)

	Yezin (UVS)	Kyauk Aoe	Ya Thar
Herbaceous legumes	**Seasonal biomass (kg ha^{-1} DM)**		
**Centrosema brasilianum*	3074	933	3897
Centrosema molle	820	323	1870
**Clitoria ternatea*	685	2368	2426
**Desmanthus*	170	970	2592
**Lablab purpureus*	119	151	946
**Macroptilium bracteatum*	1084	1500	1626
Macrotyloma axillare	1232	129	726
Stylosanthes guianensis	2350	0	379
Stylosanthes hamata	1176	404	434
**Stylosanthes seabrana*	1095	38	1047

Productivity at both sites was impacted by heavy rainfall soon after establishment, as a result, the biomass production comparisons are difficult to interpret although they do show that some species were able to adapt to the environment and still produce usable quantities of biomass. Consequently, no further research was undertaken after the 2015-16 season.

Browse legumes

Four browse legume species were grown for evaluation at each of the three research sites. *Gliricidia sepium* was the most successful browse legume species producing ~7000 kg ha^{-1} DM (leaf) over 405 days at one location and 2000 kg ha^{-1} DM at the other. *Leucaena leucocephala* and *Sesbania grandiflora* produced in the order of 1000 kg ha^{-1} DM at both village locations over a similar period. *Leucaena leucocephala* (Tarramba) had the lowest production.

On farm trials

On-farm demonstration resulted in farmer adoption of the three grasses and three browse legumes but there was little farmer interest in the herbaceous legumes which were perceived to be a poor fit within the existing farming system. Fourteen small-holder farmers were growing 15100 m^2 (3.8 acres) of grasses and feeding to draught cattle and small ruminants in Ya Thar and Kyauk Aoe villages, while 75 established ~1200 browse legume seedlings on their own farms and around homesteads. Two commercial farmers established a total of 1.2 ha (3 acres) of grass and 400 browse legumes for seed increase and forage production.

Grasses

Three of the 2015-16 pioneer grass growing farmer groups undertook (with project support) to continue irrigation later into the 2016 dry season to ensure ample vegetative root stock for planting by new growers at the commencement of the following wet season. To provide market incentive, the grass supplier received US$0.30/10 planting stems. Seed was also made available to other farmers in June/July 2016. All participating farmers opted to grow grass under irrigation, arguing that they wished to feed fresh biomass during the dry season to complement supplies of dried and chopped forage sorghum. This required some farmers to invest in irrigation infrastructure, which in one case resulted in expenditure of >US$1000. Interviews conducted with producers in late 2016 and early 2017 showed that the grass had been harvested 5-6 times over the 2016-17 dry season and was mostly used to feed draught cattle, although some farmers also opted to feed cows and calves, either as a supplement to daily grazing, or as part of a feed ration (Dalgliesh and Thein, 2017).

Browse legumes

These were grown by a small number of farmers in 2015/16. Whilst uptake was disappointing, it was considered that this was more an artefact of poor extension than the potential of the plants. Improved communication prior to the 2016/17 season, and establishment of village seedling nurseries led to increased farmer interest. Fifteen hundred seedlings were grown and distributed to growers at the commencement of the wet season in June/July 2016. Fifty one farmers in Ya Thar and 24 in Kyauk Aoe planted >1000 seedlings. This included a number of landless small ruminant farmers who planted the trees around their own homes. Training and support was provided to farmers including the provision of bamboo exclusion cages to minimise goat depredation. While this initiative reduced grazing, the survival rate of trees across the 2 villages was still low at ~30%, with mortality continuing to result from animal grazing and from poor plant location and farmer management. Where the plants were well managed, they thrived. As there was a surplus of seedlings, ~100 were planted for demonstration along the entrance roads to the two villages and 50 provided to one particularly interested Kyauk Aoe farmer who invested in the exclusion cages and established trees around the boundaries of his fields. Full details are provided in Appendix 11.3 and 11.16.

A study on the nutritive value of local and introduced forages was conducted and published by Soe Min Thein et. al. 2017 (see section 10.2 Scientific Publications).

Ruminants

Ruminant production and health

Cattle

The median number of cattle owned in Kyauk Aoe was five, whilst in Ya Thar the median number of cattle owned was seven. Nearly all adult castrates were used for draught, whilst the majority of adult females were used for breeding. Castration was generally practiced in males intended for use as draught power at around two years of age. Weaning was not practiced and calves were naturally weaned from their mothers when the cow ceased to produce milk.

All adult cattle classes were heavier in Ya Thar compared to those in Kyauk Aoe, for example cows greater than 72 months (Ya Thar: mean 280 kg, Kyauk Aoe: mean 195.5 kg). Growth rates of calves and young animals were low (average of 0.3 kg/head/day between two to eight months of age). The average hip heights of different stock classes in Kyuak Aoe and Ya Thar are shown in (Table 7). Animals from all stock classes were taller in Ya Thar than Kyauk Aoe ($P < 0.01$ for all comparisons). Cattle continued to increase in hip height throughout the first few years of life, with animals more than 6 years old being taller than animals 2–6 years old of the same sex ($P < 0.01$).

Table 7 Average hip height (cm) of different classes of cattle in KA and YT (95% CI)

Village	Female		Male	
	2-6 years	6+ years	2-6 years	6+ years
KA (Kyauk Aoe)	110 (109–112)	117 (116–118)	112 (110–114)	119 (117–121)
YT (Ya Thar)	123 (122–124)	124 (122–125)	125 (123–126)	125 (124–127)

Undernutrition of cows was reflected in poor body condition scores (BCS; average BCS 2.0 on a 1-5 scale) and reproductive performance. The average BCS of adult cows varied between villages and years but ranged between 2.0 and 2.6 in the dry season (January–May) and 1.7–2.3 in the wet season (June–October). The largest proportion of cows gave birth from the early to mid-dry season (November to February). The age of first calving was an average of 31 months (Kyauk Aoe; SEM ± 0.2; n=2) and 34 months (Ya Thar; SEM ± 1.3, n=11). Reproductive efficiency as a measure of calf birth rate based on herd observations found that the average calf birth rate was one calf per cow every 2.7 years (Kyauk Aoe) and one calf per cow every 1.7 years (Ya Thar).

The mortality rate was low in the cattle stock classes monitored across both villages, with the highest mortality rate of 3.8% in young animals in Kyauk Aoe. There was a low number of health problems reported or observed throughout the syndromic health monitoring. The highest prevalence of a syndrome was ill-thrift in cows in Kyauk Aoe, which was reported to have a yearly prevalence of 12%.The perceptions of health problems by farmers from Kyauk Aoe, Ya Thar and four other villages found that 81% had experienced at least one problem with their cattle. Advice and treatment by government and private health services was provided most often for FMD, but there were also potentially important problems, such as exhaustion occurring.

There were relatively high strongyle worm egg counts (WECs) in cattle, despite the few signs of gastrointestinal parasitism. Strongyle eggs and oocysts occurred at all sampling times. Overall, 27–73% of cows had positive WECs at any sampling time. The top 25% of individual WECs were ≥100 epg at all times, except September–January in Ya Thar. Two preliminary larval cultures suggested the main species present were *Cooperia* and *Trichostrongylus*. Average calf WEC and seasonal pattern were similar to cows, with average WEC lowest in January. However, fewer calves were sampled and there were fewer statistically significant differences between months, compared to cows. In cattle generally, nematode burdens with WECs less than those seen here may reduce growth rates or body condition scores. Thus, parasitism may be contributing to poor calf growth rates and/or low cow BCS.

Blood samples were collected across 12 villages for a survey of blood-borne parasite infections in cattle, with 180 animals sampled in each of May and September, 2016. In May, 13% (95% CI 9–19%) of animals were anaemic (PCV < 0.24), with the proportion of anaemic animals differing significantly between villages. In September, 1% of animals were anaemic

(0–4%)) and there was no difference in the proportion of anaemic animals between villages (P = 0.16). On both sampling occasions, mean PCV differed significantly between villages (P < 0.01), although all within-village means were within the reference range for cattle (0.24–0.46; Jones and Allison, 2007).

For animals in May, based on blood film examination the overall prevalences of animals infected with *Anaplasma spp.* and *Babesia spp.* were 16% (95% CI 11–22%) and 6.7% (3.5–11%), respectively. No Theileria infections were detected. Infected animals had a lower mean PCV than uninfected animals. In September, the prevalences of Anaplasma and Babesia were 11% (95% CI 7-17%) and 2.2% (0.6-5.6%) of animals based on blood film examination, respectively. Again, no Theileria infections were detected. These figures were statistically similar to figures for May (P = 0.28 and 0.07 for Anaplasma and Babesia, respectively). Comparing infected and uninfected animals from the September sampling, there were no differences in the mean PCV (P = 0.44) or proportion with an abnormally low PCV (P = 0.995) between these two groups for either parasite.

In both May and September, there was no difference in the likelihood of animals being infected with either haemoparasite based on pregnancy or lactation status. Similarly, there was no association between the risk of being infected with either parasite and owners' reports of seeing ticks on cattle, or whether animals were principally fed at home, principally by grazing, or with a combination of both.

Blood samples collected in September were also assessed by PCR. Based on the PCR assay, 33% (26–41%) of animals were positive for Anaplasma and 17% (12–24%) were positive for Babesia or Theileria. The overall estimated prevalence of haemoparasites based on PCR was 43% (36–51%).

These results show that a significant proportion of village cattle were infected with haemoparasites in the 12 villages studied, with between 20% and 43% identified positive to *Anaplasma*, *Babesia* or *Theileria*, depending on the diagnostic test used. Between 2% and 13% of animals were anaemic, depending on when sampling occurred. The greatest prevalence of anaemia occurred at the end of the dry season in May, and anaemia was significantly associated with haemoparasite infection at this time.

The prevalence data from this pilot study needs to be interpreted cautiously and demonstrate the challenges of conducting this kind of field work. There was poor agreement between the results from blood smear examination and the PCR assay, although the discrepancies were similar to what often occurs with microscopic and PCR-based diagnoses (Eamens et al., 2013; Hailemariam et al., 2017). These may be due to operator error and experience, PCR-inhibition by blood factors, the greater analytical sensitivity of PCR, and sample collection, transport and storage conditions.

The variation in our results with diagnostic technique shows the challenges of collecting, storing and transporting samples in the difficult environmental conditions of the semi-arid tropics of Myanmar, and analysing paired samples in Australia. This could be an important topic to address in future field research in Myanmar, and would help improve the accuracy and validity of diagnosing haemoparasite infections in developing country scenarios.

Cattle experiments in Australia

In Australia, an experiment to investigate the effect of different growth paths manipulated by levels of supplementation during the first dry season for early and normally weaned heifers found heifers with only a urea supplement maintained weight whilst there was a linear response in terms of live weight gain to increasing supplement intake of the copra corn mix. Early weaned heifers grew at the same rate as normal weaned heifers but at the end of two years they were still lighter in weight. This affected time for puberty and pregnancy rate because of the lower live weight (Figure 9).

There was no effect of weaning weight on growth of the animals but as a high proportion of the lighter weaners had not yet reached target mating weight then lighter weaners had a much lower reproduction rate compared to normal weaning weight heifers. Growth rate in the first dry season could be increased by supplements of energy and protein but whether this is effective is an economic decision as supplements can be costly. Early weaning is possible in Myanmar and would be an effective strategy to reduce nutrient demand on the cow, provided calves are appropriately managed. These results give confidence that early weaning is not detrimental to the calf and that a simple urea supplement would suffice.

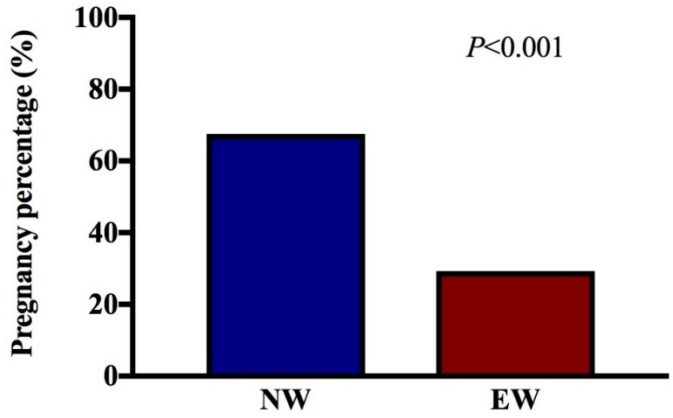

Figure 9 Pregnancy percentage of Early (EW) and Normally (NW) weaned Brahman heifers. Standard deviation of pregnancy percentage for NW and EW groups are 5.4 and 5.9 % respectively

The growth path of Brahman cross steers in northern Australia and the role of HGPs in weight and skeletal changes in these cattle were studied. Thirty-six (36) weaner *Bos indicus* steers approximately 180 kg liveweight were given a high quality pelleted diet and their liveweight and hip height monitored to maturity. Growth curves were fitted to the Brody growth equation. They were allocated into three groups; Control, C+Compudose-100 (E2) and C+Synovex Plus (TE2) where these are commercial hormonal growth implants.

At the start of the experiment, liveweight was 173 ± 1.4 kg (mean ± sem). The liveweight and hip height followed a curvilinear path to maturity (Table 8) and both were fitted to Brody equations.

Table 8 Liveweight gain and hip height gain of Brahman-cross steers that received sham implants (C), Compudose-100 (E2) or implanted with Synovex Plus (TE2) every 100 days during the experimental period

	Days				
	0-100	100-200	200-295	295-395	395-449
	Liveweight gain (kg/d)				
C	1.22^{aB}	1.08^{a}	0.80^{bA}	0.67^{b}	0.36^{c}
E2	1.47^{aA}	1.21^{b}	0.94^{cA}	0.72^{d}	0.29^{e}
TE2	1.58^{aA}	1.21^{b}	0.65^{cB}	0.70^{c}	0.40^{d}
	Hip height gain (mm/100 d)				
C	120^{a}	85^{b}	53^{cA}	30^{d}	47^{dA}
E2	130^{a}	87^{b}	57^{cA}	30^{d}	24^{dB}
TE2	125^{a}	86^{b}	37^{cB}	22^{d}	24^{dB}

Superscripts indicate means within rows (lowercase) and columns (uppercase) are significantly different at $P \leq 0.05$.

There was no difference in the early stages of growth in liveweight gain and hip height up to approximately 100 days of experiment or 300 kg in liveweight, but after that TE2 steers

approached mature hip height and liveweight at an earlier age and achieved lower estimated mature values and actual measured values at 19 months of age compared to C and E2 steers. Maximum hip height gain appeared to be approximately 120mm/100d in the early stages of the growth curve when liveweight gain was on average 1.4 kg/d for all treatment groups and this may be taken as a maximum hip height gain for this genotype of animals.

The approach adopted here for the control group could be applied to Myanmar cattle so as to better describe their growth and to be able to interpret measurements of liveweight gain and hip height gain in the field and to also characterise the unique genotype of Myanmar cattle which has not previously been described. Full details are provided in Appendix 11.4, 11.6 and 11.8.

Small ruminants

The median herd/flock size was 35 head, from which a median of 8 animals were sold annually. The average body condition score of adult does varies between villages and years but ranged between 1.2 and 1.8 in the hot, dry season (January–May) and 1.6–1.8 in the wet season (June–October). The largest proportion of animals gave birth from late wet to mid-dry season, so most growing kids and lambs experienced the nutritional limitations of the dry season at a young age. Kids only grow at between 8 and 80 g/day at this time, and only reached an average of 13–17 kg liveweight by six months of age. Overall, nutritional availability and management, of both breeding and growing animals, was poor under existing conditions.

Animals first gave birth at 14–16 months of age and the average time between births was 9–11 months. Births averaged 1.2–2.3 kids/doe and 1.1–1.6 lambs/ewe annually, varying significantly between sites and years. There was no control of breeding and only 14% of households use males from outside their own herds/flocks for breeding. Castration was very infrequently used, although there is anecdotal evidence that castrated animals are preferred by traders.

Young males and older cull animals were sold for meat at random times throughout the year. The long-term average price received for small ruminants was 46,000 Myanmar kyat (~USD34) per head, although decreases of 27–38% occurred throughout the last year of monitoring (Figure 10). Four of twelve collaborating households liquidated most or all of their herds/flocks in the last year of the study. These events were precipitated by various causes, but always followed a decrease in labour available for managing small ruminants (Figure 11).

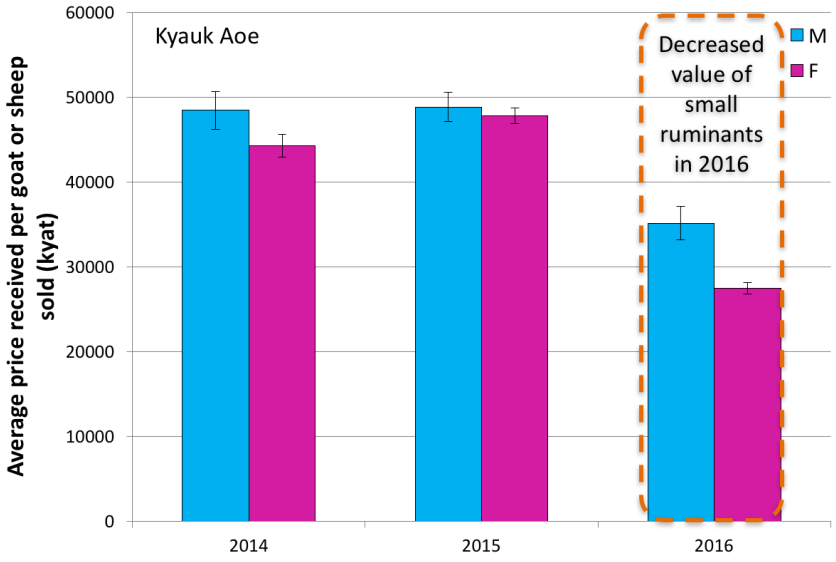

Figure 10 Average sale prices received for goats and sheep sold in study villages in first three years of study

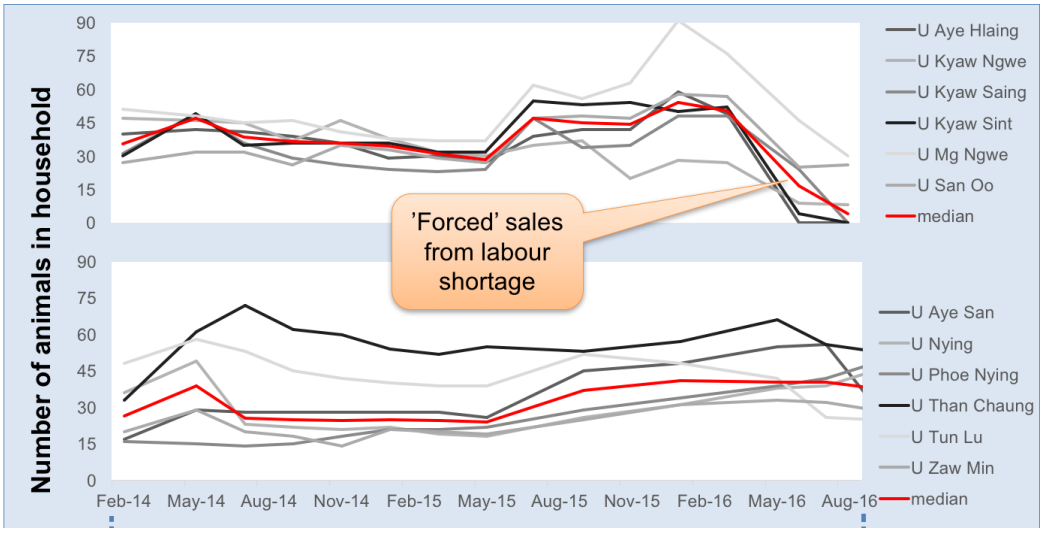

Figure 11 Small ruminant numbers in collaborating households

Syndromic monitoring identified peaks of 17–35% of animals affected by gastrointestinal conditions, illthrift and mortality, with young animals particularly affected. The annual mortality in young animals, those likely destined for sale was 15%, representing a drastic loss of potential production. This is greater than global averages (Devendra, 2013) and much larger than benchmarks for sustainable, productive small ruminant systems worldwide (Campbell, 2010). Overall, small ruminants less than one year old had nearly 10 times the risk of death of adults, and approximately four fifths of total mortality occurred in young animals. A large contribution of this was likely due to malnutrition and gastrointestinal parasitism. However, individual households also suffered severe losses in distinct outbreaks of suspected FMD, as well as a syndrome of severe nasal discharge, conjunctivitis and mortality that remains undiagnosed. On these occasions, up to 50% of a household's goat kids died, representing a devastating loss of household income. These outbreaks are relevant for other livestock species, as they suggest that small ruminants remain potential sources of FMD infection in cattle. This has implications for national control of FMD in Myanmar and access to regional markets.

Gastrointestinal parasitism was ubiquitous in small ruminants in the CDZ, with 92% of monitored animals positive on repeated faecal sampling. These infections likely contribute to sub-clinical poor production in many seasons and years, but more overt disease and mortality at other times. Strongyle faecal worm egg counts were frequently 300–500 eggs/gram, which likely affected growth rates and vigour, and coccidial oocyst counts were often much greater. Full details are provided in Hanks et. al. 2018 (see section 10.2 Scientific Publications) and Appendix 11.9.

Introduction of interventions

Cattle

The project implemented and monitored management strategies with smallholder farmers in the CDZ that specifically targeted survival and growth of young unweaned calves and weaning of calves during the dry season to increase reproductive outputs of cows.

In 2015, supplementary feeding of pre-weaned calves found that calves gained approximately 0.2 kg/day, or 20 kg and 13 kg liveweight respectively, over the 85 day supplementation period more than unsupplemented calves (Figure 12). There was no advantage in providing calves the higher level of feeding of 20g DM/kg liveweight/day compared with the 10g DM/kg liveweight/day level. Control calves demonstrated no

compensatory gain over the period of measurement in the wet season. Farmers indicated that the best result they observed from calf supplementation was the increased calf liveweight and most indicated they would implement calf supplementation in the future without project support, with some farmers indicating what feeds they planned to include in such rations (tree legume, pigeon pea husk, sesame cake).

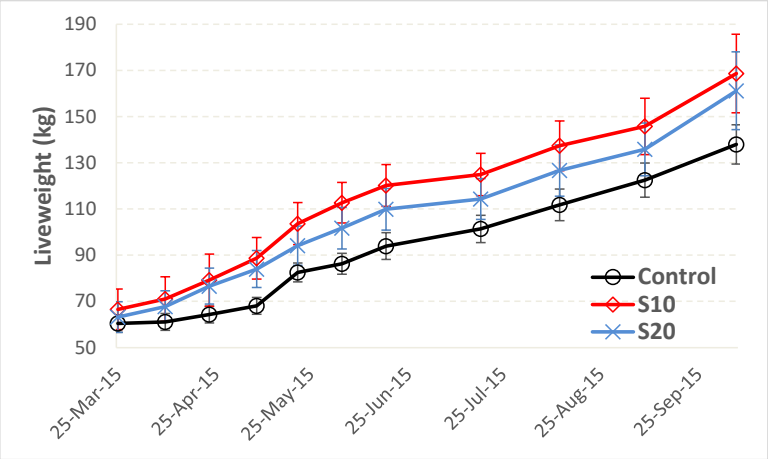

Figure 12 Change in liveweight of calves that received either no calf ration (control) or 10 (S10) or 20 (S20) g ration DM/kg LW.day during the dry season and no ration during the subsequent wet season

Calves were weaned by separating them from cows for a period of one month. The aim was to improve the reproductive output of cows. There was limited data available on the effect of this intervention given the time required to measure reproductive output of cows, and the challenges which were encountered in the implementation. Most calves were not completely separated from the cow and therefore continued to suckle (although at a reduced level). However despite these challenges the majority of farmers indicated they would implement weaning in the future without project support. Those farmers that would not wean again indicated they would feed the calf but not separate the calf from the cow. Full details are provided in Appendix 11.5.

Small ruminants

Preliminary trials of a single anthelmintic dose at strategic times, such as the early dry season, have improved growth in adult small ruminants by 0.9–1.7 kg for two months post-treatment, with reductions in WECs persisting for five months (Figure 13).

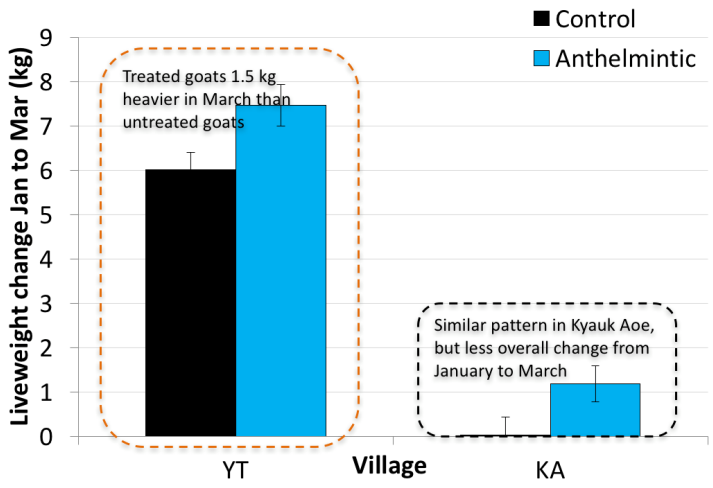

Figure 13 Effect of a single anthelmintic treatment in the early dry season on liveweight change of adult goats

A supplementary feeding system designed to deliver targeted nutrition to young kids and lambs within the household herd/flock was evaluated. It involved offering a supplement based on locally-available crop residues behind a bamboo 'creep' barrier that excluded access by animals older than about 6 months. Creep feeding produced very modest improvements in growth rate of young small ruminants of about 10 g/head/day, a 17% increase (Figure 14). Nonetheless, farmers perceived morbidity and mortality in young animals to decrease significantly, and traders preferentially sought to buy creep-fed animals from trial households. All farmers (6) in the initial trial indicated that creep feeding was simple to manage, and that they would continue to provide creep feed after the project finished. When creep feeding was extended to all small ruminant farmers in the villages (44) similar feedback was provided. A number of farmers adapted the recommendations of the project by offering feed when the adults were out grazing, rather than offering feed behind the barrier, which also appeared to be effective.

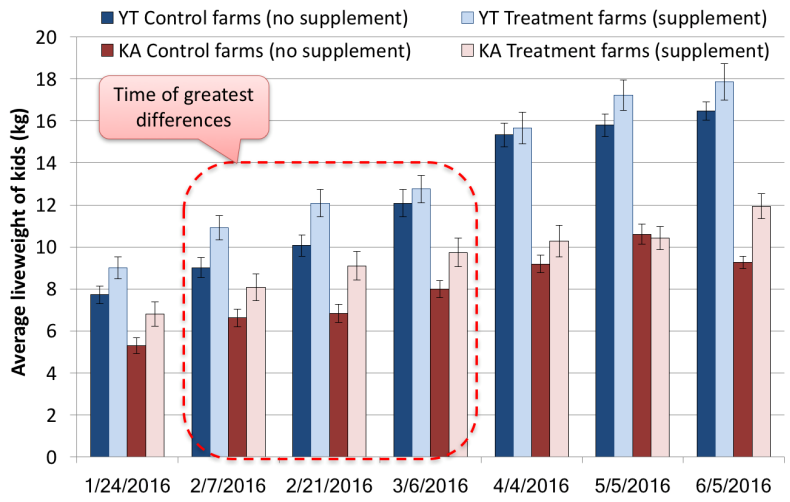

Figure 14 Effect of supplementary 'creep' feeding on liveweight of young goats and sheep

Objective 3: Strengthen the capacity of project partners and farmers to develop, evaluate and out-scale improved livestock technologies and practices for small-scale livestock producers.

The capacity of project partner and farmers was strengthened through postgraduate training, short term training, study tours, international conferences, and farmer trainings (Table 9). A key component of the postgraduate training included the Dahat Pan Masters Scholarship program. This involved the provision of an Australian co-supervisor, support in the design, implementation and analysis of field experiments, and financial support to students studying a Masters of Veterinary Science at the University of Veterinary Science. Additionally, three PhD students have been supported by the project and two Masters students at other institutions. There has been in total 29 post graduate students supported in their research by the project (Table 10).

Table 9 Capacity building activities carried out by the Dahat Pan project

Capacity category	Activity	Who / where	Female	Male	Total	Comments
Postgraduate training	Masters of Veterinary Science	LBVD & UVS staff	21	3	24	Topics include poultry, small ruminants, cattle, and forages
	John Allwright Fellowship, PhD	Tu Tu Zaw Win, Dezin Soe Lwin	2		2	UQ
	Doctor of Veterinary Science	Soe Min Thein		1	1	UVS
	Master of Science	Ei Thandar Ko	1		1	YAU
	Master of Veterinary Public Health Management	Jenny Hanks	1		1	USyd
Short term training	Staff training in animal handling, data collection, data management and Microsoft Excel	Junior scientists	2		2	On-the-job learning – these project staff live in the villages
	Cattle and small ruminant research training, Training in BCS, of cattle, goats and sheep and in the use, and rationale for using, electronic weigh scales for large and small ruminants.	LBVD, UVS project junior scientists, staff, CAHWs	10	10		Tanda Panjaitan,cattle production scientist from Indonesia + Australian scientists
	Establishment and evaluation of forages	LBVD, UVS, students & veterinary officers	15	10	25	Forage scientists, Thailand & Werner Stur, UQ
	Animal health disease syndrome monitoring training	Junior scientists, masters students, staff at UVS & LBVD & veterinary officers	21	12	33	1st Training from Angus Campbell and Elsa Glanville, UoM, 2nd training from Elsa Glanville
	Forage agronomy training focusing on harvest of trial evaluations	Junior scientists, masters students, staff at UVS & LBVD & veterinary officers	8	7	15	Forage scientists, Thailand

Capacity category	Activity	Who / where	Female	Male	Total	Comments
	Training course in I-2 vaccine production	LBVD staff from Yangon ,Pyin Oo Lwin, Taungyi, Mandalay	8	3	11	Mary Young, the Kyema Foundation
	Two survey design and interviewing techniques trainings	UVS masters students	23	3	26	1st training by Joerg Henning, UQ 2nd training by Elsa Glanville and Angus Campbell, UoM
	Data management training	UVS masters students, staff at UVS and LBVD, junior scientists	12	8	20	Elsa Glanville and Angus Campbell, UoM
	Livelihoods & Extension training on Participatory Rural Appraisal	YAU, UVS & and LBVD staff	4	2	6	ACIAR Livelihoods & Extension project
	Tree legume nursery training	Masters students, junior scientists & staff from UVS, CAHWs, LBVD	6	4	10	Ganda Nakamanee, Thailand forage expert
	Seminar of the biology behind the ruminant data	Master's students at UVS and junior scientists				Dennis Poppi, UQ
	Seminar on "Beef cattle production research in smallholder systems and northern Australia"	Master's students at UVS	60	10	70	Simon Quigley UQ,
	Seminar on "Seed harvest for forages"	Master's students at UVS	60	10	70	Ganda Nakamanee, Thailand forage expert
	Workshop on techniques for statistical analysis	Master's students at UVS	22	5	27	David McGill, CSU
	Seminar on " Forages for feeding cattle- systems in Timor Leste, Indonesia & Myanmar"	Master's students and staff UVS	15	3	18	Neal Dalgliesh, forage consultant

Capacity category	Activity	Who / where	Female	Male	Total	Comments
	Seminar on “Forage research in Thailand”	Master’s students and staff UVS	18	3	21	Ganda Nakamanee, Thailand forage expert
	UVS- ACIAR project research conference, project supported master’s students presented	UVS and YAU staff and students	30	13	43	
	Goat castration and creep training provided for the NGO; CESVI (Shae Tot program)	Attended by Shae Tot veterinarian, CAHWs, project staff	5	15	20	3 trainings provided by Elsa Glanville, Angus Campbell, Jenny Hanks (UoM)
	Workshop in poultry health and production	UVS and MLF			80	Two workshops provided by Bob Pym, UQ
	Workshop in Antimicrobial Resistance testing of poultry samples	UVS			15	Two workshops provided by Justine Gibson, UQ
	Goat trade and production research workshop in collaboration with FAO	FAO, LBVD, UVS, MLF, and traders			60	Angus Campbell, UoM
Study tour	Visit to ACIAR project LPS/2008/038: training in project management, feeding systems and scientific methodology	Indonesia	2	1	3	
	Study tour visit to forage research by the Department of Livestock Development, Thailand	junior scientists & one UVS staff member went to Thailand	3	0	3	Ganda Nakamanee, Thailand forage expert
	Seed production training in Thailand Training included skills development in seed testing and the growing and harvesting of grass seed.	Soe Min Thein (UVS) and Ei Thandar Ko (YAU)	1	1	2	Ganda Nakamanee, Thailand forage expert
	Study tour by Doctor of Veterinary Medicine students from UoM to Myanmar	UVS, Project sites	4	1	5	Angus Campbell, Elsa Glanville UoM, UoM students paired with UVS students to carry

Capacity category	Activity	Who / where	Female	Male	Total	Comments
						out surveys and sampling
	John Dillon Fellowship for research leadership	Aung Aung, UVS visit to Australia		1	1	
	Crawford Fund International Training Award for study visit to Australia focussed on livestock research management	Lwin Naing Oo, UVS visit to Australia		1	1	
Travel to International Conferences	16th AAAP Congress, Indonesia	Soe Min Thein, UVS,		1	1	Oral Presentation
	ISNH Congress in September 2014, Australia	Lwin Naing Oo, UVS		1	1	Oral Presentation
	International Grasslands Congress, India	Nang Kham Hline, Jue Jue	2		2	Poster presentation
	International Conference on Sustainable Animal Agriculture for Developing Countries, Thailand	Hnin Yu Wai, Wai Wai Min	2		2	Poster presentation
	International Sheep Veterinary Congress, England	Jenny Hanks, Elsa Glanville, Angus Campbell	2	1	3	Oral presentation
	TropAg Conference, Australia (November 2017)	Lwin Naing Oo, Dezin Soe Lwin, Hnin Moe Thu, Mo Mo Cho, Soe Pyar San, Jenny Hanks, Elsa Glanville	5	2	7	Poster presentation
Farmer training (this includes multiple trainings for each topic)	Training in various poultry diseases	Kyauk Aoe village, Hpet Yin village	63	78	141	
	Village chicken 'best practice' production	63 villages in Meiktila, 54 villages in Myingian			3,385	2131 farmers in Meiktila, 1254 farmers in Myingian

Capacity category	Activity	Who / where	Female	Male	Total	Comments
	Forage production	Kyauk Aoe village, Ya Thar village	22	21		
	Forage farm walks & community education	Natogyi farmers visited Myingian			115	
	Supplementary feeding goats	Kyauk Aoe village, Ya Thar village	22	21	43	
	Goat production	Kyauk Aoe village, Ya Thar village	13	4	17	
	Supplementary feeding & weaning cattle	Kyauk Aoe village, Ya Thar village	11	14	23	
	Field days	Kyauk Aoe village, Ya Thar village	120	80	200	200 people, including staff from the NGO: CESVI and farmers from 3-4 nearby villages
	Village chicken Masterchef competitions & field day	Kyauk Aoe village, Hpet Yin village			240	200 villagers from Hpet Yin, 40 villagers from Kyauk Aoe

Table 10 List of research titles of the 29 postgraduate students supported by the Dahat Pan project

	Student	Title
1	Thiri Zaw	Prevalence of gastro-intestinal parasites of ruminants in the Central Dry Zone
2	Aung Htet Myat	Effect of creep feeding in dry season on the growth performances of pre-weaned calves in Central Dry Zone of Myanmar
3	Shwe Sin Win	Effect of creep feeding during the dry season on liveweight, body condition score, haematological parameters of cows and milk consumption of calves
4	Ya Min	Effect of feed availability on body condition score, live weight, and kid born rate of does at dry zone area
5	Ei Mon Nyein	Effect of seasonal feed availability on body condition score, live weight and hip height of local cows at dry zone area in Myanmar
6	Hnin Yu Wai	Perceptions on biosecurity and disease in Taungtha, Mahlaing, Myingian and Mektila townships
7	Wai Wai Min	Constraints to village chicken production in Taungtha, Mahlaing, Myingian and Mektila townships
8	Nan Kham Hline	Evaluation on forage yield and chemical compositions of introduced forage grasses
9	Jue Jue	Selection of herbaceous legumes and nutritive values of selected varieties
10	Yu Nandar Aung	Comparison of the growth and production parameters in different indigenous chicken breeds

	Student	Title
11	Nay Chi Aye Aung	Effects of I_2 vaccine on haematological and antibody response to Newcastle disease in two strains of village chickens
12	Mya Hmu Mon	Parasite infections of indigenous village chickens
13	Khaing Thida Aung	Effects of cutting interval on yield, nutritive values of sorghum and two introduced grasses
14	Soe Pyae San	Effects of combination of urea, cattle manure and elements on yield and nutritive values of mombasa grass
15	Mo Mo Cho	Effects of creep feeding on live weight gain, coccidial oocyst counts and haematological parameters in goat kids
16	Hnin Moe Thu	Prevalence of tick-borne pathogens in cattle in Meiktila and Myingian Townships within The Central Dry Zone of Myanmar
17	Thinn Yadanar Soe	Comparison on the digestibility of introduced grasses, napier grass and sorghum through in vitro and in situ methods
18	Han Zin Maung	Comparative effects of two different creep feeds on the digestibility and growth performance of the pre-weaned calves
19	Yin Moe Aung	Effects of interaction between creep feed and anthelmintic on the haematological parameters, faecal egg counts and growth performance of pre-weaned calves
20	Khin Ngu Wah Htun	Comparison on the effects of two types of creep feeds on Haematological Parameters, Parasitic Oocyst Counts and Growth performance in Goat Kids
21	San San Win	Effect of fertilizer application on yield and nutritive values of sorghum and introduced grasses grown in dry season
22	Honey Wai	Antimicrobial susceptibility of non-beta-lactam antimicrobials for Escherichia coli in samples collected on integrated chicken-fish farms
23	Ei Mon Mon Wai	Antimicrobial susceptibility for Escherichia coli in samples collected from commercial broiler and layer farms
24	Shwe Sin May Lwin Oo	Antimicrobial susceptibility of beta-lactam antimicrobials for Escherichia coli in samples collected on integrated chicken-fish farms
25	Ei Thandar Ko	Comparison of Forage Crop Performance in Three Selective Grass Cultivars
26	Jenny Hanks	Longitudinal syndromic surveillance of small ruminant health in the Central Dry Zone of Myanmar
27	Tu Tu Zaw Win	Identification of constraints and opportunities for livestock production, health, biosecurity and marketing among multi-species, small-scale livestock producers in the Central Dry Zone of Myanmar
28	Dezin Soe Lwin	Nutritive value of tropical grasses as determined by plant morphology
29	Soe Min Thein	Comparison on performances between cattle fed on locally available forages and introduced forage in the dry zone area

Objective 4: Create pathways to sustainable impacts and the scaling out of technologies and practices.

Regional Learning Alliance and linkages with livestock projects

The Regional Learning Alliance was formed with livestock projects working in the CDZ, this included the following organisations; LIFT, CESVI, FAO, GRET, MFLF, Thadar Consortium, LBVD, and UVS. Four meetings were held and included discussion or training on the challenges and lessons learnt working in the livestock sector in the CDZ, gender considerations in managing and implementing livestock projects and training of CAHWs. Cross visits occurred in Yenan Chaung, Meiktila and Pokoku.

Close collaborations developed between the Dahat Pan project and other projects working with livestock farmers in the CDZ that participated in the project's Regional Learning

Alliance. Two active collaborators were the LBVD-FAO project UNJP/MYA/022/OPS *'Improving Farmer Livelihoods in the Dry Zone through Improved Livestock Health, Productivity and Marketing'* and the USAID project AID-486-11-00010 *Shae Thot 'The Way Forward'* being implemented by a consortium including the Italian NGO CESVI. FAO approached the Dahat Pan project to provide input to the development of Technical Implementation Packages (TIPs) covering cattle, small ruminant, forage and village chicken production. LBVD-FAO intend to use this information, through developing extension messages and adopting technologies outlined by the Dahat Pan project, with up to 177,000 livestock-rearing households engaged in their project activities.

Village chicken

A "village chicken extension package" that comprises of a variety of extension methods and tools was compiled. It provided a number of different educational tools that can be easily used by other organisation to conduct training of farmers on improved village chicken production. The extension package was comprised of the following items:

1. Flip charts with cartoons
2. Newcastle disease vaccination calendar
3. Key messages poster
4. Flyers with detailed instructions for improved village chicken rearing
5. Photo booklet highlighting the use of the village chicken interventions
6. Marionette play recording
7. Ethnodrama recording

Extension workshops were conducted in a total of 117 villages outside the project area, involving 3,385 village chicken farmers (Table 11). A total of 312 bags of village chicken starter feed were sold during the workshops.

Table 11 Overview on the extension work conducted on improved village chicken production

	Meikthila	Myingian
Number of villages in workshops on improved village chicken production were conducted	63	54
Number of village chicken farmers trained in improved village chicken production	2131	1254

Forages

The use of forages was actively promoted by UVS at farmer field days, institutional meetings and other forums. The Myanmar Livestock Federation has also been supportive of the Dahat Pan project and promoted the use of forages with its members. As a result of these initiatives, and farmer to farmer communication, there has been continuing scaling-out of grass and browse legume use. Grasses were grown in four CDZ townships, and browse legumes were grown in two townships. Natogyi Township is a good example of scaling-out from the initial demonstration sites. Eleven farmers from six villages approached UVS seeking Dahat Pan forage production information in February 2017 and subsequently commenced establishing 0.25 acres of grasses each, with the express purpose of feeding draught (11 farmers) and dairy cattle (two farmers with 13 head).

In collaboration with the project, two commercial farmers in Myingian and Taungtha townships established a total of 1.2 ha (3 acres) of grass to feed their own cattle and for seed/vegetative planting material production. At the Myingian site an irrigated area of ~8000 m^2 (2 acres) of *Brachiaria spp.* (Cayman), *Brachiaria spp.* (Mulato II) and *P. maximum* (Mombasa), was established in the early 2016 wet season. This site has provided a supply

of vegetative material used to scale-out grass production, provided excellent dry season grazing with the farmer purchasing seven head of cattle, and initiated seed production.

Ruminants

Both the LBVD-FAO and CESVI projects are using research outputs from the Dahat Pan small ruminant research that have been adapted into extension material. CESVI has already extended castration and creep feeding information to 641 households across the Shae Thot project. Both projects have also received technical training and direct research outputs for use in developing and implementing their own activities. CESVI collaborated with the Dahat Pan project to research uptake of castration and creep feeding by farmers at their project sites. Castration using a rubber ring caused minimal complications. The growth rate and mortality rate was similar for castrated and non-castrated goats. Farmers reported receiving higher prices for castrated goats. Research outputs from the Dahat Pan project are being used to benchmark new feeding strategies in the LBVD-FAO project, including production feeding young animals in specific fattening systems.

7.2 Discussion

Collaborative projects

In 2016 the ACIAR Myanmar program initiated competitive collaborative research grants across the five projects within the program to promote collaboration. There were four grants awarded, two of which included the Dahat Pan project collaborating with one of the other projects, each with the value of $50 000 AUD.

Seed increase capability

While seed increase capability in Myanmar was recognised by Dahat Pan as being an important issue, it was only after funding of the Collaborative Research Grant, C2015 299-*Developing capacity in forage seed increase and research in Myanmar*, in September 2016, that progress could be made. This short-term project which involves UVS, YAU and two projects from the ACIAR/DFAT Myanmar Program (SMCN/2011/047 and AH/2011/054) has provided the opportunity to increase the capability of researchers and commercial farmers in forage seed production.

Chicken Fish

The Collaborative Research Grant, C2016/015-*Undertake research on constraints and opportunities for integrated chicken-fish production in Myanmar,* involves UVS, LBVD, Department of Fisheries (DOF), and two projects from the ACIAR/ DFAT Myanmar Program (FIS/2011/052 and AH/2011/054). The objectives of this project were a) to assess the current practices (and economic benefits) of integrated chicken-fish farming to identify constraints and opportunities for this production system, b) to assess the current use of antimicrobial drugs in integrated chicken-fish farming systems and c) to build inter-sectorial capacity of national researchers and stimulate research collaboration with both, the private sector and Government's technical departments. A cross-sectional study using a CommCare App questionnaire was conducted between February and July 2017 on 301 chicken-fish farmers in the Ayeyarwady Delta to explore management practices (including antimicrobial use), constraints, opportunities and income generated from integrated chicken-fish farming. In addition, training in antimicrobial resistance testings was conducted at UVS in January and July 2017 by Dr Gibson from UQ. From all chicken-fish farms, faecal samples were collected, cultured at UVS for E.coli and E. coli isolates were tested for 12 key antimicrobials. The project will generate data that will advise on appropriate strategies to increase adoption rates of well-managed integrated chicken-fish farming.

Village chicken

Village chickens have a great potential for famers to increase their supplementary income. Village chicken are raised for multiple purposes (sales, consumption, donation, barter), and they require minimal input and investment when a new flock is set up. The interventions tested showed that substantial financial benefits will be achieved as mortality rates are reduced. Interventions were locally sourced and produced, and farmers progressively paid for them, ensuring sustainability of the interventions. Diets and equipment (coops, creep feeders) were sold to farmers through selected village sellers.

Flock sizes increased as mortalities reduced – a great benefit for the farmer. However, the scavenging feed resource is limited in a scavenging environment. Farmers requested help and support to further increase flock sizes. Semi-intensive village chicken production was established as an alternative.

Our results highlight that farmers who experienced the benefits of disease control interventions in village chickens (e.g. ND vaccinations) adopt riskier behaviours as they 'trusted' the effect of the interventions to protect their birds. Thus, disease control measures have to be accompanied and followed up with extension work to address the reduced effort of farmers to engage actively in preventive disease measures after experiencing the success of interventions.

Forages

Three grasses and three browse legumes have been identified as being suited to the CDZ climatic conditions and able to produce significant quantities of biomass for animal feeding. Importantly, farmers have also indicated their acceptance of these plants through their continuing support of research.

While the three grasses, *Brachiaria spp.* (Cayman), *Brachiaria spp.* (Mulato II) and *Panicum maximum* (Mombasa) were selected for scale-out, the reality is that the other species shortlisted in 2015-16, could just as easily have been selected, were the criteria based solely on the potential to produce biomass. However, with seed availability and farmer preference also important considerations, the decision was made to work with those selected. When compared to sorghum, the forage grasses hold a number of advantages to farmers, including perenniality and the ability to produce large quantities of biomass under rainfed conditions.

The initial research premise was for the grasses to be produced under rainfed conditions, with the majority of biomass produced during the wet season and stored as hay for dry season use when traditional feeds were in short supply and of low quality. The farmers however, had a different view. They saw that grass could be grown as a rainfed crop during the wet season, with biomass 'cut and carried' for immediate use and then production extended, using irrigation, into the dry season, with feed supply only limited by the availability of water. While it is interesting to see farmers using their initiative in the use of research results, it is also concerning that those farmers, without the ability to irrigate, now view grass production as beyond their reach. This is not the case and the issue needs to be addressed in future scaling-out, demonstrating the productive capacity of the grasses under rainfed conditions and their value in animal feeding.

Adverse seasonal condition impacted severely on herbaceous legumes evaluated at Ya Thar and Kyauk Aoe in 2015-16. Despite this, a number of well adapted species were identified which are also used in other tropical environments, although yields were lower and more variable than might have been anticipated. Of more immediate importance however, is that farmers have not seen the relevance of these plants to existing cropping systems. While herbaceous legumes, suitable for animal feeding are part of cropping systems in other countries (Nulik et al., 2013), there has to be demand or demonstration of the value of the introduction of these species to replace or complement existing plants. This demand has not

been identified by CDZ farmers, although future research should investigate the potential for alternative dual-purpose crops such as *Lablab purpureus* to complement the current production of butter bean.

Overall, the productivity of the browse legume species was disappointing. To some degree, this was an artefact of the short-term nature of the evaluation experiments. Trees take longer to establish than grasses and herbaceous legumes, putting them at a disadvantage in experiments of one-three seasons duration. While slow growth has been experienced in the experiments, mature leucaena trees of indeterminate age are present in both Ya Thar and Kyauk Aoe. This provides some optimism that the young trees will eventually contribute useful quantities of biomass to animal production, although it is unlikely that these plants will ever supply all animal protein requirements, with pulse residues continuing to be the most important protein source.

Ruminants

There is significant production potential for cattle in the CDZ of Myanmar. Currently, most farmers own small numbers of cattle, with the majority of adult males used for draught. Low reproductive rates and BCS suggest that the nutrition of breeding animals is poor; however, health, management and environment are also likely to be contributing factors. There is currently no market alignment to beef production, with the emphasis placed on breeding replacement draught cattle. Draught animals, in accordance with them being the main reason for keeping cattle, generally receive better nutritional management than cows. Whilst growing and breeding animals are an important productive unit in any cattle system, their value and potential may not currently be recognised in small holder systems in the CDZ.

The longitudinal observational studies and interventional trials to date have shown that small ruminant production by small farmers has great potential. Several significant issues have been identified, including mortality and illthrift of young animals, potential for greater and more reliable reproduction, sub-clinical and clinical effects of gastrointestinal parasites, and diseases including FMD and infectious abortion.

The productive potential of the cattle and small ruminant breeds currently used in the CDZ is unknown, even under optimal nutritional and reproductive management. When this information is viewed collectively, it is clear that, whilst modest production and reproductive efficiency is currently achieved with very few inputs, much could be done to achieve the full reproductive and biological potential of ruminants in Myanmar's small farming systems.

Trade/ market chains

The need for draught power in crop based farming systems in Myanmar is likely to change as mechanisation increases. Mechanisation, changes to government policy, increases in urbanisation and a growing middle class provide opportunities for Myanmar's beef industry to grow. Government policies currently prevent the slaughter of local cattle less than 16 years old in order to maintain a national herd of draught animals, but this is likely to change as the need for draught animals decreases. The Myanmar government currently restricts the export of live cattle, but high prices in neighbouring countries mean that there are large numbers of unofficial exports (Maclean, 2011). It is expected that relaxation of policies relating to slaughter age of animals will be accompanied by a change in policies allowing greater export of live cattle which small holders may be able to capitalise on. A market demand and market chain for beef is essential for small holders to benefit.

More information is needed to understand farmers' decisions to trade small ruminants, and updated value chain studies would identify opportunities for selling animals that are well-aligned with market specifications or can take advantage of emerging markets. There are few market signals to producers about preferred products or animal specifications, and

currently little is known about the major factors influencing product demand, costs and prices throughout the value chain.

Feeding ruminants

Farmers have an incredible challenge in feeding their ruminants. The situation can be improved with short and longer term options including:

a) Increasing feed availability through increased food and forage crop productivity/unit area.
b) The better use of communal land - currently these lands receive little attention in terms of improving forage productivity even though the majority of small and large ruminants rely on them for their nutrition.
c) Specialisation - this implies that farmers regard forages as another cash crop and more than just something to feed their own animals.
d) Increased mechanisation-the inevitable shift to mechanisation will eventually result in the scaling-down and phasing out of draught cattle. This will take some years but will free up the land currently dedicated to draught support, with opportunities for the reallocation of forage supply to other types and classes of animals.

Interventions

The series of interventions with cattle demonstrated that penning and supplementation of pre-weaned calves was an effective approach to engage smallholder cattle farmers in the CDZ of Myanmar. Farmers responded positively to the calf management strategy and indicated they would continue to implement beyond the project. However, calf supplementation is unlikely to provide any economic benefits to smallholder farmers in the absence of any evidence of high rates of calf mortality, the lack of a strong market demand for young animals and a non-existent backgrounding sector. Such a strategy is unlikely to be successfully adopted by smallholder farmers until financial returns can be demonstrated in practice which will require the development of a market for young cattle in Myanmar. Weaning calves was not successfully completed and is unlikely to be a good initial engagement strategy as farmers considered it stressful to cows and calves without immediately apparent benefits. However, weaning in all likelihood would improve the currently low reproductive outputs of cows, but there must be a demand for cows to produce more calves for farmers to benefit.

Despite an initial 100% uptake by all small ruminant owning households in the two project villages, this wide use of creep feeding has not persisted particularly well. Further research is needed to evaluate different, more cost-effective feed options suited to local areas, and also overcome other potential constraints to effective creep management, such as provision of water. These should be refined to obtain greater growth rate responses.

Preliminary trials of a single anthelmintic dose at strategic times, such as the early dry season, have improved growth in adult small ruminants which is valuable at a nutritionally limiting time of the year. Managing parasitism may help improve growth or cow reproductive efficiency, through improved condition score, and hence farmer incomes. A preliminary anthelmintic trial in calves was carried out in 2017 by a Masters student at UVS, with results of the effects on production and health available at the completion of her studies. More research is needed to identify efficient parasite management strategies and size of treatment effects in adult and young cattle and small ruminants.

Roles and responsibilities for keeping ruminants

Ruminants require a lot of labour for their husbandry and the division of labour and increased labour associated with intervention practices needs to be carefully evaluated. Women play very prominent roles in keeping small ruminants in village households in the CDZ, usually being the majority of attendees at farmer discussion groups during the project. However, in villages where labour migration is widespread, the impact of a relatively labour-

intensive activity such as small ruminant farming needs careful description and analysis. Changes to ruminant production can then be targeted to meet these peoples' specific needs, for the greatest and most equitable impact. Farm amalgamation and improved economies of scale which will flow through to the increasing use of mechanisation and less reliance on draught are also likely to influence labour availability.

8 Impacts

The project developed an impact pathway for its efforts and during the project review there was an acceptance of its principles.

8.1 Scientific impacts – now and in 5 years

Scientific impacts were in the form of new information gained from village monitoring and intervention activities, as well as experiments at the university campuses at Yezin (UVS and YAU). This knowledge documents ruminant production in a detailed, longitudinal study for the first time in Myanmar, the introduction of improved forage species and their performance in the CDZ, and extends the knowledge on village chicken production from the Yangon division to the CDZ.

To our knowledge, the monitoring of cattle and small ruminants in villages is the largest and most rigorous survey of smallholder ruminant production in Myanmar. Although this information has not yet been published, we intend to and it is expected that these results will contribute to development of ruminant production in Myanmar and significantly contribute to the direction of new ACIAR projects on cattle, forages and small ruminants. Collated data on village chicken production and health has provided useful information about current constraints and suggested that there are opportunities for semi-intensive village chicken production which would benefit small holder farmers.

Key research outcomes include:

- Evidence based information from longitudinal surveillance on animal production systems and limitations resulting from nutrition and disease
- Key diseases partly identified and their contribution to loss in production
- Identification of forages suitable to the CDZ with application also to the dairy industry
- Further demonstration of the efficacy of Newcastle disease vaccination and coops in reducing mortalities and improving income from village chicken

When fully documented, the publication of the process by which the project sites were selected based on a good understanding of the livestock systems and statistically-justified methods to arrive at farmer and village numbers will have an impact on the execution of future R&D livestock projects in smallholder systems. The core results for the project on the application of fairly well-described interventions (such as creep feeding, castration and new forage varieties) in smallholder systems adds to the pool of knowledge on the successes and failures of their implementation.

The research outputs of the project have been provided to the relevant stakeholders to strengthen the scientific impacts that the project has made and the projected impacts that it will continue to make. Research results were compiled to formulate technical implementation procedures (TIPs) which were requested by the LBVD-FAO project UNJP/MYA/022/OPS *'Improving Farmer Livelihoods in the Dry Zone through Improved Livestock Health, Productivity and Marketing'.* These TIPS which cover cattle, small ruminant, forage and poultry production will be incorporated into LBVD-FAO extension materials aimed at reaching the target of 177,000 livestock owning farmers engaged in their project activities.

Research outputs from the project have also been provided to the UVS and YAU. A forage seed production manual, "Producing tropical forage seed in Myanmar", is now used by YAU and UVS as the basis of new course materials being developed for undergraduate students. Research outputs have also been developed into extension materials used by the project in scaling out activities, resulting in farmers receiving sound information. Economic modelling of the village chicken interventions provides good information to farmers and researchers

that incomes from village chicken production can be doubled using the recommended interventions.

The contribution the project has made to develop the scientific capabilities of partner organisations has been as significant as the research results the project has produced. Postgraduate students have developed skills in field research design and implementation, and data analysis. This has created a cohort of 28 Myanmar postgraduate students who have enormous potential to contribute to the future direction of livestock research in Myanmar. The support the project has provided not only resulted in personal skills development and experience for the students but also contributed to the overall knowledge of livestock production in Myanmar. Postgraduate research projects have covered the following areas of research (one student has not commenced her research yet):

- 8 students studying village chicken production and the health belief model
- 11 students studying ruminant production and health
- 8 students studying forage production and feeding management
- 1 student studying market chains and patterns of disease spread

In Myanmar there are already signs that the project is having impact on the capacity of LBVD and university staff to conduct well-designed, implemented and analysed field experiments and we would anticipate this would have a long-term effect on the quality of agricultural science in the country and the ability of Myanmar scientists to participate in national, regional and international exchanges that depend on sound science.

8.2 Capacity impacts – now and in 5 years

Capacity of individuals

Collaborating organisations

Capacity has been developed within the collaborating organisations, with farmers and with key stakeholders, such as NGOs. This includes staff and students of UVS, LBVD and YAU, village-based junior scientists tasked with managing the field research program, and Community Animal Health Workers (CAHWs).

The project has increased knowledge and skills of researchers at LBVD, UVS and latterly YAU with the most tangible evidence being the number and quality of master's students who have graduated or about to graduate from UVS. Most are young professionals from LBVD and it is impossible not to conclude that this would have an impact on both individual and institutional capacity through their participation in the project and the training elements. A key component of that capacity has been to design, implement and analyse trials conducted in the communities where the results may be applied, and not solely in a university facility.

There were three PhD students supported by the project; two received the John Allwright Fellowship (JAF) scholarship to study at UQ, and one completed his PhD based at UVS. There were a total of 24 Master of Veterinary Science students who were supported throughout their research thesis at UVS. Seventeen master's students have completed their field experiments and received their degree. A further seven master's students will complete their studies in 2018. In addition to Master's students enrolled at UVS, there has been one student complete her studies from the University of Sydney, and one current student studying at YAU. The capacity developed during the guidance of the project is already evident. Two of the 2015 graduates of this program are employed by UVS as demonstrators and had responsibilities for aspects of the village-based research managed forage program. The PhD student from UVS employed as a lecturer had responsibility for the village-based forage program and seed increase program. One of the Master's students employed by LBVD has been seconded to the LBVD-FAO project.

Gender equity was an underpinning principle of the Project. Jenny Hanks and Elsa Glanville (UM), Di Mayberry (CSIRO) and Fran Cowley (UNE), are members of a group of young female scientists with significant experience and ambitions in international agriculture for development and who have contributed to this Project. An outlet for sharing their experiences has been the RAID network to which Jenny Hanks has contributed a number of blog posts (http://www.raidaustralia.net). Karen Harper was responsible for UQ financial management and expertise gained in the project positioned her to become the project manager of a large ACIAR project in Indonesia. The Project field officers and the majority of master's students are women.

Staff of UVS, YAU, LBVD, the village based junior scientists tasked with managing the field research program and the CAHWS now have skills and knowledge in village chicken, ruminant and forage production with around 24 short-term trainings held (Table 9). An example was the training of two researchers from YAU and UVS in seed production. In November 2016, staff members from UVS (Soe Min Thein) and YAU (Ei Thandar Ko) undertook seed production training in Thailand with the Dahat Pan consultant, Ganda Nakamanee. Training, over two weeks, included skills development in seed testing and the growing and harvesting of grass seed. Their new skills have since been put to the test, working with two commercial farmers interested in seed increase, providing advice to farmers on forage production including those in Ya Thar and Kyauk Aoe and in Natogyi Township and undertaking forage related experiments at YAU and on-farm.

In addition to short term trainings, opportunities to attend study tours and international conferences have been created for staff and students of the partner organisations in Myanmar. A total of six study tours were attended by Myanmar researchers; including opportunities for senior UVS researchers to further develop their research management and leadership skills through the Crawford Fund International Training Award, and the John Dillon Fellowship for research leadership. There were six international conferences attended by staff and students of the partner organisations, and this included 11 students who presented their research. For many this was their first time overseas and an invaluable opportunity for exposure to the international scientific community.

Farmers

Mentor or model farmers and CAHWS now have the skills to support longer-term village chicken, ruminant and forage production. For example in 2015/16 a small number of farmers from the CDZ villages of Kyauk Aoe and Ya Thar trialled the growing of grasses and legumes for animal feeding. In the following season, these demonstrations, supported by the technical expertise of the Dahat Pan project had increased to 89 farmers, a result of the positive outcomes of the initial demonstrations and continuing training and mentoring of farmers and extension staff. While not all of the farmers will continue to grow the introduced forages, it is expected that there will be sufficient interest to ensure longer-term forage production in each village, supported by experienced farmer mentors.

Farmer education through groups is widely known as an effective way to scale out improved technologies, because farmers learn best from fellow farmers. Therefore farmers with positive experiences were involved in workshops and field days held by the project. Regular meetings were held with the interest groups for the livestock species in each project village to receive information on current production and health, and to provide training. Numerous techniques were used to effectively engage with farmers and deliver information, including videos, puppet plays, billboards, flyers, booklets, flipcharts, and calendars.

Key Stakeholders

Close collaborations developed between the Dahat Pan project and other projects working with livestock farmers in the CDZ that are participating in the project's Regional Learning Alliance. Two active collaborators were the LBVD-FAO project UNJP/MYA/022/OPS

'Improving Farmer Livelihoods in the Dry Zone through Improved Livestock Health, Productivity and Marketing' and the USAID project AID-486-11-00010 *Shae Thot 'The Way Forward'* being implemented by a consortium including the Italian NGO CESVI. CESVI has already extended castration and creep feeding information to 641 households across the Shae Thot project. Both projects have also received technical training and direct research outputs for use in developing and implementing their own activities. In particular, three training workshops were delivered to CESVI to enable collaborative research of the uptake of castration and creep feeding by farmers at their project sites. They also attended the farmer field days held by the project and the project final meeting.

Infrastructure and institution capacity

Post graduate training has had an impact on both individual and institutional capacity through the participation of students in the project and the training they have received in field research. The majority of the students were young women (25/29). The long term impact for institutions is that there are now well trained women of large numbers to move into senior roles. Through the process of co-supervision between Australian and Myanmar researchers the post-graduate supervision provided by UVS has improved. New information has also been gained by supervisors which are highly applicable to future students.

Funding to support linkages between projects within the ACIAR Myanmar Program has enabled UVS and YAU to collaborate in seed production research, initiating linkages between the two universities. Collaborative activity was aimed at improving the teaching materials available to lecturers on forage production with longer-term benefits to student skills expected. This included the use of the forage seed production manual, "Producing tropical forage seed in Myanmar", as the basis of new course materials being developed for undergraduate students. Similarly the same funding source was used to develop linkages between UVS, LBVD, World Fish and the Department of Fisheries (DoF) to examine chicken-fish integrated systems and anti-microbial resistance.

The project has developed infrastructure at collaborating institutions to support future research and training. Forage production research facilities have been established and expanded at UVS and YAU, including installation of irrigation at the UVS site. Herbaceous legumes are being grown for seed production using weed mat for the first time in Myanmar. Small, but significant quantities of legume seed were collected in late 2016 and larger plantings in 2017 are expected to contribute to supplies. This is important work as it provides a reserve of viable seed for undergraduate forage training and for future research and extension activity in Myanmar. UVS has identified an opportunity for *Stylosanthes guianensis* to be used for common land grazing in the CDZ and anticipate that it will be used in UVS extension work and potentially in future ACIAR animal production projects. Equipment, such as microscopes were provided to the LBVD parasitology laboratory based in Mandalay to facilitate the processing of samples for worm egg counts (WECs) for the project, additionally this has provided a resource to improve the throughput of routine samples examined by LBVD. Equipment was also supplied to LBVD to improve the monitoring of temperature during production and transportation of the I-2 vaccine.

8.3 Community impacts – now and in 5 years

This was primarily a research project to investigate the production and health of village chicken and ruminants, and work with farmers to trial ways to improve production. Longitudinal monitoring occurred in the villages and the focus was on creating good quality data, rather than extension. However, significant efforts were made for impacts to occur beyond the immediate sphere of the project and some of these are listed below. Principally this involved engagement with the next users of the project, these were identified early in the project and the relationship was strengthened as the project increasingly had research

results to share. The focus was on the formation of a Regional Learning Alliance which facilitated sharing information across the projects working with livestock in the CDZ. An example was the interaction with the Thai NGO, Mae Fah Luang which involved a field visit to see the work they have done using a goat bank model and growing Ruzi grass. There are bound to be diffuse benefits of increased awareness of interventions and possible uptake and impact that have and will occur, but cannot easily be traced back to the project. Additionally the formation of the Regional Learning Alliance led to closer collaboration with two projects in particular.

The project collaborated with the LBVD-FAO project which is training extension workers throughout the CDZ. Much of the material developed by the project for ruminants (small ruminants and cattle), forages and village chicken production was further developed for the LBVD-FAO project as TIPS material. Aspects of these TIPS will be incorporated into LBVD-FAO extension materials aimed at reaching their target of 177,000 livestock owning farmers across six townships engaged in their project activities. Research outputs from the Dahat Pan project are being used to benchmark new feeding strategies in the LBVD-FAO project, including production feeding young small ruminants in specific fattening systems.

Collaboration with the USAID project AID-486-11-00010 *Shae Thot 'The Way Forward'* being implemented by a consortium including the Italian NGO CESVI has also been a significant way for the project to contribute to community impacts. CESVI has already extended castration and creep feeding information provided by the Dahat Pan project to 641 households with goats across the Shae Thot project.

8.3.1 Economic impacts

The production effects of the village chicken interventions in the CDZ were used to conduct a cost–benefit analysis to identify the net benefits for households adopting these interventions. The cumulative sum of the net difference of improved village chicken management compared to no interventions over a 3-year period was about 133,000 Kyat (double the income). Over a 10-year period the village chicken interventions were analysed to be highly profitable with a Net Present Value of about 302,000 Kyat, compared to no interventions.

Promoted village chicken interventions are becoming self-sustainable, with farmers recognizing additional income generated from improved village chicken production and purchasing promoted intervention equipment at market prices. Additionally, with increased chicken numbers now occurring, farmers are asking about semi-intensive systems which would further increase production.

The intervention equipment and starter feed was sold to village chicken farmers within the project villages through designated sellers. Sellers included shop owners or the village head men or leaders of village chicken interest groups, who received a small profit or incentive from the sale of intervention equipment and starter feed. These sellers had to work closely with the supplier of the chick starter feed and the weaver producing the coops and creep feeders. Therefore a supply chain for intervention equipment and starter feed was established in the project villages. Approximately 200 farmers purchased extension equipment and starter feed.

There have been market incentives for grass suppliers, who received US$0.30/10 planting stems of transplanting materials. Farmers have invested in irrigation to grow grass forages. This required some farmers to invest in irrigation infrastructure, which in one case resulted in expenditure of >US$1000. At least one farmer invested in exclusion cages to protect tree legumes. Two commercial farmers at various stages of establishment intend to produce seed in 2017/ 2018 with potential for distribution to farmers.

Goats have started to be castrated in Ya Thar village using project equipment, and also in multiple villages around Kyauk Aoe village. Approximately 150 animals have been castrated by one of the CAHWs assisting Dahat Pan, U Nyo, in 4 villages in Meiktila township.

- U Nyo started buying young animals to castrate, fatten and on-sell, making 100% return on investment for the first 30 animals he purchased (30,000 Myanmar Kyat gross margin per head)
- About 75 animals have been castrated in Ya Thar, some by traders who requested the animals be sold to them. Prices for castrates are currently twice that of entire males. There is a developing demand for castrated goats.

Some farmers who provided supplementary feeding to their calves reported an increased price received, up to 50% more than the price that they otherwise expected to receive. However, long term impact for cattle will not occur unless the policy changes regarding the sale of cattle. Information generated by the project can contribute to economic evaluation of policy proposals so as to make sound decisions.

8.3.2 Social impacts

Farmers adopted and adapted project interventions to an increasing degree throughout the project:

- Newcastle disease vaccinations, protecting chicks from predation using bamboo coops and providing supplementary feed to chicks in creep feeders was tested by 174 farmers.
- Grasses were grown in four CDZ townships, two of which commenced in 2016-17. There were 14 growers in Ya Thar and Kyauk Aoe who planted 15100m^2 (3.8 acres), and it is anticipated that this will increase over time. In mid-2017, 10 farmers from the Natogyi township established 1000 m^2 (0.25 acres) of grass for the feeding of draught and dairy cattle. Browse legumes were grown in two townships with seven farmers establishing 300 plants with support and advice from UVS, in addition to the 51 farmers in Ya Thar and 24 farmers in Kyauk Aoe who planted more than 1000 seedlings. Two commercial farmers established a total of 1.2 ha (3 acres) of grass and 400 browse legumes for seed increase and forage production.
- All farmers (44) owning goats and sheep in the two villages provided supplementary feed, improving survival and growth of young goats and sheep. Additionally farmers strategically drenched their sheep and goats for worms.
- Sixty two (62) farmers evaluated supplementary feeding of young cattle, some of whom additionally experimented with weaning calves.

The project has supported model farmers to provide training to other farmers in the project villages and in other township villages during extension workshops. Key model or leader farmers now have the skills and knowledge to continue using the interventions and sharing their experiences with other farmers within their village and in neighbouring villages. This was facilitated by the project as farmers were encouraged to share their own experiences with fellow farmers and mentor other farmers in village chicken and forage production, and it is hoped this will continue after the project concludes. CAHWs who are also pivotal to the continued use of interventions in the project villages received extensive training and participated actively in the interventions; not only promoting their use within the village but also using the techniques on their own farms.

The beneficiaries of livestock production, particularly village chicken and small ruminants are often women. The majority of chicken farmers are women and income from this source directly affects women and youth, the high percentage of women who attended meetings on village chicken and small ruminant production was indicative of this. Small ruminants are mostly owned by landless farmers. The dynamics of these families are undergoing change because younger members are working away from villages and labour is becoming scarce.

At this stage there is no evidence for marked changes in the division of labour as a consequence of the interventions. Perhaps of more significance was the high degree of migration of young people and men to jobs away from Kyauk Aoe village with better opportunity for remittance money to the family unit. Machinery is rapidly replacing draught animals. This means that more land is available for cropping or raising cattle and small ruminants, and the decision as to which enterprise to develop will have a major impact on income and labour requirements by each family member.

8.3.3 Environmental impacts

No negative environmental impacts have been recorded by the project to date. There were no adverse environmental impacts from improved village chicken production as additional birds surviving were sold and not used to increase flock sizes (which could have detrimental effects on the scavenging feed resource base in the environment). However there was interest from farmers to increase their flock size, but in this case a semi-intensive system with a fully enclosed cage would be recommended.

UVS have identified an opportunity for *Stylosanthes guianensis* (an herbaceous legume) to be used for common land grazing in the CDZ and anticipate that it will be used in UVS extension work and potentially in future ACIAR animal production projects. *Stylosanthes guianensis has been* planted for seed increase at the forage research plot at UVS. Herbaceous legumes can contribute to animal production through their introduction to common grazing lands, directly to the quality of available feed which currently comprises mostly low quality local grasses and, by increasing the nutritive value of the existing grasses through N fixation.

The MyPulse project, a part of the ACIAR Myanmar program indicated that soil organic matter (OM) is very low in soils in the CDZ. Therefore there is a high risk of plant disease if cropping increases and the proportion of pulses is too high. Forage grasses offer a way around the problem and we now have the capability and evidence that grasses can contribute positively both in terms of yield (3 vs 24t DM/ha/yr) and potential for soil OM from roots when used in a rotation.

In addition, international studies show the advantage of animal waste for compost, fertiliser and biogas. Greenhouse gasses (GHG) / unit product can be reduced if reproduction rate and liveweight gain is increased and there is potential for a reduction in overgrazing of the common lands by feeding introduced forages. Implementation of a more efficient ruminant production system could reduce the need to use more land for cattle and small ruminant production. This would include better utilisation of existing feed resources such as crop residues and by-products, and better use of available land resources to grow additional feed (e.g. tree legumes as living fences).

8.4 Communication and dissemination activities

Communication of research results has been an important part of the Dahat Pan project. Information from the project was shared with collaborator farmers and the wider farming industry and scientific communities. Details of the types of communication and dissemination activities are outlined below.

Scientific and strategic communication

The establishment of the Regional Learning Alliance provided the means for communication with a wider audience and a way to update organisations which have greater means of policy influence, such as the Livelihoods and Food Security Trust Fund (LIFT) and the Food and Agriculture Organisation of the United Nations (FAO).

Throughout the project, the team met with the Chairman of the Parliamentary Committee for Agriculture, Livestock and Rural Development, the Permanent Secretary of the Ministry of Agriculture, Livestock and Irrigation, the Regional Director of Mandalay, the Mandalay Chairman of the Myanmar Livestock Federation, the Director General of the Livestock Breeding and Veterinary Department, and the Rectors of the University of Veterinary Science, and Yezin Agricultural University, providing briefing notes of the project and some influence over policy decisions in relation to livestock.

Development of technical implementation procedures (TIPS) for FAO has used project scientific outcomes on village chicken, ruminant and forage production. These TIPS will be incorporated into FAO extension and training for farmers and CAHWs with potential to influence policy and government interaction.

Engagement with key private sector collaborators, in particular the Myanmar Livestock Federation (MLF) has developed and increased throughout the project duration. In particular MLF was involved in the village chicken and forage activities. This included the production of the chick starter diet, and establishment of forages for initiation of seed production in Myanmar and distribution to smaller farmers. Additionally, engagement with the New Zealand Dairy Excellence project has facilitated knowledge and resource sharing with some dairy farmers in Meiktila.

UVS and YAU have collaborated in seed production research with support of the project team. This has provided an opportunity to strengthen ties between the two premier agriculture-based universities and has the potential to strengthen ties more broadly between the universities. The seed manual was developed for use by researchers in Myanmar with YAU and UVS using it as the basis of new course materials being developed for undergraduate students.

Scientific results of the project have been shared through conference proceedings, publications (full list contained in Section 10.2), annual project meetings and annual ACIAR program meetings. There were six international conferences attended by staff and students of the partner organisations, and this included 11 students who presented their research. Conferences which have been attended include:

- 16th AAAP Animals Science Congress, Indonesia
- Joint ISNH/ ISRP Congress Harnessing the Ecology and Physiology of Herbivores, Australia
- International Grasslands Congress, India
- International Conference on Sustainable Animal Agriculture for Developing Countries, Thailand
- International Sheep Veterinary Congress, England
- TropAg Conference, Australia

Communication with the farming community

FAO have contracted the project to provide technical input into the development of TIPs focussing on animal production and feeding in the CDZ. This engagement is recognition of the value that FAO sees in both the project research and in the ability to transform research outputs into extension tools. Over the next 2 years, FAO aims to expose 177,000 farmers in 6 CDZ townships to extension activity focussed on improved animal production. Collaboration with the NGO CESVI has also been a significant way for the project to contribute to community impacts. CESVI has already extended castration and creep feeding information on small ruminants provided by the Dahat Pan project to 641 households.

There were numerous activities with farmers, particularly from the collaborating villages where the research occurred but also more broadly with villages across the CDZ. Useful information was provided to farmers using several modes of communication. In total, approximately 3520 farmers received information and extension messages from the project

outside of the project focal villages of Kyauk Aoe, Ya Thar and Hpet Yin. In Kyauk Aoe, Ya Thar and Hpet Yin, approximately 420 farmers received information about the project, and 290 farmers received ongoing support and engagement in activities. Key farmers from all three villages were invited to the project annual meeting and were given a session to outline their views on the project. The key engagement activities have focused on the following topics:

- Training in various poultry diseases
- Village chicken ‘best practice’ production
- Forage production
- Forage farm walks & community education
- Supplementary feeding of goats
- Goat production
- Supplementary feeding & weaning cattle
- Field days to celebrate the project and share extension materials
- Village chicken MasterChef competitions & field days

Extension materials which were delivered to farmers and provided to government and non-government extension services are listed in Section 10.2.

9 Conclusions and recommendations

9.1 Conclusions

Village chickens

Village chickens have great potential for famers to increase their supplementary income. Village chicken are raised for multiple purposes (sales, consumption, donation, barter), they are commonly the most frequent livestock species within a village, and they require minimal input and investment when a new flock is set up.

Interventions such as Newcastle Disease vaccination, chick starter diets sourced from local ingredients and locally produced coops reduced mortality rates significantly and improved income. Farmers progressively paid for these interventions ensuring sustainability of the interventions. These improvements directly benefited women as they were responsible for all aspects of village chicken production.

Flock sizes increased as mortalities reduced but the feed resource is limited in a scavenging environment. Pilot trials exploring semi-intensive village chicken rearing were established as an alternative business for village chicken farmers with the potential to establish greater flock sizes under supplementary feeding and thereby generating higher income for village chicken farmers.

Ruminants

Traditionally, farmers have grazed small ruminants on village common lands while using a combination of grazing and direct feeding for large ruminants. Feeding priority is given to the draught cattle that provide agricultural and transport capability. Stock classes that are grazed do so in uncultivated areas during the crop growing period and in the cultivation areas once all crops have been harvested. Feed resources are very limited in the late dry / early wet season (March–June) and to a lesser extent in the late wet/ early dry season. The longitudinal monitoring of production of small and large ruminants provides a comprehensive view of the potential and limitations of the current production systems for the first time.

Small ruminants are largely owned by both landless and land-owning households and have variable—but frequently satisfactory—reproduction rates, but high mortality of kids and lambs in the months after birth. The longitudinal observational studies and interventional trials to date have shown that small ruminant production by small farmers has great potential. Several significant issues have been identified, including mortality and ill-thrift of young animals, potential for greater and more reliable reproduction, sub-clinical and clinical effects of gastrointestinal parasites, and diseases including FMD and infectious abortion. Mortality was on average 36% per annum in young animals, births averaged 1.2–2.3 kids/doe and 1.1–1.6 lambs/ewe annually, varying significantly between sites and years and kids and lambs reached an average of 13–17 kg liveweight by six months of age. These figures suggest that average reproductive efficiency of breeding females is largely satisfactory, albeit with opportunities to improve reproductive rates under certain village/household and seasonal conditions. However, enormous wastage occurs between birth and the potential saleable ages of young animals and is a major area of lost opportunity for farmers and the country's small ruminant value chains.

Ill-thrift (poor growth and/or increased disease susceptibility) and internal parasitism were widespread. Additionally, sporadic outbreaks of suspected foot and mouth disease (FMD) and infectious abortion occurred. Overall, nutritional availability and management, of both breeding and growing animals, was poor under existing conditions and some simple management changes could make significant improvements to productivity. Targeted provision of higher-quality feeds to young stock ('creep feeding') reduced average mortality

of young animals from 44% to 0%. Creep-fed animals received increased interest from livestock traders.

There was no control of mating or castration of bucks. Several case studies also suggested that castrated animals would receive price premiums from livestock buyers. The rubber ring method of castration was widely accepted by farmers and animal health workers and did not affect growth rates of young animals.

Large ruminants exhibited poor reproduction and growth. Undernutrition of cows was reflected in poor body condition scores (BCS; average BCS 2.0 on a 1-5 scale) and reproductive performance, although other potential contributors to poor reproductive efficiency were not evaluated. The average calf birth rate varied between sites from one calf per cow every 1.7-2.7 years. Mortality of young stock was low (3.8%). Approximately 80% of farmers reported observing health problems with cattle each year, with sporadic outputs of FMD treated by government veterinary officials. Syndrome of 'weakness/exhaustion' and 'abdominal straining' were widely reported, especially during the hot summer season, but more research is needed to describe the actual impact of these conditions, if any, on production, and their underlying causes. There were internal parasites in both young and mature animals (27-73%), with unexpectedly high worm egg counts observed in 25% of breeding cows. The overall estimated prevalence of haemoparasites was 43% (36–51%). More research is needed to quantify the impact of these infections on animal production, and identify efficient and practical treatment and prevention strategies. The opportunity to develop more productive cow-calf and fattening systems was huge given the shift away from draught to mechanisation in cropping systems but this depended on developing a better nutritional base with basic animal husbandry procedures.

Forages

There will need to be a more productive forage base if the shift from draught to cow-calf systems is to be successful. Three grasses and three browse legumes have been identified as being suited to the CDZ climatic conditions and able to produce significant quantities of biomass for animal feeding. Importantly, farmers have also indicated their acceptance of these plants through their expansion of areas, though modest due to shortages of seed and vegetative material. Grass yields were five times greater, grew earlier after the first rain, grew longer into the dry season than traditional forage such as sorghum and were available at the critical periods of feed demand of livestock. Forage legumes, such as Dolichos lab lab, showed potential but the evaluation of forage legumes was limited due to establishment problems. Seed production was a major limitation to further distribution of all grasses and legumes and whilst a market for vegetative distribution was expanding, the need for commercial seed production was evident.

Market value chains

The need for draught power in crop based farming systems in Myanmar is likely to change. Mechanisation, changes to government policy, increases in urbanisation and a growing middle class provide opportunities for Myanmar's beef industry to grow. It is expected that relaxation of policies relating to slaughter age of animals will be accompanied by a change in policies allowing greater export of live cattle which small holders may be able to capitalise on. A market demand and market chain for beef is essential for small holders to benefit. More information is needed to understand farmers' decisions to trade small ruminants. Updated value chain studies would identify opportunities for selling animals that are well-aligned with market specifications or can take advantage of emerging markets. There are few market signals to producers about preferred products or animal specifications, and currently little is known about the major factors influencing product demand, costs and prices throughout the value chain.

Producing a larger number of village chickens under semi-intensive conditions would require a detailed value chain analysis, in particular breeding, supply of feed and vaccines, disease management, training and marketing of chickens raised under semi-intensive conditions

Capacity

R&D capacity has been developed within the collaborating organisations, with farmers and with key stakeholders, such as NGOs. This includes staff and students of UVS, LBVD and YAU, village-based junior scientists tasked with managing the field research program, and Community Animal Health Workers (CAHWs).

The project has increased knowledge and skills of researchers at LBVD, UVS and latterly YAU with the most tangible evidence being the number and quality of master's students who have graduated or are about to graduate from UVS (24). Most are young professionals from LBVD and this will have an impact on both individual and institutional capacity.

Pathways to sustainable impacts

The Regional Learning Alliance was a useful model to engage with other organisations working with livestock in the CDZ. This, in part led to the collaboration with the LBVD-FAO project and the development of Technical Information Packages (TIPS) to be incorporated into the LBVD-FAO project. Collaboration with the NGO CESVI also arose from the Regional Learning Alliance. CESVI has already extended castration and creep feeding information on small ruminants provided by the Dahat Pan project to 641 households.

Promoted interventions are more likely to be sustainable if there is a sustained increased income for the farmers, and this was demonstrated for the village chicken interventions. Entrepreneurs who support the value chain for improved village chicken production (e.g. local chick starter producers, sellers of equipment) were identified and engagement with village chicken farmers was facilitated by the project. Additionally, information on recommendations for improved village chicken management was shared widely across the CDZ.

9.2 Recommendations

A number of areas have been identified for further research based on the finding of the Dahat Pan project. Further research and extension is needed to progress the research to date and ongoing engagement with Myanmar farmers, private sector, and government and non-government organisations is highly recommended.

Research questions remaining

The promoted village chicken interventions improved survival rates of birds and increased sales, but the limited feed resource in the scavenging environment restricted increases in flock sizes. Thus, farmers would like to receive advice and training in approaches to increase village chicken outputs despite the limiting scavenging feed resource base. Village chicken meat is sold at premium prices (three times higher than broiler), which offers many opportunities for alternative production and marketing of village chickens. New village chicken research should focus on alternative and profitable approaches such as semi-intensive village chicken production, and premium-tailored value chains for village chickens. The economics of these approaches should be evaluated, and the human health impact of increased consumption of chicken products measured. Appropriate breeding and feeding strategies as well as marketing approaches of indigenous chickens raised under semi-intensive conditions need to be compared for efficiency and cost-effectiveness in longitudinal studies.

There is currently low availability of high quality feedstuffs, especially during the dry season when feed gaps are most common. The Dahat Pan project introduced new forage (grasses and legumes) that produce five times as much feed as the currently grown sorghum. These forages have the potential to dramatically improve cattle production but ways need to be found to integrate these with the crops that farmers currently grow. Cost-effective feed options and feeding management strategies without compromising yields of crops grown for human consumption need further investigation. This includes further evaluation of herbaceous legumes, agronomic research and investigation of options for forage conservation. Additionally, farmers need better assistance choosing appropriate feeds for different stock classes and production objectives from amongst their existing and future feed resources. This includes better directing current crop by-products to livestock that will benefit most from them (e.g. growing stock intended for sale), and sustainable production and use of new forages.

Farmers in Myanmar should be assisted to improve their ruminant production from an opportunistic, low-input/output activity to market-focussed, profitable enterprises, through more efficient animal production and improved animal health. Improved knowledge of different markets for ruminants, and the kinds of animal specifications preferred by traders and consumers, is needed to enable all participants in value chains to increase farm income by meeting market requirements. The roles of different household members, including women and young people, in raising ruminants requires further evaluation to determine the implications of changed management.

There is a need for studies to properly diagnose the key diseases in the CDZ. This will support more effective disease treatment and prevention to support ruminant production and human health. Furthermore, improved understanding of the FMD status of small ruminants and evaluation of prevention strategies in goats and sheep would help mitigate the risk of severe losses on smallholder farms, and provide critical support for national FMD control efforts and enhanced trade. More research is required to evaluate anthelmintic strategies in large and small ruminants to identify the most cost-effective and sustainable strategies for small farmers.

Project implementation

The project focused on the transfer of key research findings and interventions to larger scale initiatives run by the government and NGOs. This is a useful model for research for development in Myanmar. However, more direct engagement with farmers is needed to support them as they incorporate change into their farming systems and help them engage even more comprehensively with project activities. This could be significantly aided by better communication between researchers and farmers, particularly supported by in-country members of the project team, particularly at the local government level. Myanmar research and extension staff would benefit from additional opportunities to strengthen their skills in engagement with farmers.

Outside the project, awareness of the project's importance, activities and outcomes would be improved by developing clearer channels between researchers, local authorities and key Regional and Union government stakeholders. For effective implementation of project outcomes, regular briefing of policymakers through these channels would help ensure support and facilitation of future work.

Students have gained important field research knowledge during the project. However, the scholarship program for postgraduate students needs to be further developed to strengthen the supervision provided by in-country and Australian researchers, and to ensure that there are career options whereby their skills can be utilised. Additionally, there is a strong need for ongoing support of future students and junior research staff to develop critical skills in experimental design, carrying out field experiments in a well-controlled, methodical manner, and fundamental data management and integrity.

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10.2 List of publications produced by project

Conference Proceedings

Ruminant production research in the Central Dry Zone of Myanmar. Authors: Angus Campbell, Hanks J, Henning J, Quigley S, Naing Oo K, Aung A, Stür W, Myint Thein W, Myint YY, Min Latt Z, Zaw Win TT, Naing Oo L, Min Thein S, Poppi D. Presented at the World Buiatrics Congress, July 2014.

Assessment of feed availability for cattle, sheep and goats in two villages in the Central Dry Zone of Myanmar. Authors: Soe Min Thein, Aung, A., Oo, KN., Hline, NK.,Thein, SM., Oo, LN., Latt, ZM., Win, TTZ., Hanks,J, Stur, W. Presented at the 16th AAAP Congress, November 2014.

Longitudinal cattle parasite monitoring in Myanmar's Central Dry Zone. Authors: AJD Campbell, JE Hanks, EJ Glanville, T Zaw, TN Nway, WM Thein, YY Myint, SP Quigley, SM Thein, ZM Latt, LN Oo, A Aung, KN Oo, DP Poppi. Presented at World Buiatrics Congress, Dublin, July 2016.

Evaluation of tropical herbaceous legumes for drought resistance in Myanmar. Authors: Jue Jue, Hline, NK., Mu, KS., Htun, MT., Oo, LN., Thien, SM., Lwin, DS., Hanks,J., Nakamanee,G., Stur, W., Aung, A. Presented at International Grasslands Congress, New Dehli, November 2015.

Selection of Suitable Varieties of Grasses for Myanmar from the Introduced Grasses. Authors: Nang Khan Hline, Jue, J., Mu, KS., Htun, MT., Oo, LN., Thien, SM., Lwin, DS., Hanks, J., Nakamanee, G., Stur, W., Aung, A. Presented at International Grasslands Congress, New Dehli, November 2015.

Farmers' Knowledge, Beliefs and Barriers to Prevent Newcastle Disease in Village Chickens in Central Dry Zone of Myanmar. Authors: Wai, H. Y., L.L.Htun, S.Bawm, K.N.Oo & J.Henning. Presented at Sustainable Animal Agriculture for Developing Countries, Pattaya, October 2016.

Understanding of Village Chicken Production and Health Care Management at the Central Dry Zone of Myanmar. Authors: Min, W.W., S. Bawm, L.L. Htun, K.N. Oo & J. Henning. Presented at Sustainable Animal Agriculture for Developing Countries, Pattaya, October 2016.

Distribution of gastro-intestinal helminths of ruminants in two villages in the Central Dry Zone. Authors: Thiri Zaw, Bawn,S., Htun, LL., Oo,LN., Campbell, A. Presented at Myanmar Veterinary Association Conference, Yangon, December, 2016.

Response of pre-weaned calves to dry season supplementation. Authors: Aung Htet Myat, Win, SS, Oo, LN., Mu, KS., Htun, MT., Quigley, S., Poppi, D., Aung, A. Presented at Myanmar Veterinary Association Conference, Yangon, December, 2016.

The effect of calf supplementation during the dry season on liveweight, body condition score and milk yield & haematological parameters of mother cows. Authors: Win, SS., Myat, AT., Oo, LN., Aung, A., Mu, KS., Htun, MT., Quigley, S., Oo, LN. Presented at Myanmar Veterinary Association Conference, Yangon, December, 2016.

Seasonal Effect of Body Condition Score and body Weight of does at Dryzone Area in Myanmar. Authors: Ya Min, Thein, SM., Aung, A., Mu, KS., Htun, MT., Campbell, A., Oo, LN. Presented at Myanmar Veterinary Association Conference, Yangon, December, 2016.

Body Condition Score and liveweight changes of Native Cows in the Dry and Wet Season at Dryzone Area in Myanmar. Authors: Ei Mon Nyein, Mu, KS., Quigley, S., Htun, MT., Thein, SM., Oo, LN., Poppi, D., Aung, A. Presented at Myanmar Veterinary Association Conference, Yangon, December, 2016.

Small ruminant production systems in the Central Dry Zone of Myanmar. Authors: Angus JD Campbell, JE Hanks, SM Thein, KN Oo, TTZ Win, LN Oo, A Aung, EJ Glanville. Presented at the International Sheep Veterinary Congress, May 2017.

Strategic drenching and creep feeding - practical interventions to improve small ruminant production by smallholders in Myanmar. Authors: Elsa J Glanville, MM Cho, JE Hanks, SM Thein, KN Oo, LN Oo, A Aung, AJD Campbell. Presented at the International Sheep Veterinary Congress, May 2017.

Longitudinal syndromic surveillance of small ruminant health in the Central Dry Zone of Myanmar. Authors: Jenny Hanks, E Glanville, E Phyu, N Hlaing, LN Oo, A Aung, KN Oo, AJD Campbell. Presented at the International Sheep Veterinary Congress, May 2017.

Assessment of feed and feeding practice for ruminant in central dry zone area. Authors: Soe Min Thein, LN Oo, A Aung. Presented at the Myanmar Veterinary Association Conference, December 2016.

Effects of creep feeding on liveweight gain, coccidial oocyst counts and haematological parameters in goat kids. Authors: Mo Mo Cho, Htun, LL., Aung, A., Campbell, A., Glanville, E., Hanks, J., Oo, LN. Presented at the TropAg Conference, November 2017.

Small ruminant production in the Central Dry Zone of Myanmar – opportunities to improve livelihoods by addressing constraints to production. Authors: Elsa J Glanville, JE Hanks, SM Thein, KN Oo, LN Oo, A Aung, Angus Campbell. Presented at the TropAg Conference, November 2017.

Cattle production systems in the Central Dry Zone of Myanmar. Authors: Jenny Hanks, Oo, LN., Glanville, E., Quigley, S., Thein, SM., Oo, KN., Aung, A., Poppi, D., Campbell, A. Presented at the TropAg Conference, November 2017.

Prevalence of tick-borne pathogens in cattle in Meiktila and Myingian Townships within the Central Dry Zone of Myanmar. Authors: Hnin Moe Thu, Htun, LL., Linn, KS., Oo, LN., Glanville, E., Hanks, J., Campbell, A., Bawm, S. Presented at the TropAg Conference, November 2017.

Field experiments in a Masters of Veterinary Science training program at the University of Veterinary Science, Myanmar. Authors: Lwin Naing Oo, Mu, KS., Htun, MT., Quigley, S., Campbell, AJD., Hanks, JE., Thein, SM, Aung, A., Glanville, EJ., Poppi, D. Presented at the TropAg Conference, November 2017.

Effect of Combination of Urea, Cattle Manure, and Elements on Yield and Nutritive Value of Mombasa Grass. Authors: Soe Pyae San, Oo, LN., Mu, KS., Dalgliesh, N., Nakamanee, G., Aung, A. Presented at the TropAg Conference, November 2017.

Comparison on the Digestibility of Introduced Grasses, Napier Grass, and Sorghum through In Vitro and In Situ Method. Authors: Thin Yatanar Soe, Thein, SM., Oo, LN., Mu, KS., Nakamanee, G., Dalgliesh, N., Aung, A. Presented at the TropAg Conference, November 2017.

Selection of suitable grasses for animal feeding in the Central Dry Zone of Myanmar. Authors: Dezin Soe Lwin, Oo, LN., Thein, SM., Hline, NK., Poppi, DP., Dalgliesh, N., Hanks, J., Nakamanee, G., Aung, A. Presented at the TropAg Conference, November 2017.

Perceptions Of Small-scale Livestock Farmers On The Risk Of Acquiring Zoonotic Diseases From Their Livestock: A Cross-sectional Study In Myanmar. Authors: Tu Tu Zaw Win, Campbell, A., Soares Magalhães, RJ., Oo, KN., Henning, J. Presented at 4th International One Health Congress and 6th Biennial Congress of the International Association for Ecology and Health, Melbourne, Australia, December 2016.

Do year-long health and management interventions for village chickens in Myanmar influence farmers' perceptions on the prevention of poultry diseases? Authors: Joerg Henning, Wai, HN., Min, WW., Htun, LL., Bawm, S., Latt, ZN., Oo, KN. Presented at 4th International One Health Congress and 6th Biennial Congress of the International Association for Ecology and Health, Melbourne, Australia, December 2016.

Multispecies livestock rearing in developing countries – a challenge to collect, present and interpret surveillance data. Authors: Tu Tu Zaw Win, Campbell, A., Soares Magalhães, RJ., Oo, KN., Henning, J. Presented at 3rd International Conference on Animal Health Surveillance, Auckland, New Zealand, February 2017.

Insurance promotes riskier behaviour – how health interventions for village chickens in Myanmar influence farmers' perceptions on the prevention of poultry diseases. Authors: Joerg Henning, Wai, HN., Min, WW., Latt, ZM., Oo, KN. Presented at Science Week, Gold Coast, Australia, July 2017.

Scientific Publications

Accepted or submitted for publication

Soe Min Thein, Min Aung, Lwin Naing Oo, Moe Thidar Htun, Khin San Mu, Jenny E. Hanks, Werner W. Stur, Dennis P. Poppi, Aung Aung. (2017). Comparisons on the nutritive values of local and introduced forages and feed mixtures for ruminant feed in the Central Dry Zone of Myanmar. *Journal of Scientific Agriculture*, 1, 209-215. doi:10.25081/jsa.2017.v1.65.

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Zaw Win, Tu Tu (2019) *Constraints and opportunities to improve livestock production and health, and reduce zoonotic risks in small-scale native chicken, cattle and small ruminant farms in the Central Dry Zone of Myanmar*, PhD thesis, University of Queensland.

Planned for future submission

Farming systems economics in 2 villages of the Central Dry Zone, Myanmar. Authors: Neal Dalgliesh, Soe Min Thein.

The use of cluster analysis for developing a sampling frame – a practical sampling approach. Authors: Joerg Henning, et al. to be submitted to *Preventive Veterinary Medicine* in 2018.

The economics of keeping village chickens alive - the impact of interventions to improve village health and production. Authors: Joerg Henning, et al. The paper will be submitted to *Preventive Veterinary Medicine* in 2018.

The insurance that promotes riskier behaviour – how interventions to improve village chickens' health influence farmers' perceptions on the prevention of poultry diseases. Authors: Joerg Henning, et al. *PLosOne* in 2018.

Ethnodrama, puppets and cooking competitions – communication of veterinary and public health messages in resource-poor settings. Authors: Joerg Henning, et al. The paper will present a review of interactive communication and extension methods. It will provide examples on how innovative approaches were used to communicate research findings to poultry farmers in Myanmar. The concept paper will be submitted to *Frontiers in Veterinary Medicine* in 2018.

Opportunities and constraints to cattle production by smallholder farmers in the Central Dry Zone of Myanmar. Authors: Jenny Hanks, Poppi, D., Quigley, S., Oo, LN., Hlaing, N., Phyu, E., Campbell, A. The paper will be submitted to *Animal Production Science* or *Tropical Animal Health and Production*.

Prevalence of *Theileria*, *Babesia* and *Anaplasma* infections in native cattle in six villages in the Central Dry Zone of Myanmar. Authors: Angus Campbell, Thu, H.,M., et al. *Transboundary and Emerging Diseases* 2018

Opportunities to improve production by smallholder farmers raising small ruminants in the CDZ of Myanmar. Authors: Angus Campbell, Glanville, E.J., et al. The paper will be submitted to *Agricultural Systems* in 2018.

The importance of rearing small ruminants to households in the CDZ of Myanmar. Authors: Elsa Glanville, Hanks, J.E., Campbell., AJD., et al.The paper will be submitted to *Small Ruminant Research*.

Selective supplementary ('creep') feeding of young small ruminants improves growth and survival. Authors: Angus Campbell, Glanville, E.J., Cho, M.M. et al., The paper will be submitted to *Small Ruminant Research.*

Efficient management of endoparasites in small ruminants in the Central Dry Zone of Myanmar. Authors: Elsa Glanville, Campbell., AJD., Hanks, J.E., et al. To be submitted to *International Journal of Parasitology.*

An analysis on the impact of management practices on the health of livestock, the biosecurity status of multispecies livestock farms and the income generated from livestock production. Authors: Tu Tu Zaw Win, et al. To be submitted *Preventive Veterinary Medicine*.

What drives small-scale farmers raising multiple livestock species to vaccinate their animals against common infectious diseases? Authors: Tu Tu Zaw Win, et al. To be submitted *Preventive Veterinary Medicine*.

Perceptions and behaviours of farmers and traders that impact on the risk of acquiring zoonotic diseases from their livestock: A cross-sectional study in Myanmar. Authors: Tu Tu Zaw Win, et al. To be submitted *BMC Public Health*.

Factors influencing multispecies livestock trading in Myanmar. Authors: Tu Tu Zaw Win, et al. To be submitted to *Plos One*.

Extension Materials

All extension and training materials are available on request from organisations as indicated

- Technical Implementation Packages (Appendix 11.11, 11.12, 11.13, 11.14) (Available from FAO Myanmar office).
    - Improved village chicken production under scavenging conditions in Myanmar. Produced for the LBVD-FAO project, March 2017.
    - Forage production for ruminants. Produced for the LBVD-FAO project, March 2017.
    - Goat and sheep husbandry. Produced for the LBVD-FAO project, March 2017.
    - Cattle husbandry and technologies for improved production. Produced for the LBVD-FAO project, May 2017.
- Village chicken extension package (includes flip charts with cartoons, key messages poster, Newcastle disease vaccination calendars, information flyer with detailed instructions for improved village chicken rearing, billboards, photo booklets on best practice village chicken management) (Available from LBVD and Dr J. Henning).
- Forages extension package (includes "Forage production for ruminants" manual, "Producing tropical forage seed in Myanmar" manual, forage booklet with key messages on how to grow forages in the CDZ). (Available from UVS).
- Ruminant extension package (includes goat booklet with key messages on health, husbandry and nutrition, cattle booklet with key messages on husbandry and nutrition, report cards for participating households to benchmark their herds to others in the village, creep feeding flyer giving instruction on how to implement, billboards with key monthly BCS and liveweight measurements) (Available from LBVD and UVS).

- Development of a marionette play on improved village chicken production with a professional marionette company. The play was recorded and shown on Myanmar TV SkyNet.(Available from Dr J. Henning).
- Development of 5 ethno-dramas on methods to improve village chicken biosecurity, health and production using actors, directors and film crews. (Available from Dr J. Henning).
- Development of a video highlighting the key activities of the project filmed in Ya Thar village, and shown on Myanmar TV SkyNet. (Available from LBVD).
- Partners In Research For Development, Issue 2, 2017, Myanmar: Agriculture in transition, pp 11-17. (Available from ACIAR).

11 Appendices

The following appendices contain reports and/or publications covering key activities throughout the project in greater detail. They provide additional descriptions of Materials and Methods, and detailed Results and/or Discussion sections that supplement the summaries contained in the body of the report in Sections 7- 9. These are supplied in a separate PDF document. Please use the bookmarks to navigate to each Appendix.

11.1 Appendix 1: Project participants

Livestock Breeding and Veterinary Department (LBVD)

Dr Kyaw Naing Oo

Dr Zin Min Latt

Dr Tu Tu Zaw Win

Dr Wint Wint Aung

Daw Mu Mu Aye

Dr Win Myint Thein

Dr Soe Naing

Dr Phyu Phyu Aung

Dr Yin Yin Myint

Dr Kaung Myint Hein

Dr Aung Khine Htwe

Dr Nway Nway

University of Veterinary Science (UVS)

Prof Aung Aung

Dr Lwin Naing Oo

Dr Soe Min Thein

Dr Bo Hein

Dr Nang Kham Hline

Dr Jue Jue

Dr Dezin Soe Lwin

Dr Khin San Mu

Dr Moe Thida Htun

Junior Scientists

Ma Ei Phyu

Ma Nandar Hlaing

Community Animal Health Workers (CAHWs)

U Thaung Myint

Ko Kyi Lyi Maung

U Nyo

U Tun Tun Lu

U Kyaw Kyaw

University of Queensland (UQ)

Prof Dennis Poppi

Dr Joerg Henning

Dr Simon Quigley

Dr Karen Harper

Dr Joanne Meers

Dr Frances Cowley

Dr Werner Stur (until Sep 2014)

University of Melbourne (UoM)

Dr Angus Campbell

Dr Elsa Glanville

Dr Jenny Hanks

Consultants

Mr Neal Dalgliesh

Ms Ganda Nakamanee

11.2 Appendix 2: Village chicken research

Detailed report of village chicken research activities in ACIAR project AH/2011/054, including methodology, detailed results and discussion.

11.3 Appendix 3: Forage Research

The potential for grass and legume forages to contribute to animal feed supply in the Central Dry Zone of Myanmar. Detailed results and description of forage research results in ACIAR project AH/2011/054 ‘Dahat Pan’, covering trials and farmer demonstrations.

11.4 Appendix 4: Cattle research- longitudinal monitoring

Opportunities and constraints to cattle production by smallholder farmers in the Central Dry Zone of Myanmar.

11.5 Appendix 5: Cattle research- intervention studies in the CDZ

Supplementation of calves and weaning as management tools to improve productivity of smallholder cow-calf herds in the Central Dry Zone of Myanmar.

11.6 Appendix 6: Cattle research- blood borne parasites

Prevalence of Theileria, Babesia and Anaplasma infections in native cattle in six villages in the Central Dry Zone of Myanmar.

11.7 Appendix 7: Cattle research- household livelihoods survey

The role of cattle rearing in the livelihoods of smallholder farmers in the Central Dry Zone of Myanmar.

11.8 Appendix 8: Cattle research- experiments in Australia

Feeding strategies for Early and Normally weaned replacement heifers in northern Australia.

Developing a growth curve of weight and skeletal dimensions in Brahman-cross steers post-weaning.

11.9 Appendix 9: Small ruminant research – longitudinal monitoring

Detailed results and description of small ruminant research results in ACIAR project AH/2011/054 ‘Dahat Pan’, covering longitudinal production and health monitoring, feeding and anthelmintic intervention studies, key household livelihood survey results.

11.10 Appendix 10: Small ruminant research- household survey

The importance of rearing small ruminants to households in the CDZ of Myanmar.

11.11 Appendix 11: TIP- Improved village chicken production

Technical Implementation Procedure: Improved village chicken production under scavenging conditions in Myanmar. Produced for the LBVD-FAO project, March 2017.

11.12 Appendix 12: TIP- Forage production for ruminants

Technical Implementation Procedure: Forage production for ruminants. Produced for the LBVD-FAO project, March 2017.

11.13 Appendix 13: TIP- Goat and sheep husbandry

Technical Implementation Procedure: Goat and sheep husbandry. Produced for the LBVD-FAO project, March 2017.

11.14 Appendix 14: TIP- Cattle husbandry and technologies

Technical Implementation Procedure: Cattle husbandry and technologies for improved production. Produced for the LBVD-FAO project, May 2017.

11.15 Appendix 15: Tropical seed production manual

Producing tropical forage seed in Myanmar – technical manual and teaching material used in undergraduate animal science and agricultural science courses at Myanmar’s University of Veterinary Science and Yezin Agricultural University.

11.16 Appendix 16: Farming systems economics report

Farming systems economics in 2 villages of the Central Dry Zone, Myanmar. Authors: Neal Dalgliesh and Soe Min Thein.

11.17 Appendix 17: Conference proceedings

Abstracts included in conference proceedings are provided in the order listed in Section 10.2.

11.18 Appendix 18: Postgraduate student abstracts

Abstracts from students listed in Table 10. Students who commenced their research in 2017 have not completed an abstract, but have completed proposals which are available upon request.

11.19 Appendix 19: Castration- participatory research & extension with CESVI

ACIAR Project AH/2011/054 ‘Dahat Pan’ – Results from participatory research with the NGO,CESVI in the Shae Tot project on castration of goats.

11.20 Appendix 20: Farmer booklet- Management of cows and calves

Management of Cows and Calves: Recommendations for Smallholders in the Central Dry Zone of Myanmar-Key messages to help improve cattle growth and reproduction.

11.21 Appendix 21: Farmer booklet- Management of goats and sheep

Management of Goats & Sheep: Recommendations for Smallholders in the Central Dry Zone of Myanmar- Key messages to help improve goat health, growth and reproduction.

11.22 Appendix 22: Farmer booklet- Forage production

Forage production: Recommendations for Smallholders in the Central Dry Zone of Myanmar-Key messages for growing tree legumes and grasses.