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Final report

project

Forage legumes for supplementing village pigs in Lao PDR

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1 Acknowledgments

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2 Glossary of abbreviations used

ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
ADF	Acid detergent fibre
ADG	Average daily gain
ADRA	Adventist Development and Relief Agency
AusAID	Australian Agency for International Development
Ca	Calcium
CCL	Comité de Coopération avec le Laos
CesVi	Cooperazione e sviluppo
CF	Crude fibre
CIAT	International Center for Tropical Agriculture
CP	Crude protein
CRWRC	Christian Reformed World Relief Committee
DAFO	District Agriculture and Forestry Office
DE	Digestible energy
DEEDI	Department of Employment, Economic Development and Innovation
DLF	Department of Livestock and Fisheries
DM	Dry matter
EASLP	Extension Approaches to Scaling out Livestock Production in Northern Lao PDR
FCR	Feed conversion ration
FLSP	Forages and Livestock Systems Project
GAA	German Agro Action (Welthungerhilfe)
GE	Gross energy
GtZ	Deutsche Gesellschaft für Technische Zusammenarbeit
LARF	Lao Agricultural Research Fund
LDP	Northern Region Sustainable Livelihoods Through Livestock Development Project
LFSP	Livestock Farmer Support Project
LRC	Livestock Research Center, NAFRI
N	Nitrogen
NAFES	National Agriculture and Forestry Extension Service
NAFRI	National Agriculture and Forestry Research Institute
NDF	Neutral Detergent Fibre
P	Phosphorous
PAFO	Provincial Agriculture and Forestry Office
QDPI&F	Queensland Department of Primary Industries and Fisheries (recently integrated into DEEDI)
RMDA	Lao - German Program Rural Development in Mountainous Areas of Northern Lao PDR
SADU	Small-scale Agro-enterprise Development in the Uplands project
SIDA	Swedish International Development Assistance
SLU	Swedish University of Agricultural Science
VLA	Village Learning Activities

3 Executive summary

The Lao government has placed highest priority in its rural development strategy to improving livestock production systems, given the potential of livestock production to alleviate poverty and reduce shifting cultivation. Pig rearing is a common smallholder livelihood activity in northern Laos with almost all farm households raising a few pigs. Pigs are sold to cover household expenses such as school fees and medications, and they are an asset that can be liquidated to cover expenses in emergencies. Pig production is almost invariably the domain of women, who spend 2-3 hours each day to collect and prepare feed for pigs. Recent surveys identified poorly balanced pig diets in northern Laos, particularly highlighting very low protein content, as a major contributor to the observed poor growth rates and poor reproductive performance of pigs in northern Laos, and showed that farmers who had started to supplement traditional pig diets with the forage legume *Stylosanthes guianensis* (Stylo) were experiencing increased animal growth rates and reduced labour requirements for feeding.

The 'Forage legumes for supplementing village pigs in Lao PDR' project was designed to investigate the use of forage legumes as a protein supplement to traditional pig diets, and ran from January 2006 to August 2010. The project was managed by the International Center for Tropical Agriculture (CIAT) in partnership with the National Agriculture and Forestry Research Institute (NAFRI). The CIAT project leader was based on the NAFRI campus in Vientiane, Laos. In Australia, the Department of Employment, Economic Development and Innovation (DEEDI) provided support to the project in the area of pig nutrition and laboratory analysis. Through NAFRI, the project linked with Provincial and District Agriculture and Forestry Offices, who were responsible for agricultural extension, to work in villages in three districts: Pak Ou and Xieng Ngeun districts in Luang Phabang province and Pek district in Xieng Khouang province. The project conducted feeding experiments at the Livestock Research Center, NAFRI and worked with extension workers and farmer groups in villages in the three target districts. The project also linked up with several NGOs and rural development projects by forming and facilitating a Pig Production Learning Alliance. Through this Alliance the project strengthened the capacity of extension workers to implement and extend improved pig production technologies, identified by the project, to many villages and districts in northern Laos.

The project found that growing and using Stylo as a supplement to traditional feeds doubled the weight gain of pigs fattened in pen from 100 to 200 g/day, and saved women 1-2 hours of work each day as they no longer had to search for naturally growing green feeds. These benefits encouraged many households to improve pig nutrition, housing and husbandry as they could now see pig production as a way to improve their household income. As farmers intensified pig production, some started to purchase protein supplements to further increase productivity. Stylo had a key role in enabling this transition to more intensive and market-oriented pig production. Stylo supplementation was found to be effective for pigs weighing at least 15 kg. Smaller pigs (ie. piglets and weaners), needed more protein than Stylo (and other forage legumes) was able to supply. The project found that supplementing only small amounts of soybean meal were effective in ensuring high growth rates of weaners; thus overcoming a major problem for farmers.

Facilitating a Learning Alliance to link with multiple development partners and strengthening the capacity of their staff through workshops and training courses proved to be an effective way to develop and scale out improved pig production technologies. By 2010, project partners had extended project results to more than 100 villages in 16 districts in 8 provinces in Laos. More than 1200 households had adopted Stylo supplementation, and at least 30 extension workers of NGOs and government offices were capable of continuing to scale out Stylo supplementation. NGOs and other Learning Alliance partners are continuing the scaling out of Stylo supplementation and other improved pig production interventions.

4 Background

The Lao government has given highest priority in its rural development strategy to improving livestock production systems, given the potential of livestock production to alleviate poverty and reduce shifting cultivation (GoL, 2004). In 2004, shifting cultivation occupied approximately 40% of the land area of Laos and was the dominant agricultural system in the northern mountainous provinces. It was also the system in which the most entrenched poverty existed. Shifting cultivation had always been a time-consuming agricultural system with a high element of risk associated with season climatic variability. In the past, however, when crops failed, farmers were able to rely on traditional coping strategies, such as hunting and selling products from the forest to survive. Many of these strategies were now over-utilised or no longer available due to increased pressure on the land, particularly forest resources. Increasingly, farmers were relying on their livestock to provide livelihood security (Chapman et al., 1998). In 2000, 89% of all farm households surveyed in the national agricultural census reported that they raised one or more livestock types and over 95% of all livestock in the country were being produced by smallholder farmers (Stür et al., 2002). In remote areas, more than 50% of household income often came from the sale of livestock (ADB, 2002).

Rearing pigs was a widespread smallholder livelihood activity in the northern mountainous area of Laos, especially among the upland ethnic groups, and was carried out mostly by women. With an average of 3-4 adult pigs per household, the sale of pigs contributed substantially to household income. Pigs were sold when there was a need for cash such as school fees, medical expenses and agricultural inputs. Pigs were walked or transported by motorcycle, pick-up or public transport from the village to the local market either by the owner or by a local trader who bought several animals in a village. Retail traders bought pigs at local markets for slaughter or movement to larger markets. Slaughtering of animals within villages during festivals, weddings and rituals was common and estimated to account for 7 to 10% of the total annual pig production (Zola and Souvannavong, 2005). In villages close to roads and markets, pig production (and agricultural production in general) was more market-oriented and farmers were selling animals regularly as a source of cash income.

Pigs were typically fed a mixture of carbohydrate rich feeds (such as cassava, canna lily and maize) and other feeds that were opportunistically available (in particular, banana stems, rice bran, leafy vegetables from the forest and kitchen by-products). As many of these feed resources were becoming scarcer, searching for feeds was the single most time consuming activity in raising pigs, with women often taking 2 – 4 hours per day, 4 – 7 times per week to gather feed for their pigs. Feed intake appeared to be limited and pig diets were likely to be protein and mineral deficient. This resulted in poor growth and reproduction. The outbreak of epidemic diseases, which could decimate the pig population, was another problem in village pig production.

One promising option for improving these village pig production systems was the planting of forage legumes as a managed crop, supplying high protein leaf supplements which could be fed fresh or dried and could supply feeds at the time of year when other feeds were in shortest supply (first half of the wet season). Many forage legumes have high protein content (18-25%) and are excellent sources of minerals to supplement poorly-mineralized tubers and cereals. Farmers in northern Laos had been reporting substantial benefits from supplementing pigs with the forage legume *Stylosanthes guianensis* CIAT 184 ('Stylo'). These benefits included labour savings in collecting feed at critical times of the year (savings of 2-3 hours per day during the wet season) higher survival rates of young pigs (from 10 – 30% without supplementation to 80 – 100% with supplementation) and faster growth rates (reaching saleable weight 2 months earlier than un-supplemented pigs). Despite such reports, very little was known about the ideal characteristics, utilisation and potential impacts of forage legume leaf in pig diets.

The 'Forage legumes for supplementing village pigs in Lao PDR' project (subsequently referred to as 'Legumes for Pigs' project) investigated the productive potential and socio-economic impacts of selected forage legumes for supplementing feeds of village pigs. Apart from this research component, the project linked research and development by forming an alliance with development partners to scale out the adoption and benefits of Stylo 184 to a large number of farm households. The scaling out process was monitored closely to identify opportunities for and on-farm constraints to adoption. This information, in conjunction with identification of the underlying factors for the production increases and new best-bet legume options, was used to develop guidelines for accelerated scaling out. Capacity building was integrated to ensure that development partners would be able to accelerate scaling out beyond the end of this project.

The target group for this project was farm households, predominantly ethnic minority groups, located in poor villages in the uplands of Xieng Khouang and Luang Phabang provinces. The project was integrated with a network of district extension staff, farmers and NGOs in these provinces who worked together for five years to develop market-oriented forage and livestock systems. As pigs were fed and managed mainly by women (Oparaochoa, 1997), they were the main beneficiaries of the labour saving (1-3 hours /day) achieved by planting and feeding Stylo. Increased productivity of pigs enabled the targeted households to increase sales of pigs, so adding to family income. As pig productivity increased some households chose to increase this livelihood activity (instead of other less profitable farm enterprises) and used pig production as a regular income source.

The 'Legumes for Pigs' project built on several other ACIAR research projects in Laos and the region (Table 1).

Table 1: The relationship to other ACIAR projects

Project	Relevance to the objectives of this project and actual inputs
ASEM/2001/107 Accelerating the impacts of participatory research and extension on shifting cultivation farming systems in Laos. ASEM/2005/124 - Extension Approaches to scaling out livestock production in northern Lao PDR, April 2007 to March 2011.	Provided lessons on extension approaches from other projects for AH/2004/046. ASEM 2005/124 participated in Learning Alliance workshops and provided input into relevant trainings courses. It also provided an assessment of the use of the learning alliance approach to assist in improving this approach for engaging development partners (objective 1).
LPS/2001/029: Selection of forages for the tropics. The information database developed by this project will assist in the selection of additional best-bet legumes.	Factsheets on nutritive value of forage legumes in the Soft database were helpful in selecting additional forage legumes for evaluation in AH/2006/046.
AH/2006/161 - Management of pig associated zoonoses in the Lao PDR, January 2008 to December 2010.	Participated in several project meetings and Learning Alliance workshops. Project leaders regularly exchanged information on research progress on both projects.
AH/2003/001 - Management of CSF and FMD at the village level in Lao PDR, July 2003 to June 2009.	Occasional exchange of information on changes occurring in village pig production systems and emerging diseases.
AH/2007/106 - Improvement and diversification of sweet potato-pig production systems to support livelihoods in highland Papua and West Papua, Indonesia, Jan 2009 - December 2011.	Lessons from successful pig feeding and management interventions from AH/2007/106 incorporated into AH/2004/046. Provided feedback on successful nutritional interventions in Laos to AH 2007/106.
LPS/2002/079 - Utilisation of local ingredients in commercial feeds for pigs, Vietnam, April 2004 – March 2009.	Sharing of nutritional information on locally available feeds in Laos and Vietnam. Dr. Kopinski was involved in both projects and provided the link to LPS/2002/079.

The project also built on and/or linked to three large livestock development projects in Laos:

1. The AusAID-funded Forages and Livestock Systems Project (FLSP), completed in June 2005.
2. The ADB-funded Northern Region Sustainable Livelihoods Through Livestock Development Project (short title: Livestock Development Project - LDP) which commenced in 2006. The overall aim of LDP was to contribute to government initiatives in poverty reduction through smallholder livestock development in the Northern Region of Laos. Three immediate objectives (components) contributed to this aim: (i) enhanced village livestock systems, (ii) community mobilization and capacity building, and (iii) enhanced project management and implementation. The first immediate objective was further divided into three sub-components: (i) improved livestock productivity, (ii) increased market orientation and livestock enterprise development, and (iii) an improved participatory extension network. The project area comprised 18 priority poor districts in five northern provinces of Bokeo (2), Houaphanh (6), Luang Namtha (4), Luang Phabang (4) and Xieng Khouang (2).
3. The EU-funded Livestock Farmer Support Project (LFSP) which commenced in 2006. The project aimed to increase profitability of livestock farmers in Northern Laos with four immediate objectives being to improve (i) livestock marketing systems, (ii) animal health support services, (iii) animal nutrition services, and (iv) animal husbandry, including the provision of credit. Target beneficiaries were estimated at 2,500 livestock-farming households in 33 districts in Luang Namtha, Luang Phabang, Oudomxai, Bokeo, Xayaburi and Xieng Khouang provinces.

The ‘Legume for Pigs’ project was conducted in two phases. The original 3-year phase of the project (January 2006 – December 2008) and an extension phase (January 2009 – August 2010). The original phase of the project evaluated local feeds, the growth potential of the local Moolath breed, the feeding value of Stylo and other forage legumes for growing/fattening pigs, and developing a vibrant pig production learning alliance (the ‘Alliance) to build capacity of the staff of NGOs and other development projects to scale out forage legume supplementation for pigs. The focus of the extension phase was on using Stylo and other protein supplements to reduce mortality and improve growth of piglets and weaners. It continued building capacity of Alliance partners and facilitated the scaling out of Stylo supplementation and pig husbandry improvements.

5 Objectives

The 'Legumes for Pigs' project consisted of two phases: original 3-year phase from January 2006 to December 2008, and an extension phase from January 2009 to August 2010. The objectives are presented consecutively for the two phases of the project.

5.1 Original phase (Jan. 2006 – Dec 2010)

The specific objectives of the original phase of this project were:

1) To collate and analyse baseline information on the existing pig production systems in upland Lao villages.
    - Conduct village meetings and case study surveys in target villages to describe and quantify pig feeding and production systems.
    - Prepare a working document including the results of the surveys and key findings from other relevant sources to assist planning and benchmarking for impact assessment.
2) To determine the nutritional factors of legumes that are responsible for improved pig productivity, and evaluate best-bet legumes for their feeding value for pigs.
    - Review the current state of knowledge of pig nutrition in village situations in a workshop with project stakeholders and key international researchers.
    - Determine the nutritional value of Stylo 184 and other best-bet legumes as supplementary feed for village pigs using laboratory analysis and feeding experiments. Only legume species known to be well adapted to the uplands of Laos will be considered as potential feed supplements for pigs.
    - Conduct conventional and on-farm feeding experiments to measure growth rates of pigs on diets with different levels of legume supplementation.
3) To scale-out the integration of Stylo 184 in smallholder pig feeding systems, using Stylo 184 as a model for investigating on-farm factors that influence adoption of forage legumes.
    - Establish a development alliance commencing with a field day and workshop for potential project partners from the development sector.
    - Develop strategies and plans for the integration of Stylo 184 with development partners, and assist implementation through training, mentoring of staff, logistics and follow-up in the field.
    - With development partners, monitor and evaluate the uptake of Stylo 184.
    - Assess the economic, social and environmental impacts of feeding Stylo 184.
4) To develop guidelines for scaling out improved pig feeding systems using forage legumes.
    - Synthesise the results of activities from Outputs 1, 2 and 3.
    - Conduct a workshop to discuss project outcomes and develop guidelines for the scaling out of Stylo 184 and other best bet legumes for supplementation of village pigs.

5.2 Extension phase (January 2009 – August 2010)

The overall aim of the project extension was to facilitate farmers' access to improved legume-based pig feeding strategies that would increase the financial returns from smallholder pig production in Laos.

This was achieved through two objectives:

1) To improve the capacity of development practitioners to scale-out the use of Stylo 184 and other forage legumes as high-quality supplements to protein deficient, traditional pig diets in smallholder farming systems.

   - Expand the existing development learning alliance to other interested researchers and development practitioners in Laos.
   - Support alliance partners by facilitating workshops for exchanging information and experiences, providing access to information on how to improve pig feeding and management, facilitating formal and informal linkages between experienced and less experienced practitioners and providing training based on needs identified by alliance partners.
   - Improve existing and develop new information material and practical tools that assist farmers and extension workers to combine locally-available feeds with high-protein legumes to formulate more nutritious pig diets throughout the year.
   - With alliance partners, monitor and evaluate the adoption of forage legumes and improved pig feeding and management systems.

2) To improve the survival and growth of piglets in smallholder production systems through improved protein nutrition derived from forage and dual-purpose legumes.

   - Identify practical options for protein supplementation of feed for lactating sows and weaned piglets in village situations.
   - Monitor piglet survival and growth in 3 villages in order to develop a better understanding of sow-piglet production and provide baseline data for assessing impacts of interventions.
   - Conduct both an in vivo feeding experiment, and village learning activities with the help of alliance partners, to evaluate the effect of legumes supplementation on piglet survival and growth before and after weaning.

6 Methodology

The 'Legumes for Pigs' project was managed by CIAT, based in Laos, in partnership with the National Agriculture and Forestry Research Institute (NAFRI). CIAT provided the international project leader and engaged a full-time research fellow to manage day-to-day activities of the project. NAFRI provided the Lao project leader, a project scientist and support staff. DEEDI provided support in the area of pig nutrition and laboratory analysis. Through NAFRI, the project linked with PAFO and DAFO offices to work in villages in three districts: Pak Ou and Xieng Ngeun districts in Luang Phabang and Pek district in Xieng Khouang provinces.

Field work was coordinated by a PAFO representative in each of the two provinces and carried out by 2-3 DAFO extension workers in each of the three districts where the project worked directly with farmer groups. The project encouraged the involvement of women extension workers and the involvement of extension workers from ethnic minorities; this was an essential component for being able to work effectively with women farmers and in ethnic minority villages. Approximately one third of the extension workers involved in the project were women and approximately one third of extension workers came from ethnic minorities.

Most feeding experiments were carried out at the Livestock Research Center (LRC) of NAFRI at Nam Suang; one was conducted at DEEDI in Brisbane. Chemical analysis of feed samples was carried out by DEEDI in Brisbane.

Scaling out beyond project sites was achieved by forming and facilitating a Learning Alliance with NGOs, other government agencies and development projects. This mechanism provided an avenue for raising interest in improving pig production, sharing experiences on how to help farmers improve their production systems and extend project results to a broad range of development practitioners.

Project partners participated in relevant scientific and develop-oriented workshops in the Mekong region to present and publicise the results of the project.

Methods are outlined below by project objectives.

6.1 Original phase (Jan. 2006 – Dec 2010)

Objective 1: To collate and analyse baseline information of the existing pig production systems in upland Lao villages.

Two studies were conducted at the start of the project in the three target districts (Pak Ou and Xieng Ngeun districts in Luang Phabang and in Pek district in Xieng Khuang), where the project worked directly with farmers. The first study was designed to describe the prevailing pig production systems with emphasis on feeding and animal husbandry, and was conducted from 13 March to 12 April 2006. The second study was designed to provide an early estimate of the benefits of growing and supplementing Stylo in the diets of village pigs and was carried out during the project development phase in mid-2005. Both studies were conducted by a team consisting of project staff, and national partners from NAFRI, PAFO and DAFO. Two study methods – farmer focus group discussions followed by semi-structured interviews of randomly selected households - were used in the two surveys. The results of these two studies were analysed and presented at the project inception workshop.

Objective 2: To determine the nutritional factors of legumes that are responsible for improved pig productivity, and evaluate best-bet legumes for their feeding value for pigs.

The 'Legume for Pigs' project arranged an inception workshop to review current knowledge of village pig production in Laos and neighbouring countries, form hypotheses on nutritional constraints encountered in these systems and identify critical research needs 12-15 June 2006 in Luang Phabang. Field activities commenced with collection of common feeds used by farmers in northern Laos. These were dried, ground, and samples were send for chemical analysis to DEEDI in Australia. 'Best-bet' forage legumes, identified at the inception workshop, were grown in two project villages and samples were collected, dried, ground and sent to DEEDI for analysis. These were also evaluated by farmer groups in small plots at two sites. Forages were cut by farmers and fed to their pigs. Farmers evaluated these legumes on the basis of ease of establishment, productivity, regrowth, ease of harvesting and palatability. They selected five legumes with high potential and seed of these 5 legumes was given to farmers in several villages for further evaluation on their own farms in 2008. Farmers reported their findings at the end of the 2008 and 2009 seasons.

During the project, a series of feeding experiments were carried out at the Livestock Research Center (LRC) at Nam Suang and one feeding experiment was conducted at DEEDI in Brisbane. The first experiment was conducted at LRC in late 2006 to determine the growth potential and carcass composition of the local Moolath pig. The second feeding experiment was a metabolism study aimed at assessing the digestible energy and protein value of Stylo, and was conducted at DEEDI in Brisbane in 2007. The third feeding experiment investigated the effect of Stylo 184 supplementation rates (0% Stylo control, 10% fresh Stylo, and 10, 20 and 30% Stylo leaf meal) on feed intake and growth of Moolath pigs fed a rice bran based diet at LRC in 2008. The fourth in-vivo experiment investigated the effect of different supplementation rates of *Leucaena leucocephala* (0% Leucaena control treatment, 10% fresh Leucaena leaf, and 10, 20 and 30% Leucaena leaf meal) on feed intake and growth of Moolath pigs at the NAFRI Livestock Research Center (LRC), Nam Suang in 2009. Experimental details are presented in the key results section.

On-farm evaluations were carried out throughout the project. Project partners and extension workers were trained in conducting "Village Learning Activities" (VLA) with farmer interest groups. VLA was a learning tool which allowed farmers (and extension workers) to evaluate new technologies by comparing these with current farmers' practice. For example, VLA compared current feeds to current feed + fresh Stylo diets by monitoring the growth and body condition of the pigs. Each VLA was designed with the farmer group and was then implemented by one or more volunteer farmers. The results were then shared and discussed with all farmers to maximise learning. Extension workers in Pek, Pak Ou and Xieng Ngeun districts and NGO staff from other areas in northern Laos conducted numerous VLA with farmer groups comparing Stylo supplementation with traditional feeding practices. The results of VLA were reported and shared with all project partners at Alliance workshops, which were held every 6 months.

Objective 3: To scale-out the integration of Stylo 184 in smallholder pig feeding systems, using Stylo 184 as a model for investigating on-farm factors that influence adoption of forage legumes.

The project assembled a list of NGOs and development projects whose projects had livestock components and who were interested in linking up with the 'Legume for Pigs' project to get access to improved pig production technologies. In June 2006, the project held a field day and workshop for representative of these NGOs, development projects and government agencies to discuss the formation of a Pig Production Learning Alliance (the Alliance). The objective of the Alliance was to provide a platform for sharing information on improving village pig production in Laos. The project facilitated the Alliance, arranged two workshops each year and shared its research results with all

Alliance partners. It also facilitate cross visits, provided training sessions on topics requested by Alliance partners and linked young or new extension workers with more experienced extension workers at project sites to provide mentoring. The project also conducted several training courses on pig feeding, production and marketing. Alliance partners paid for the funds needed for their staff to participate in workshop and training courses. From a project perspective, the Alliance provided an avenue for building capacity of extension and development workers from a wide range of organisations to scale out Stylo supplementation and other pig production interventions. Alliance partners provided feedback on implementation issues and so improved the relevance of research conducted by the project.

At each Alliance workshop, project and alliance partners reported on the progress with adoption of Stylo and other pig production improvements in their project areas. This was a means of monitoring scaling out, and provided an opportunity to share experiences and difficulties associated with implementing improved pig feeding interventions. The project provided guidelines for reporting to ensure comparable reporting from the different agencies at the workshops. Partners also reported economic, social and environment outcomes during the Alliance workshops, and it was the reported impacts that continued to generate enthusiasm for legume supplementation throughout the project.

Objective 4: To develop guidelines for scaling out of improved pig feeding systems using forage legumes.

Presentations from, and summaries of all project results were prepared for the final workshop, which was held on 9-10 December 2009. This workshop brought together all project partners as well as senior representatives from the Lao government, related ACIAR projects and ACIAR to discuss the results of all project activities, and agree on guidelines for accelerated scaling out of legume supplementation for pigs. The project prepared ‘Best Practice Guides’ for 'Pig Fattening' and ‘How to conduct Village Learning Activities’. The former included a step-wise introduction to pig production improvements.

6.2 Extension phase (Jan 2009 – Aug 2010)

No major change from the original project methodology. The project continued to work with the same partners as during the original phase. The main difference was a change of focus from pig fattening (growers and fatteners) to sow-piglet production.

Objective 1: To improve the capacity of development practitioners to scale-out the use of Stylo 184 and other forage legumes as a high-quality supplement to protein deficient, traditional pig diets in smallholder farming systems.

The Alliance was expanded to include several new NGO projects. This was achieved through ‘word-of-mouth’ rather than active recruitment. Throughout the project, new NGO and development projects joined and participated in the Alliance. Two review and planning meetings were facilitated each year, and other support functions such as facilitating cross visits, mentoring and training continued. In addition, the project organised four training courses during the extension phase. The project continued to collect and analyse feeds commonly used by farmers in northern Laos and collected repeat samples of feeds that were of particular interest. The chemical analysis data have been prepared in a draft report for publication in Laos. A small project-internal workshop was held in the first week of December 2009 to discuss the development of a simple diet calculator and example diets for village pig producers in Laos. Based on this discussion, a simple diet spreadsheet-based diet calculator was developed by John Kopinski using the results of the chemical analyses of Lao feeds, and estimating the digestibility and nutrient availability of the various Lao feeds the nutrient requirements of local pigs. The diet calculator was tested with extension workers and other members of the Learning Alliance during a workshop on pig nutrition and diet calculation. Numerous example diets

were formulated by extension workers for use by farmers. The diet calculator proved to be an excellent training tool. Monitoring the uptake of Stylo supplementation was continued and reported at Alliance workshops.

Objective 2: To improve the survival and growth of piglets in smallholder production systems through improved protein nutrition derived from forage and dual-purpose legumes

Practical options for protein supplementation were identified and discussed with project and learning alliance partners during the March 2009 Alliance workshop, and finalised during a training course on sow-piglet nutrition and management at the Livestock Research Center, Nam Suang near Vientiane between 29 June and 1 July 2009. These were then evaluated with farmers at project sites and by Alliance partner projects.

The project intended to monitor piglet survival and growth in 3 villages to develop a better understanding of sow-piglet production and provide baseline data for assessing the success of interventions. It proved to be difficult to reliably monitor piglet growth and survival of individual sows in remote villages and we decided on a different approach. The project conducted a detailed survey in the three project districts asking farmers to recall this information for particular sows and their litters. This survey was undertaken in six villages in Pek (Xieng Khuang), Xieng Ngeun and Pak Ou (Luang Phabang) districts in July 2009. Methods are described in detail in the key results section.

Two experiments were carried out at LRC, Nam Suang in 2009 and early 2010. The first experiment investigated the effect of 3 levels of protein supplementation during lactation of Moolath sows on the growth of piglets and body condition of sows. The second experiment investigated the effect of protein and fibre content of the diet on the growth of weaned piglets (March-June 2010). Methods are presented in the key results section.

7 Achievements against activities and outputs/milestones

The project consisted of two phases: The initial 3-year project from January 2006 to December 2008, and an extension phase from January 2009 to August 2010. Achievements and outputs are presented consecutively for the two phases of the project.

7.1 Initial project (Jan. 2006 – Dec 2010)

Objective 1: To collate and analyse baseline information on the existing pig production systems in upland Lao villages.

no.	activity	outputs/ milestones	completion date	Comments
1.1	Conduct village meetings and case study surveys in target villages	A sound understanding of the productivity and constraints of current village pig feeding systems.	July 2006	Two pig production studies (each consisting of village meetings and household surveys) were conducted in the three project districts: (i) A survey of village pig production systems, and (ii) The impact of feeding Stylo to village pigs (early adopters). The first survey provided excellent baseline information on pig systems; pig feeding, management and productivity; and major issues associated with village pig production. The second study evaluated the impact of Stylo on labour and pig productivity in villages where farmers had already experience with feeding Stylo to pigs (early adopters). The results confirmed the benefits that can be achieved by supplementing Stylo: time saving of up to 1.5 hours each day with the main beneficiary being women who generally were responsible for pig feeding, and a doubling of growth rates from 100 to 200 g/day.
1.2	Prepare a working document which includes the results of the surveys and key findings from other relevant sources.	A working document describing and quantifying predominant pig production and feeding systems in upland areas of Laos.	July 2006	Presentations detailing the findings of the two pig production studies were prepared for the inception workshop which was held in June 2006. The results of the surveys were published in two papers at international workshops on pig systems in Asia.

Objective 2: To determine the nutritional factors in legumes that are responsible for improved pig productivity, and evaluate best-bet legumes for their feeding value for pigs.

no.	activity	outputs/ milestones	completion date	comments
2.1	Review the current state of knowledge of pig nutrition in village situations and identify research needs in a workshop with project stakeholders and key international researchers.	Hypotheses formed on key nutritional factors responsible for the productivity improvements observed with Stylo 184 feeding.	June 2006	The production constraints identified in the pig production surveys were discussed at the inception workshop and compared to experiences from other countries. It was hypothesised that the main cause of the observed low productivity of village pigs was poor diets, which were likely to be severely deficient in protein and essential minerals, as well as high in fibre. High fibre diets have a low nutrient density and so do not supply sufficient nutrients for high productivity. This hypothesis was consistent with the observed doubling of weight gains of pigs supplemented

				with the forage legume Stylo 184.
		From the set of forage legume species known to be well adapted to the uplands of Laos, range of potentially promising legumes for pig feeding will be identified.	June 2006	A range of potentially useful legumes were selected during the inception workshop. Selection was based on known environmental adaptation to northern Laos, together with documented high protein and low fibre content.
		Plans developed for conventional and on-farm experiments.	June 2006	A strategy for experimentation and farmer evaluation of improved feeding options was developed at the inception workshop. Annual plans were developed. During the project these were reviewed frequently as feedback from the field became available. Workshop participants identified two research areas that had not been foreseen during project development but were critical to the success of the project. These were (1) growth potential and nutrition requirements of native pigs, and (2) nutritional value of locally-available feeds. This basic information was needed to understand the potential for improvement, to assess current diets and for successful diet formulation.
2.2	Conduct laboratory analysis, and feeding experiments to determine the nutritive value of Stylo 184 and other best-bet legumes as a supplementary feed for village pigs.	Key nutritional factors of best-bet legumes determined.	Dec 2008	The previously identified best bet forage legumes (including Stylo) were planted and evaluated by farmer groups at two project sites in Luang Phabang and Xieng Khouang. Samples of these plants were collected, dried and sent to the DEEDI in Brisbane for chemical analysis. The analysis showed that these legumes had a high nutritive value with protein contents ranging from 20-31%, available lysine = 0.3-0.5% (9 -13 mg/g), Ca = 0.9-3.3% and P = 0.1-0.6%. A potential constraint to their use was the relatively high fibre content, which may limit their use for young pigs as they are less able to cope with fibrous diets than older pigs. As indicated in section 2.1, the project team identified the need for analysing the nutritive value of locally-available feeds. A list of commonly used feeds was assembled at the inception workshop and updated during the project as more information became available. More than 50 feeds were collected, dried and sent to DEEDI for chemical analysis. The analyses confirmed that the local feeds that made up pig diets in Laos tended to be deficient in protein. The information from these analyses was used (i) to assess village diets for pigs and formulate improved diets, (ii) to construct nutritional tables of common pig feeds in Laos, and (iii) as basic information in the pig diet calculator tool (see activity 1.3 of the extension phase).
		Legumes with high nutritional value with potential use in village pig feeding identified.		In 2007, farmer groups evaluated 17 best bet forage legumes at two project sites, in Ban Phonesavanh, Xieng Ngeun district, Luang Phabang and in Ban Khang Done, Pek district, Xieng Khuang. Farmers selected *Vigna unguiculata, Stylosanthes guianensis* 'composite' and 'Stylo 184', *Aeschynomene histrix* BRA9690, and *Arachis pintoi* CIAT 18744 as the most suitable legumes species. In 2008, these 5 legume species were evaluated by more farmers in villages in Pek, Pak Ou and Xieng Ngeun districts. Farmers

				selected *Stylosanthes guianensis* 'composite', *Stylosanthes guianensis* CIAT 184 and *Aeschynomene histrix* BRA9690 as the most promising species. Farmers chose these species as they were: easy to plant, fast growing, quickly regrowing, easy to cut and palatable to pigs. This evaluation showed that there were many legumes that may be used for pig feeding. The main selection criteria used by farmers were related to yield and ability to fit into the existing farming system, rather than the quality of the feed. Quality difference among legumes may be important for young pigs and piglets, which have a small gut capacity and are less able to cope with more fibrous leguminous feeds.
2.3	Conduct conventional and on-farm feeding experiments to determine growth rates of pigs on diets with different levels of legume supplementation.	Impact of level of legume supplementation on pig productivity known.	June 2007	As indicated in section 2.1, the project team identified the need for an experiment to assess the growth potential of local pigs. An experiment was conducted that investigated the growth potential and protein deposition of the native Lao pig, 'Moolath,' fed a range of restricted diets at the NAFRI Livestock Research Center (LRC), Nam Suang . It showed that 'Moolath' were able to grow >500g per day when fed a nutrient-dense diet and that they deposited at least as much fat as meat. The protein deposition rate was influenced by diet. There was considerable variation between individual animals with some gaining 800 g/day. The large variability indicated that there is considerable scope for animal selection within the Moolath breed.
			Dec 2007	The second experiment was a study of invivo digestibility of Stylo 184 in exotic pigs and was carried out by John Kopinski and Soukhanh Keonouchanh at DEEDI in Brisbane. Inclusion of 23-25% Stylo in the diet increased N supply to the pigs. Young Stylo material had better nutrient digestibility than older material. This experiment showed that Stylo has potential as a protein source in pig diets, with young material being a better protein source than older material.
			June 2008	A third in-vivo experiment investigated the effect of Stylo 184 supplementation rates (0% Stylo control, 10% fresh Stylo, and 10, 20 and 30% Stylo leaf meal) on feed intake and growth of Moolath pigs at LRC, Nam Suang. Pigs fed fresh Stylo and those fed 10% Stylo leaf meal had higher weight gains (160 g/day) than pigs fed other diets (mean of 115 g/day). This result was unexpected; we had hypothesised that higher rates of Stylo would result in higher weight gains. This result appeared to be related to: 1) Piglets used in this experiment were very young (10-15 kg) and were unable to cope with the high fibre content of the 20 and 30% Stylo supplementation treatments. 2) Stylo leaf meal prepared for the experiment was from old Stylo plants rather than young Stylo and so contained a relatively high level of fibre. Although the inclusion of Stylo leaf meal increased protein content of diets, nutrient digestibility would have been reduced because of the high fibre content of the older Stylo material. This lower digestibility would have limited the benefits of Stylo inclusion for the relatively young pigs used in this experiment.

			Dec 2008	A fourth in-vivo experiment investigated the effect of different *Leucaena leucocephala* supplementation rates (0% Leucaena control treatment, 10% fresh Leucaena leaf, and 10, 20 and 30% Leucaena leaf meal) on feed intake and growth of Moolath pigs at LRC, Nam Suang. This experiment was funded by a Lao Agricultural Research Fund (LARF) grant. Pigs supplemented with 10% leaf meal had the highest daily weight (266 g/day), which was almost twice the weight gain recorded in the control treatment. Pigs supplemented with higher rates of Leucaena showed symptoms of mimosine toxicity with loss of appetite and hair loss. Leucaena leaf meal was an excellent protein source for pigs, provided its rate of inclusion was limited to less than 10%. Leucaena leaf meal may be particularly useful as a component of leaf meal mixtures that include several legumes and green feeds.
		Increased capacity of project partners in conducting on-farm experiments, data collection and analysis.	Dec 2008	Project partners and extension workers were trained in conducting "Village Learning Activities" (VLA) with farmer interest groups. VLA was a learning tool which allowed farmers (and extension workers) to evaluate new technologies by comparing these with current farmers' practice. For example, VLA compared current feeds to current feed + fresh Stylo diets by monitoring the growth and body condition of the pigs. Each VLA was designed with the farmer group and was then implemented by one or more volunteer farmers. The results were then shared and discussed with all farmers to maximise learning. A 'best practice guide' explaining the use of VLA has been produced and is attached in the Appendix. Extension workers in Pek, Pak Ou and Xieng Ngeun districts and NGO staff from other areas in northern Laos conducted numerous VLA with farmer groups comparing Stylo supplementation with traditional feeding practices. They consistently reported that supplementation of fresh Stylo and Stylo leaf meal at least doubled daily weight gains. For example, farmers in Village #10 found that young pigs had a daily growth rate of 83g on a traditional diet, 225g when the traditional diet was supplemented with fresh Stylo and 266g when supplemented with Stylo leaf meal. There were many other reports of similar results. Feedback from farmer groups who had conducted VLA on Stylo supplementation showed that (1) Stylo was an excellent pig-feed supplement for growers and fatteners; (2) Stylo had to be cut young to provide maximum benefits (2-3 weeks during the wet season); (3) Stylo was less beneficial for young pigs (those weighing less than 15 kg); and (4) the main problem with Stylo was that it had a low yield during the dry season. By December 2008, at least 15 partner staff were proficient in carrying out a range of VLA with farmer groups. This included 7 staff from PAFO and DAFO, and at least 1-2 staff from each NGO and development project partner.

Objective 3: To scale-out the integration of Stylo CIAT 184 in smallholder pig feeding systems, using Stylo 184 as a model for investigating on-farm factors that influence adoption of forage legumes.

no.	activity	outputs/ milestones	completion date	Comments
3.1	Establish a development alliance commencing with a workshop and field day for potential project partners from the development sector.	Effective partnership established with government and international development projects to scale out the feeding of Stylo 184 for village pigs to at least 1000 farm households by the end of the project.	Jul 2006 Dec 2008	In June 2006, the project invited several NGOs, development projects and government agencies to a field day and workshop to discuss the formation of a Pig Production Learning Alliance (the Alliance). The objective of the Alliance was to provide a platform for sharing information on improving village pig production in Laos. The ACIAR project offered to facilitate the Alliance, arrange 2 workshops each year and share its research results with all Alliance partners. It also offered to facilitate cross visits, and the training and mentoring of young extension workers by linking them to more experienced extension workers. From a project perspective, the Alliance would provide an avenue for building capacity of extension and development workers from a wide range of organisations to scale out Stylo supplementation and other pig production interventions. Alliance partners would provide feedback on implementation issues and so improve the relevance of research conducted by the project. Four NGOs, 2 development projects, 3 government extension units and 2 research organisations made up the original Learning Alliance partnership. In late 2008, 49 participants from 7 NGO projects, 1 development project, 2 research projects and 5 government extension units participated in the mid-season review of the Learning Alliance. By this time, Alliance partners had scaled out Stylo 184 supplementation to 1,280 households in 120 villages in 16 districts in 8 provinces in northern Laos. In comparison, the project was working directly with only 3 districts in 2 provinces. The Alliance proved to be an effective way to scale out Stylo 184 supplementation. In addition, it created an informal network of like-minded professionals from a diverse range of organisations who supported (and continue to support) each other with information, knowledge and experiences. It increased the capacity of Alliance members to evaluate new technologies with farmers and extended successful interventions to many villages. A paper describing the impacts of the Pig Systems Development Alliance was presented at the recent Innovation Asia-Pacific Symposium in Nepal (Stür et al, 2009). In 2008, ACIAR Project ASEM/2005/124 'Extension approaches to scaling out livestock production in northern Lao PDR' conducted a survey of Alliance participants to assess the effectiveness of the Alliance and identify ways of improving this approach of linking research and development partners (Stelling and Millar, 2008). .
3.2	Develop strategies and plans for the integration of Stylo 184 with development partners, and	Annual implementation plans detailing extension strategy, capacity building and	Dec 2008	Seven Pig Production Learning Alliance review and planning workshops were held from May 2006 to December 2008. These workshops provided a platform for sharing progress in improving pig production, comparing experiences and planning joint activities. The workshops were hosted by

	assist implementation through training, mentoring of staff, logistics and follow-up in the field.	resources required.		alliance partners at their project sites, so participants could visit farmers and see field activities of different alliance partners. The last mid season review workshop of the original 3-year phase of the project was held in Oudomxay province in September 2008. It was hosted by a GAA project, one of the development alliance partners. The workshop reviewed and summarized (1) the results (adoption and impact of Stylo) gathered by alliance partners, (2) the outcomes of working with farmers using Stylo and other improvements in village pig production, and (3) coordinated joint activities.
		Project partners trained in participatory approaches to scaling out, forage agronomy and pig nutrition.	Dec 2008	13 training courses were organised for alliance partners during the first three years of the project. 11 of these were held as part of alliance workshops. Before and at each workshop, alliance partners were asked to provide and prioritise a list of issues and topics in which they felt they required training. The Project then arranged appropriate trainers and developed training material to meet these identified needs. Topics included participatory approaches for working with farmers, forage agronomy, seed production of Stylo 184, pig nutrition, pig management, pig health and scaling out methodology. In 2008, in response to requests from Alliance partners two additional training courses were organised. They were held in between Alliance workshops and so provided additional opportunities for interaction among Alliance members. They addressed the issues of livestock marketing and pig diet formulation. Each training course was attended by 20-25 staff of alliance partners. In addition to formal training, the project encouraged linkages between projects. It also linked non-government alliance staff and experienced government extension workers to provide mentoring, on-site training and facilitation of cross visits. In total, 15 mentoring visits were supported by the project. NGO Alliance partners arranged 4 cross visits to advanced pig production sites of other Alliance and Project partners and NGO projects arranged several on-site training sessions by inviting experienced extension workers to their sites.
		At least 10 project partners capable to continue scaling up beyond the end of the project.		By December 2008, at least 30 staff from NGOs, PAFO, DAFO and development projects were capable of scaling out Stylo supplementation and other pig production improvements.
3.3	Monitor and evaluate the uptake of Stylo 184 with development partners.	Efficient project implementation possible because of feedback from monitoring and evaluation.	Dec 2008	Feedback on uptake of Stylo 184 supplementation and other pig production interventions was provided by alliance partners at each review and planning workshop. This feedback was the basis for discussions, evaluation and analysis of progress. For each workshop, the project provided a list of questions as a guide for reporting. These varied depending on the focus of each workshop.
		Opportunities and constraints to adoption of legume supplementation		Supplementation of village pigs with forage legumes such as Stylo 184 was an excellent entry technology for improving pig production in northern Laos. It addressed several major issues in pig production in this area: (i) it reduced labour

		identified.		demands on women by at least 1 hour per day, (ii) it was low-cost as forage legumes could be grown on-farm with minimal labour inputs, and (iii) it doubled weight gains of pigs (growers and fatteners) and so converted a marginal farm activity into an attractive farm enterprise, which then stimulated farmers to further improve pig production. Growing and using Stylo as supplementary food for pigs may be a transient technology. From here farmers may move to higher-input systems and purchase protein feeds. This has been observed in some villages where the most progressive farmers have moved to more intensive, market-oriented production systems. One of the constraints to adoption of Stylo is the need for seed, both for the initial planting and for replanting the Stylo area after 3 years of frequent cutting. The project supplied 5-20 kg Stylo seed annually to each Alliance partner and some NGOs purchased additional quantities to supply seed to farmers in their project area. While this free seed supply was necessary to scale out Stylo for pig-feed supplementation, it may have inhibited farmers from producing their own seed for replanting their Stylo areas after 3 years of use as they felt they could easily get more from NGOs. The project provided training on Stylo seed production to NGOs and extension workers and showed that Stylo seed can be collected easily by farmers themselves using a small portion (20-40 m^2) of their Stylo area. Seed production is only needed once every 3 years for replanting the original Stylo area but few farmers have felt the need to produce seed; instead they are relying on NGOs to provide additional seed. This issue of seed supply needs to be addressed.
3.4	Assess the economic, social and environmental impacts of adoption of Stylo 184 for feeding to pigs.	Benefits of feeding Stylo 184 on farm households described and quantified.	Dec 2008	An impact study baseline was established in the first year of the project (see activity 1.1). At the last mid-season workshop in September 2008, alliance partners reported on impacts of Stylo feed-supplementation in their project area. Key benefits included: 1) An improved growth rate of pigs from 100 g/day in traditional systems to up to 300 g/day for pigs (grown and fattened for sale) whose fed was supplemented with Stylo leaf meal. 2) An intensification of production systems. Approximately 80% of farmers, who adopted Stylo 184, changed pig management from scavenging to keeping pigs in pens or enclosures. This enabled farmers to take better care of animals and may have reduced the risk of the introduction and spread of diseases. 3) Farmers were able to sell more pigs each year and had a higher income from pig production.
		Environmental effects of growing and feeding Stylo 184 determined.	Dec 2008	No major positive or negative environmental effects of growing the legume Stylo 184 have been observed. Although most farmers grew Stylo on sloping land (as they do all of their non-rice crops), the planting of Stylo in densely sown rows along the contour effectively controlled water runoff and no soil erosion was observed. Being a vigorously growing and freely nodulating legume, Stylo may have had some positive effects on soil fertility and certainly no negative environmental effects were

				observed or reported by Alliance partners. In the longer term, an emerging issue may be the need for effluent management associated with more intensive pig production systems. In the majority of cases, production units are still too small to constitute a major hazard but this will become an issue as farmers produce more pigs and/or individual production units are sited adjacent to each other in a particular area of the village. There is an opportunity to address this issue as production systems intensify and find practical ways of recycling nutrients of pig effluents to agricultural fields. Some initial evaluations of composting systems were encouraging but there is a need to evaluate potential disease and parasite implications of using pig effluent on crops.

Objective 4: To develop guidelines for scaling out of improved pig feeding systems using forage legumes.

no.	activity	outputs/ milestones	completion date	Comments
4.1	Synthesise the results of activities from Objectives 1, 2 and 3.	Papers detailing the results of project activities prepared, ready for presentation at the final project workshop.	Dec 2008	Six presentations highlighting the results of the project were prepared for the December 2008 project workshop: 1) Nutritive value of local feed - implications for village pig production. 2) The potential of other forage legumes for feeding local pigs. 3) Growth performance of the native Lao pig, Moolath on high quality diets. 4) The effect of Stylo 184 supplementation on growth of Moolath pigs. 5) The nutritive value for pigs of *Stylosanthes guianensis* CIAT 184. 6) The outcomes of scaling out Stylo 184 for feeding village pigs.
4.2	Conduct a workshop to discuss project outcomes and develop guidelines for the scaling out of Stylo 184 and other best-bet legumes for supplementation of village pigs.	Development partners feel ownership of the technology.	Dec 2008	The final workshop of the original 3-year phase was held in December 2008 in Luang Phabang. 31 participants attended the workshop including participants from NAFRI (7), CIAT (3), DLF (2), NAFES (2), PAFO Xieng Khuang (3), PAFO Luang Phabang (4), ACIAR (1), DEEDI (1) and NGOs and development projects (8). A copy of the presentations made at the workshop is available on request.

		Guidelines finalised and working document published.	Dec 2008	The project has produced a series of 'Best Practice Guides' on 'Pig Fattening' and 'How to conduct Village Learning Activities'. Copies are attached in the Appendix. A further two guides are available in draft form and will be finalised in the next few months. The first is the Pig DIET CALCULATOR, which consists of a manual with nutritional information, instructions, and a spreadsheet on which users can calculate appropriate diets for their animals. The first edition for general use will be available by December 2010. The second looks at the nutrient composition of the local Lao pig feeds, forage legumes and selected grain legumes. This publication will include descriptions of feeds and their chemical composition. Some of the key analysis results are not yet available but should be ready before the end of 2010 and the booklet will then be completed.

7.2 Extension phase (January 2009 – August 2010)

Objective 1: To improve the capacity of development practitioners to scale-out the use of Stylo 184 and other forage legumes as a high-quality supplement to protein deficient, traditional pig diets in smallholder farming systems.

no.	activity	outputs/ milestones	completion date	Comments
1.1	Expand the existing development learning alliance to other interested researchers and development practitioners in Laos	Development practitioners from at least 10 projects (NGOs, Lao government and donor projects) from different provinces in Laos participate in the development alliance.	Dec 09	In addition to existing Alliance partners, four new projects / organisations joined the Learning Alliance. These were CARE Phongsaly, RMDA Muang Sing in Luang Namtha, CCL Phongsaly and ADRA Muang Long in Luang Namtha. In 2010, staff of 10 NGO projects, 1 ADB project, 2 PAFO, 3 DAFO extension offices and 2 national government organisations (NAFRI and NAFES) were active members of the Learning Alliance.
1.2	Support alliance partners by facilitating workshops to exchange information and experiences, providing access to information on how to improve pig feeding and management, facilitating linkages between experienced and less experienced practitioners and by providing training based on needs identified by alliance partners.	Hold 2 review and planning workshops per year	Mar 09, Oct 09, Mar 10	The first review and planning workshop for 2009 was held in Luang Phabang on 31 March to 2 April. The theme of the workshop was Sow-Piglet production. Participants presented information on sow-piglet production systems in their project areas, and feedback from farmers on problems and opportunities for improving these systems. The group discussed and prioritised problems and opportunities, and agreed on options for testing in 2009. The 2009 mid-season review was held in Xieng Khouang on 21 to 23 October 2009. The focus of the workshop was to review progress in improving sow-piglet nutrition and management, and discuss activities for the following 6 months. A special session was held on private animal health service providers, facilitated by the CIAT-SADU project. A total of 35 participants from 7 NGOs (and associated DAFO staff), 3 DAFO extension offices, 2 PAFO offices, the ADB-funded Livestock Development Project (LDP), NAFRI, NAFES (ACIAR-funded EASLP project) and CIAT (Legume for Pigs project and SADU) attended the workshop. The 2010 review and planning workshop was held

				in Muang Sing, Luang Namtha on 29-31 March 2010. This workshop was hosted by the RDMA project, and reviewed experiences in introducing improved sow-piglet technologies, and the adoption and impact of the project. Despite the remote location, 43 staff of 6 NGOs (and collaborating DAFO staff), 3 DAFO extension offices, 2 PAFO offices, the LDP, NAFRI, NAFES (ACIAR-funded EASLP project) and CIAT (Legume for Pigs project and SADU) managed to attend this workshop.
		Conduct at least 5 cross visits per year between different alliance partners.	5 visits before the end of 2009	Six cross visits were organised by Alliance partners to each other's sites (LDP, ADRA, and World Vision). Additionally, a further 3 cross visits to project sites were arranged for other development projects (including the SIDA-NAFRI Northern Research and Development Project).
		Hold at least 2 training courses on topics requested by alliance partners. These will be organised in between alliance workshops to increase opportunities for interaction among alliance partners	Jul 09, May 10	Four training courses were held during the extension phase. The focus of the first training course was options for improving sow and piglet nutrition and management. The course was held from 29 June - 1 July 2009 at the Livestock Research Center, Nam Suang near Vientiane. Trainers included staff of the Pig Breeding Station and Livestock Research Center of NAFRI, Mr. Gavin Varney and CIAT staff. 34 participants from NGOs, government extension offices and NAFRI attended the training course. During the course, participants agreed on the range of interventions that may be introduced to farmers practicing sow-piglet production. A second training course was organised jointly by the project and ADRA. The course was held in Luang Namtha province from 1 - 7 March 2010. 37 DAFO extension workers, project staff and key farmers participated in the training course which focussed on problems encountered with sow-piglet production in Luang Namtha. The subject of the third training course was 'Pig nutrition and diet formulation' and was held from 3-7 May 2010 in Luang Phabang. 27 participants from NGOs and government extension services attended this training. As part of the training course, the newly developed Diet Calculator was introduced to participants and feedback on possible improvements was collected. A fourth training course was organised at LRC Nam Suang from 23-27 August 2010. This training course reinforced all of the key findings of the project on improving village pig production in Laos. 26 participants from 6 NGO project and DAFO extension office participated in this training.
		Government and NGO staff hold regular provincial or regional meetings among to encourage joint activities	Every 1-2 months	Alliance partners often discussed the desirability of increasing the interaction among NGO staff (and other projects and DAFO extension staff) operating in the same geographical area. They felt that a major benefit of the Alliance had been to bring together organisations that don't usually meet. They learnt a lot from each other and felt that similar platforms for sharing experiences, learning and planning at local level (e.g. districts or provinces) would be very beneficial. The project encouraged Alliance partners to organise such platforms but did not organise these for them. Some initiatives of organising such local platforms were reported but, to our knowledge, no formal

				platforms involving multiple partners have been established. Several NGOs now hold more regular monthly or quarterly meetings between NGO and DAFO staff in their district. Examples include the WorldVision Xieng Ngeun, CARE in Phongsaly, ADRA in Luang Namtha and GAA in Oudomxay and Phongsaly.
1.3	Improve existing and develop new information material and practical tools that assist farmers and extension workers to combine locally-available feeds with high-protein legumes to formulate more nutritious pig diets throughout the year	Publish nutritional tables of common pig feeds and legumes available in Laos	Aug 10	Chemical analyses of feeds were carried out during the project by DEEDI in Brisbane and most of the results are now available. Draft nutritional tables have been prepared for publication, but we are still waiting for some chemical analysis results which we would like to include in the final version. These relate to a small number of feed samples which are still being processed by DEEDI in Brisbane; these include some repeat samples of feeds with high potential. For example, the first sample of brewer's waste from village rice wine production had extremely high protein content and may have potential as a protein supplement for weaners and young growers, however, the content of one of the key amino acids, Lysine, was low. Before jumping to conclusions about the potential use of this brewer's waste as a protein concentrate, we collected another sample to confirm the results. There are several other samples that are also being repeated to confirm interesting results. We hope that the remaining analysis results will be available soon and hope to finalise and publish the nutritional tables by late 2010.
		Develop a simple tool for use by farmers and extension workers to formulate effective pigs diets	Mar 10	A small project-internal workshop was held in the first week of December 2009 to discuss the development of a simple diet calculator and example diets for village pig producers in Laos. Based on this discussion, a simple diet spreadsheet-based diet calculator was developed by John Kopinski using the results of the chemical analyses of Lao feeds, and estimating the digestibility and nutrient availability of the various Lao feeds the nutrient requirements of local pigs. The diet calculator was tested with extension workers and other members of the Learning Alliance during a workshop on pig nutrition and diet calculation. Numerous example diets were formulated by extension workers for use by farmers. The diet calculator proved to be an excellent training tool. Several issues emerged during the development and use of the diet calculator: (1) We had to include assumptions about the nutrient requirements of local Moolath pigs as there is little information available on the energy and protein (lysine) requirements of Moolath pigs at different stages of growth. It was also necessary to make assumptions about acceptable levels of fibre in the diet. The project showed that Moolath pigs were able to cope with high-fibre diets much better that exotic pigs, however, more experiments are required to confidently predict the nutritional value of diets with different fibre levels. (2) Assumptions had to be made about the energy and protein (particularly lysine) digestibility of the various feeds in Moolath pigs. While there is good information available for commonly used feed ingredients for exotic pigs, there is little information on local pig breeds such as Moolath. Also, generally, there is little information on the

				digestibility of green feeds, particularly of forage legumes. Changes in digestibility levels have big impacts on the nutritional quality of diets and research is needed to improve the assumptions made in the current version of the diet calculator. The current version of the diet calculator is available.
1.4	Monitor and evaluate the adoption of forage legumes and improved pig feeding and management systems with alliance partners	Extent of adoption of improved pig feeding practices known and adoption pathways understood by alliance partners	Mar 09, Sep 09, Mar 10	Monitoring and evaluation of adoption of forage legumes and improved feeding and management systems was conducted by project and Alliance partners and reported at Alliance Workshops. These workshops provided an opportunity to review progress of adoption of Stylo and other improvements, and discuss implementation problems. Issues identified by partners were discussed during the workshop and, if needed, followed up with a training course designed to resolve and address these issues. Village Learning Activities, cross visits and on-site trainings were some of the tools used to scale out successful technologies and methods. In the most recent Alliance workshop in March 2010, partners reported that just over 1,200 households had adopted Stylo and improved pig feeding and management practices. Two useful lessons were highlighted by Alliance partners during this meeting: • Using Stylo 184 as an entry point for improving the feeding systems, increased productivity and encouraged farmers to better manage their pigs. Many farmers then became more market-oriented, and produced pigs for sale on a regular basis. • Village learning activities provided farmer groups with a tool to learn about the new improved feeding systems, such as the use of Stylo and leaf meal mixtures (Stylo + other green leaf) for fattening, and management improvements. The number of households growing Stylo dropped slightly in 2009. Alliance partners felt that this was related to the high price of maize in 2007-8, which encouraged many farmers to reduce pig production, stop planting Stylo and instead plant maize. When the maize price collapsed in 2009, many farmers returned to pig production and there were many farmers who requested seed for planting Stylo in the 2010 wet season. This situation is likely to occur again when prices of a particular cash crop is high and entices farmers to concentrate on producing this high value crop. Another reason for the decline in farmers growing Stylo was related to its life cycle. Stylo plants produce good yields for 3-4 years and then production from individual plants starts to decline and the plant eventually dies. At this stage, farmers need to produce seed so they can replant Stylo. Many farmers did not do this and suddenly found that their Stylo crop was no longer productive. A large proportion of farmers had reached this stage in 2009 and there have been many requests for seed for 2010. The project tried to address this issue by discussing the Stylo lifecycle but for many farmers (and extension and development workers) 2009 was the first time that they experienced this on their farms. The project discussed seed production and

				supply, and held several training sessions on simple ways for farmers to produce their own Stylo, but the effectiveness of these activities was negated by free seed supplies from many development project and NGOs (and the project, even if it only supplied small amounts).

Objective 2: To improve the survival and growth of piglets in smallholder production systems through improved protein nutrition derived from forage and dual-purpose legumes

no.	activity	outputs/ milestones	completion date	Comments
2.1	Identify practical options for protein supplementation of lactating sows and weaned piglets	Working paper discussing practical options based on published information and consultations with researchers and extension workers in related projects, alliance partners and farmers.	Jul 09	Practical options for protein supplementation were identified and discussed with project and learning alliance partners during the March 2009 Alliance workshop, and finalised during a training course on sow-piglet nutrition and management LRC, Nam Suang between 29 June and 1 July 2009. Options were presented in a series of PowerPoint presentations at the training course and the most promising options were selected by participants for on-farm testing. The most promising options identified for weaners were soy bean meal and commercial supplements, while Stylo (with or without soy bean supplementation) was suggested for lactating sows. These options were evaluated with farmers by project and Alliance partners in the following year.
2.2	Monitor piglet survival and growth in 3 villages to develop a better understanding of sow-piglet production and provide baseline data for assessing the success of interventions	Key data on survival and growth of piglets in village situations	Jun 2010	It proved to be difficult to reliably monitor piglet growth and survival of individual pigs in remote villages. We therefore decided on a different approach and conducted a one-off detailed survey in project district asking farmers to recall this information for particular sows and their litter. Piglet mortality prior to weaning was of major concern to farmers. The survey showed that mortality rates ranged from 53-55% in Hmong and Khmu villages, who reared their pigs in enclosures and/or scavenging systems, to 13% in Lao-loum villages, who raised their pigs in pens. The management system clearly had a major effect on piglet mortality. This was particularly apparent in a village where farmers had recently changed from a free-scavenging to a confined system (mostly enclosures). In this village, more than 90% of piglet had died and this appeared to be related to poor understanding of what pigs need in terms of feed and management. The most common causes of death reported by farmers were disease outbreak and diarrhoea. These may have been related to observed poor hygiene, lack of disease preventive measures and poor nutrition of sows during gestation and lactation. Growth rates of piglets were low, especially during the period from weaning to 20kg. During this period, the growth rates ranged from 20 to 35 g/day. Pigs larger than 20 kg had higher growth rates of 100-150 g/day.
2.3	Conduct *in vivo* feeding experiments and village learning activities with alliance partners to evaluate the effect	Village learning activities that evaluate different options for protein supplementation conducted in at	Aug 10	Project and Alliance partners evaluated protein feed supplementation options for weaners with farmers groups in their area. The main interventions evaluated were supplementation with either soy bean meal or commercial concentrate at different rates. These showed that protein supplementation of either soy bean meal or

	of legumes supplementation on piglet survival and growth before and after weaning	least 10 villages per year		commercial concentrate were highly effective and increased growth rates of weaners and young growers to up to 100 g/day. This compared to 10-20 g/day for piglets that were not supplemented. This clearly showed that protein was the main limiting nutrient for young pigs. Stylo, and other green feeds, cannot not supply the amount of protein needed to ensure good growth of weaners, and other high-protein sources such as soybean meal are required. Two experiments were carried out at LRC, Nam Suang in 2009 and early 2010. The first experiment investigated the effect of 3 levels of protein supplementation during lactation of 12 Moolath sows on both the growth of piglets and body condition of sows. Diets consisted of a (i) basal diet of rice bran (75%) and maize (25%) - control; (ii) control diet with 20% Stylo leaf meal; (iii) control diet with 20% Soy bean meal. Diets were fed ad libitum. The experiment used gilts which were joined with one of two boars when they reached a weight of at least 50 kg and had gone through at least two heat periods. Unfortunately, the results of the experiment were inconclusive as half of the sows developed hind leg lameness 2-3 weeks prior to giving birth and could no longer get up and move around the pen. We suspect that the condition was femoral head epiphysiolysis, which may have been caused by a combination of the relatively high growth rates (too fat and heavy during pregnancy), the young age of gilts and hard concrete floors in pig pens. Insufficient number of sows and piglets, and high animal variability resulted in inconclusive results. Briefly, the mean growth rate of piglets ranged from 71 – 86 g/day for the different sow diet treatments, and all sows lost body weight during lactation. While the lowest weight loss (6 kg) was for the only sow left in the soy bean diet treatment, variability among other healthy sows was high (14 – 42 kg) and no definite conclusions could be drawn. The relatively small variation in growth rate of piglets may have been related to the very good body condition of sows at farrowing, which allowed them to use body reserves to supply milk to their piglets. This situation would be different in villages where often sows are thin at farrowing, have limited body reserves and may thus not be able to supply sufficient milk to their offspring. The second experiment (partially funded by a LARF grant) evaluated the effect of protein (8% or 16% crude protein) and fibre levels (8% or 20% crude fibre) in diets fed ad libitum to weaners. Protein had an overriding effect on growth rates of weaners with growth rates of 120 g/day (high protein + low fibre), 100g/day (high protein + high fibre), 10 g/day (low protein + high fibre) and 3 g/day (low protein + low fibre) for the 4 treatment groups. The low protein diets were typical of village diets and explain the poor performance of weaners in village situations. Protein is the key to improving growth of weaners in village pig production. The experiment also showed that Moolath piglets were able to cope with quite high fibre levels in the diet provided that the protein level was adequate.

8 Key results and discussion

Key results are presented in two parts:

8.1 The research component: Using forage legumes as a protein supplement for improving the growth and productivity of village pigs in Laos.

8.2 The scaling out component: Facilitating a Learning Alliance with multiple development partners.

8.1 The research component: Using forage legumes as a protein supplement for improving the growth and productivity of village pigs in Laos

8.1.1 Current village pig production systems and their productivity

The project conducted two surveys designed to described pig production and feeding systems and estimate productivity of pig systems in village situations. The first was a small survey of a range of villages in the project districts and had the objective of providing an overview of production and feeding systems, and identifying key issues at the start of the project. The second survey was a larger study designed to provide more detailed information on the productivity of village pig systems, particularly on sow productivity and piglet mortality, and identify the factors driving the observed change to more confined systems of pig production. This survey was conducted during the extension phase of the project.

Pig production system survey, March 2006

The first survey was conducted early in the project and described the prevailing pig production systems in the three districts where the project was working with DAFO extension officers, Pak Ou and Xieng Ngeun districts in Luang Phabang and in Pek district in Xieng Khuang. A total of six villages were selected for the survey by local DAFO staff on the basis that (i) pig raising was an important household activity, (ii) the range of village represented the range of ethnic groups in the district, and (iii) that the range of villages covered the range of production systems present in the district. The survey was conducted from 13 March to 12 April 2006, by a team consisting of project staff, and national partners from NAFRI, PAFO and DAFO. First, a village meeting was organised in each survey village to gain a general understanding of pig management and the importance of pig production to farmers' livelihoods. Following these village meetings, a total of 30 households were randomly selected from a list of all pig-raising households in each village for individual household surveys using a semi-structured questionnaire. The team encouraged participation of women in the village discussions as the raising of small animals (such as pigs and poultry) was usually the responsibility of women. The 30 interviewed households included 13 Hmong, 11 Lao-loum and 6 Khmu families. In 12 households, women were the main respondent and participation of both women and men was encouraged during interviews.

The survey showed that there were three main pig production systems: (1) Semi-scavenging (free scavenging except during cropping season when pigs were confined in enclosures), (2) Confining pigs in enclosures (all year), and (3) Confining pigs in pens (all year). The type of system employed was related to the purpose of raising pigs and ethnicity of the producer. The two main purposes of raising pigs were: (1) Producing piglets for sale, and (2) Grow and fatten pigs for sale. Half of the respondents were engaged mainly in fattening while the other half was producing piglets (Table 2). All Lao-loum producers, except one, were engaged in pig fattening, buying weaned piglets from

piglet producers and fattening for sale. Most Hmong and two thirds of Khmu producers were producing piglets for sale. Just over 50% of producers were keeping pigs in pens (Table 3); these were mainly producers fattening pigs for sale while piglet producers mostly kept sows and piglets in enclosures or used a semi-scavenging system.

Table 2. Primary purpose of pig production, stratified by ethnicity of producer

Ethnicity of producer	Households engaged in	
	Piglet production	Fattening
Hmong (n=13)	10	3
Khmu (n=6)	4	2
Lao-loum (n=11)	1	10

Table 3. Production systems, stratified by ethnicity of producer

Ethnicity of producer	Households using		
	Semi-scavenging	Enclosure	Pens
Hmong	4	6	3
Khmu	1	2	3
Lao-loum	0	1	10

All respondents kept native pigs; these were either Moo Lao-soung (Hmong producers) or Moolath (Khmu and most Lao-loum producers). These types were well adapted to free range systems, where they could scavenge part of their feed. All local breeds are high-fat, swaybacked breeds, which produce more fat than meat. In remote villages, pig fat has been the only available oil for cooking and thus has been (and still is) very important for people living in remote areas.

Farmers producing piglets mostly kept 1-2 sows (mean=1.3) and, on average, had 5-6 piglets (mean = 5.5). Many piglet producers also fattened 1-2 pigs (mean=1.4) they had not sold or because the producers especially selected the piglets for fattening for home consumption during special traditional ceremonies (such as New Year, weddings or religious celebrations). Farmers, who specialised in fattening pigs for sale, on average, produced 2-3 pigs per fattening cycle. Not every farmer kept a boar. In most villages, there were only few boars available for servicing sows and in some village no boars were available and the service had to come from another village.

The main feeds for pigs were planted crops such as maize and cassava (and to a lesser extent canna and sweet potato with leaves fed to pigs as green feed), crop by-products such as rice bran and broken rice, and green feed occurring naturally in local areas. All producers reported that they fed rice bran and most fed green feed (leaves and stems) to their pigs (Table 4). In Lao-loum villages producers fed mainly rice bran and green feeds, and some added broken rice or brewery waste from rice wine production. Lao-loum tended to produce lowland rice as their main crop and income source, and made use of rice bran, a by-product of rice production, for pig production. In Hmong and Khmu villages (upland and mountainous agriculture) farmers grew less rice (enough for their family only) and had only small amounts of rice bran available. They fed mainly maize and/or cassava with some rice bran and green feeds.

Table 4. Feed resources for pigs, grouped by ethnicity of producers

Feed resources	Number of respondents		
	Lao-loum	Hmong	Khmu
	(n = 11)	(n = 13)	(n = 6)
Rice bran	11	13	6
Broken rice	5	0	0
Maize	2	11	5
Cassava	2	12	2
Green feed	9	13	6

Feeds were not available year-round and could not be stored safely for long periods, therefore farmers reported that they fed whatever they had available at the time and that this varied with the season. Most farmers fed pigs twice a day, in the morning and late afternoon. All pigs received the same diet irrespective of age, and most farmers fed all their pigs as one group. This would have had the consequence that larger and dominant pigs were able to secure a larger amount of feed than smaller or more timid animals.

Respondents reported that a household spent up to 3 hours each day collecting natural green feeds and cooking feed for pigs (Table 5). This work was almost invariably done by the women with some assistance from men and children. Feeding pigs, particularly collecting green feeds and preparing it for pigs, was a very time-consuming activity.

Table 5. Time spent collecting and preparing feed for pigs (minutes/day)

Activity	Wet season		Dry season	
	Mean	Range	Mean	Range
Collecting feed	113	30-120	126	30-180
Preparing and cooking	57	30-60	56	30-60

The survey estimated growth rate of pigs in fattening systems by establishing the initial weight of pigs when they entered the fattening pen, the final weight at sale and the length of time taken for fattening. The mean length of the fattening cycle of pigs fattened for sale was 15.4 months which resulted in a calculated ADG of 111g (Table 6). Then growth rate of pigs fattened by Hmong farmers for traditional feasts was very similar at 110 g per day.

Table 6. Growth rates of pigs fattened for sale

	Fattening pigs for sale (n = 16)		Fattening pigs for traditional feasts (Hmong producers) (n = 13)	
	Mean	Range	Mean	Range
Length of fattening period (months)	15.4	7-24	21.3	8-24
Initial weight (kg)	12.7	6-20	43.3	30-50
Final weight (kg)	63	40-100	117	60-130
Average daily gain (g)	111	83-195	108	83-145

Sows produced, on average, 1.5 litters per year. Mean litter size was 7.4 piglets per litter, but only 3.9 piglets survived to weaning. Farmers reported that piglets that died were very thin and had diarrhoea. Squashing of piglets was not mentioned as a cause of mortality.

Disease epidemics were a major concern for producers. All villages reported disease outbreaks within the last few years that killed 90% or more pigs in the village.

It was concluded that major improvements in pig productivity may be achieved by addressing the three main constraints of (i) poor feeds and feeding systems (quality and quantity), (ii) high mortality of piglets, and (iii) outbreak of disease epidemics.

Survey of sow-piglet productivity, July 2009

This study was undertaken in six villages in the target districts of the project in July 2009. The villages and districts were:

- Ban Fai and Ban Hadkham in Pak Ou district, Luang Phabang.
- Ban Nong On and Ban Phou Khua in Xieng Ngeun district, Luang Phabang.
- Ban Khang Yao and Ban Nasala in Pek district, Xieng Khouang.

The objectives of the survey were to provide information on (i) how and why pig production systems were changing (as there appeared to be a trend towards more confinement), and (ii) productivity of sow-piglet production, with emphasis on piglet mortality and growth. High piglet mortality (reports of 50% of piglets dying before

weaning) and slow growth of piglets were major concerns for farmers. Improvements in survival and growth could create an opportunity to dramatically improve pig productivity.

Villages were selected after consultation with the District Agricultural and Forestry Office, district staff and heads of village, and selection was based on the size of the pig population in the village, number of households raising pigs and an emphasis on sow-piglet production. All possible project target villages were ranked according to the total population of pigs, and the two villages with the highest pig population in each district were selected for the survey. The project had already worked with farmers in some of the selected villages to improve pig fattening and farmers had recently started to produce their own piglets (e.g. Ban Fai). Other villages were new villages with a strong emphasis on piglet production (e.g. Ban Phou Khua); in these villages DAFO extension workers had already extended some of the project outcomes and had already made some improvements to village pig production. In each village 15 pig-raising households, or 10 % of pig raising households, whichever was the lesser/greater number, were randomly selected from amongst all pig raisers in the village. In total 112 respondents were interviewed. These included 58 households of Lao-Tai (Lao-loum and Leu), 38 households of Mon-Khmer (Khmu), and 16 households of Hmong-Mien (Hmong) ethnicity.

Two methods were used to collect primary information: (i) farmer group meetings, followed by (ii) household surveys using a semi-structured questionnaire. The group meeting was used for collecting general information about the main agriculture and livestock activities in the village, as well as pig production systems. The individual household surveys were used to collect details on management, productivity, problems and benefits in raising pigs. This information, gathered through face to face interviews, was based on a semi-structured questionnaire and probing questions to gain a deeper understanding of pig-rearing issues. Topics covered in the questionnaire included rearing and management systems (how did they keep their pigs, had they changed to other systems and why; feed and feeding systems), growth rates, reproductive performance and growth and mortality of piglets.

The survey showed that farmers raised pigs for two main purposes, piglet production and fattening pigs (weaners, growers and fatteners) for sale. Many households (40.2 %) kept pigs for both purposes. The average number of pigs per household was low and differed depending on the purpose of production (Table 7).

Table 7. Size of household pig herd by production purpose

Pig type	Piglet production (n=33)		Fattening for sale (n=34)		Mixed Piglets & fattening (n=45)	
	n	Mean	n	Mean	n	Mean
Sows	33	1.5 ±0.87[1]	0	0.0	45	1.7±1.04
Boars	7	1.0 ±0.37	1	1.0	9	1.0±0.33
Piglets	33	6.7 ±5.61	0	0.0	45	6.5±3.50
Growers / Fatteners	1	3.0	34	4.9 ±5.81	45	3.9±2.66

[1] Standard deviation

There were differences among ethnic groups in term of production purpose. The Lao-loum and Lue groups (50%) raised pigs primarily for fattening for sale, while the Khmu and Hmong (52 and 56%) were engaged more in piglet production. However, all ethnic groups (43% of Lao-loum and Leu, and 37% for both Khmu and Hmong) had started to move to mixed production systems involving sow-piglet production and fattening.

The survey found that around 82 % of households raised indigenous native pigs and the rest raise exotic, crossbreds, or both crossbred and exotic pigs. The latter households were mainly from the Lao-loum group (33%) living close to the large towns, and engaged in more market-oriented production systems. The Khmu and Hmong kept almost only native pigs (97 and 100%, respectively). Moolath and Moo Hmong, were the major indigenous breeds (or types) in the study area.

The survey revealed that farmers raised pigs in three production systems: free scavenging, semi-scavenging and year-round confinement. Around 90 % of households kept pigs in year-round confinement, either in pens or enclosures. The Lao-loum group, who raised pigs mainly for fattening for sale, kept pigs in pens (100%), while other ethnic groups engaged with other systems (Table 8).

Table 8. Distribution of production systems by ethnic group

Ethnicity	Total	Production system							
		Free-scavenging		Semi-scavenging		Year-round confinement			
						Enclosure		Pen	
	(n)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Lao-loum	58	0	0	0	0	0	0	58	100
Khmu	38	4	11	7	18	13	34	14	36
Hmong	16	0	0	0	0	15	94	1	6

In the past, free scavenging was very common in Khmu and Hmong villages, however, farmers from these ethnic groups in project target villages have moved to more confined production systems. Farmers reported that the system change was driven by five main factors: village regulations (80% of respondents), intensity of crop production (60%), disease outbreaks (45%), improved village sanitation (28%) and the ease of provision of better management in confinement systems (20%).

The farmers in the surveyed villages commonly used agricultural by-products and other locally available feeds for feeding pigs. These feed resources were mainly rice bran, distiller's waste, maize, cassava root and green plant material (leaves and tops of crops).

Rice bran was used by almost all the farmers surveyed (99.1 %). Maize, cassava, paper mulberry (*Morus papyrifera*) and a taro-type plant called Bon (*Colocasia esculenta*) were also often used. Other feeds, such as broken rice, pumpkin fruits, banana stems, distiller's waste and green plant material (leaves of "Yahuabin" (*Crassocephalum crepidioides*), sweet potato leaves and Stylo 184) were used, depending on availability. Commercial feed was used by 7.1 % of the interviewed farmers.

The type of feed used in the surveyed area depended mainly on availability, traditions and ethnicity. The Lao-loum, who often live in lowland areas and have larger surpluses of rice, used more rice bran, broken rice, local alcohol distiller's waste and various green plant materials. All households that used commercial feed were from the Lao-loum group only. The other two groups used mixtures of available feedstuffs, including rice bran, maize, cassava and green plant material.

Around 95.5 % of surveyed farmers fed their pigs twice a day, in the morning and in the afternoon. About 57 % of farmers fed all their pigs together, while 43 % separated piglets from larger pigs and gave them better quality feeds.

All interviewed farmers provided water to pigs during feeding time as a mixture with feed. Around 48 % of farmers also supplied extra water during the day, but the number of time per day differed from farmer to farmer. Fifty percent of these farmers supplied extra water only once per day, 22% twice per day and 28% all the time from water nipples. Extra provision of water to pigs was more common in Lao-loum households (83%), compared with Khmu households (16%) and Hmong households (0%).

Women and children were commonly responsible for pig feeding and husbandry. Only 5% of the interviewed households mentioned that the men collected feed for their pigs. Generally, men were not involved in any of the other activities necessary for feeding pigs, such as cooking, giving the animals feed and cleaning the pens.

The average daily growth rate of weaned pigs in the survey villages ranged from 107-204 g/day for different production systems (Table 9). It was highest in villages where farmers usually practiced free-scavenging and penning (approx. 200 g/day) and lowest in households where farmers practiced semi-scavenging and enclosure systems (approx.

110 g/day). At first glance the high growth rate of pigs fattened in villages where farmers practiced free-scavenging systems was unexpected. In fact, these animals were actually fattened in pens for special purposes such as weddings and New Year celebrations. They were already quite big by the time they were put into pens and fattened for relatively short periods. Farmers raised only few animals in this way and fed them well.

Table 9. Growth rates of pigs fattened in pens in smallholder systems by production system

	Production systems			
	Penning (n=66)	Enclosure (n=16)	Free-scavenging (n=3)	Semi-scavenging (n=4)
Fattening period, month	10.1 ± 4.70	18.3 ± 6.50	3.7 ± 1.15	19.3 ± 2.21
Initial weight, kg	14.1 ± 9.40	30.8 ± 21.75	35.0 ± 5.00	11.2 ± 2.98
Final weight, kg	66.2 ± 15.50	89.3 ± 26.45	56.7 ± 5.77	72.5 ± 9.53
Average daily gain, g	195 ± 79.0	114 ± 40.2	204 ± 32.7	107 ± 14.1

* Standard deviation

There was also a difference in growth rates between the different breeds of pigs (Table 10). Exotic and cross bred pigs grew faster than local pigs. Exotic and cross-bred pigs were raised mostly by farmers near city markets who had already adopted improved feeding and husbandry practices.

Table 10. Growth rates of pigs fattening in pens in smallholder systems by breed

	Pig breed		
	Local (n=63)	Exotic (n=11)	Crossbreed (n=12)
Fattening period, month	13 ± 6.7[1]	8 ± 2.3	11 ± 5.0
Initial weight, kg	20.7 ± 16.1	11.6 ± 4.8	11.7 ± 7.8
Final weight, kg	71.0 ± 21.5	73.7 ± 13.9	60.9 ± 15.4
Average daily gain, g	129 ±	259 ±	149 ±

[1] Standard deviation

Reproductive performance of pigs was similar irrespective of production systems (Table 11). The only significant difference was for the percentage of surviving piglets per litter at weaning, which was highest in the penning system (79 %) and much lower in the enclosure (44%), free-scavenging (34%) and semi-scavenging (41%) systems.

Table 11. Reproductive performance of sows by production system

	Production systems			
	Penning (n=47)	Enclosure (n=28)	Free-scavenging (n=4)	Semi-scavenging (n=7)
No. of litters per year	1.5 ± 0.49[1]	1.2 ± 0.42	1.0 ± 0.33	1.3 ± 0.48
No. of piglets per litter	7.9 ± 1.64	6.8 ± 1.26	8.0 ± 0.81	7.3 ± 0.95
No. of surviving piglets	6.2 ± 2.76	3.0 ± 1.38	2.7 ± 1.70	3.0 ± 2.53
Weaning age, months	2.6 ± 1.22	3.6 ± 0.67	3.5 ± 0.57	3.3 ± 0.48
Weaning weight, kg	7.9 ± 2.80	8.7 ± 2.43	8.0 ± 1.63	7.0 ± 1.15
Age at 1st service, months	7.9 ± 1.80	6.9 ± 2.21	7.2 ± 0.50	6.7 ± 0.75
Weight at 1st service, kg	46.5 ± 12.97	29.4 ± 10.01	38.7 ± 2.50	40.0 ± 6.45
Duration of using sow, years	2.8 ± 1.05	3.8 ± 1.31	2.5 ± 1.29	2.4 ± 1.27

[1] Standard deviation

There were also differences in reproductive performance between the breeds of pigs used by farmers. Exotic sows had a higher reproductive performance than local breeds and crossbreds (Table 12). As discussed earlier, farmers raising 'improved' breeds tended to be those near city markets with improved animal husbandry practices.

Table 12. Reproductive performance of sows by breed

	Breed		
	Local (n=63)	Exotic (n=11)	Crossbreed (n=12)
No. of litters per year	1.3 ± 0.46	1.7 ± 0.41	1.5 ± 0.48
No. of piglets per litter	7.2 ± 1.36	9.0 ± 1.48	5.8 ± 2.27
No. of surviving piglets	3.9 ± 2.29	8.5 ± 2.29	5.8 ± 2.72
Weaning age, months	3.4 ± 0.90	1.4 ± 0.33	2.2 ± 0.81
Weaning weight, kg	7.7 ± 2.48	9.0 ± 2.77	9.0 ± 2.42
Age at 1st service, months	7.1 ± 1.79	7.8 ±1.32	9.0 ± 2.19
Weight at 1st service, kg	34.9 ± 9.64	60.4 ± 11.71	46.2 ± 12.81
Duration of using sow, years	3.3 ± 1.36	2.5 ± 0.68	2.7 ± 0.75

* Standard deviation

Farmers were also asked about the main problems they faced with pig production. The main problems they identified were outbreaks of disease, slow growth rates, difficulty in finding feed and high mortality of piglets (Table 13). In addition to these, several other problems were mentioned, such as insufficient funds to expand pig production, lack of labour to properly manage pigs and the high cost of commercial feed.

Table 13. Pig production constraints in smallholder production in survey villages (n=112)

Problem	Pig production constraint ranking			Mentioned by respondents %[1]
	First	Second	Third	
Outbreak of disease and diarrhoea	36	20	4	53.6
High mortality of piglets	25	21	3	42.0
Difficult to find feed	21	12	7	35.7
Slow growth of pigs	11	13	15	34.0
Lack of labour	2	1	5	7.1
High cost of concentrate	4	0	0	3.6
Insufficient funds	2	0	0	1.7
Low price of pigs	2	0	0	1.7
Theft of pigs	0	0	3	2.6

[1] Total of observations exceeds 100% due to multiple responses.

Figure 1 shows that outbreak of disease was ranked as the most serious problem by respondents with around 45 % of interviewed farmers reporting that an outbreak of disease usually occurred twice per year, often coinciding with a change of seasons. Interestingly, only 17 % of interviewed households identified introduction of sick pigs and meat from other areas as causes of outbreaks of disease. The remaining farmers said that they did not know what caused these diseases.

There were some differences in the impact of the identified constraints on pig production related to the ethnicity of respondents. High mortality of piglets was ranked second as the most serious problem by many Khmu and Hmong, but not by Lao-loum farmers who are generally engaged in pig fattening rather than sow-piglet production. Other problems were ranked similarly by all ethnic groups.

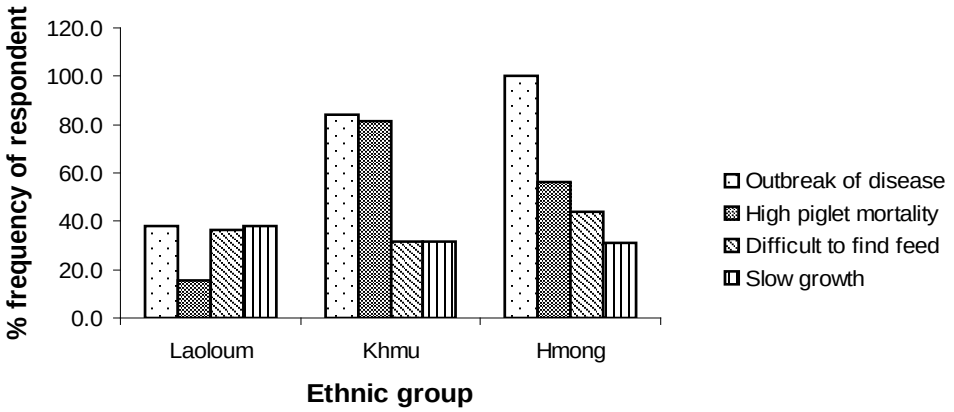

Figure 1. Constraints in pig smallholder production by ethnicity

The survey found that the outbreak of disease and high mortality of piglets were the main problems in free scavenging, semi-scavenging and enclosure systems, but were less important where farmers used penning systems (Figure 2).

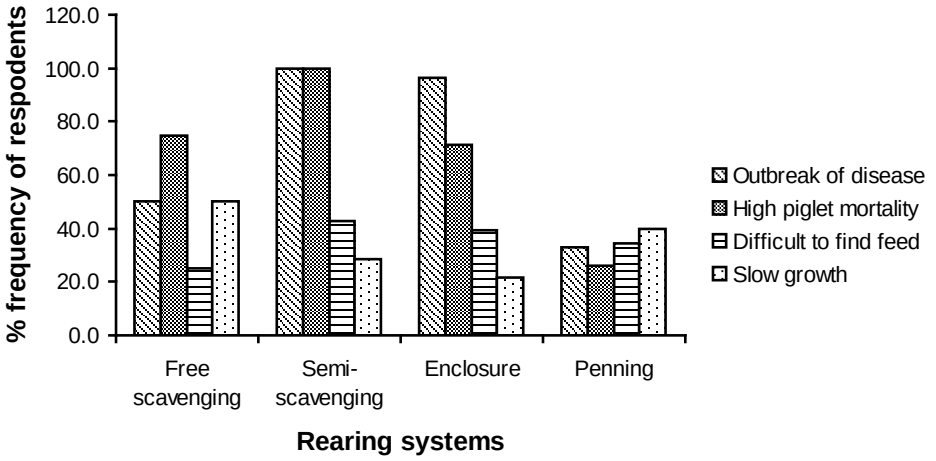

Figure 2. Constraints in pig smallholder production by rearing systems

Disease outbreaks have caused severe losses for farmers. 53 % of respondents reported that pigs had died within the last 3 years, and of these 81 % mentioned that only piglets and young pigs died. Mortality varied depended on rearing system and management experience; penning resulted in by far the lowest mortality (Table 14).

Table 14. Percentage of pigs died during the last disease outbreak

	% of respondents					
	0	1-20	21- 40	41-60	61-80	>80 % mortality
Free scavenging	0	0	0	40	60	0
Semi-scavenging	0	0	25	50	25	0
Enclosure	4	6	24	28	28	9
Penning	75	9	9	1	2	4
Total	47					

8.1.2 Nutritional quality of local feeds and diets

Collection of local feeds and their nutritive content

A list of commonly used pig feeds was assembled during the inception workshop, based on experiences of project partners. Samples of these feeds were collected during the first year of the project and analysed for nutritional quality by our project partner at DEEDI, Brisbane, Australia. Additional samples of feeds of particular interest were collected and

sent for analysis in years 2 and 3, and during the extension phase. A sub-set of the results of the chemical analyses is shown in Table 15.

Table 15. Example of chemical analysis results

Category	**Rice bran**	**Legume**	**Green feeds**			**Roots**			**Grains**
Species	*Oryza sativa*	*S.*[1] *guianen.*	*C.*[2] *crepid.*	*Morus papyrifera*	*Colocasia esculenta*	*Manihot escul.*	*A.*[3] *paeoni.*	*A.*[4] *macro.*	*Zea mays*
Local name	Rice bran	Stylo 184	Ya Hua Bin	Paper mulberry	Bon (taro)	Cassava	Duk Deua	Phouk, Kabouk	Maize (white)
Sample details	white, upland	Leaf and stems	Leaf and stems	Young leaves	Leaf and stem	Tuber, <1y	Tuber	Tuber	Grain
Proximate analysis									
Dry Matter, %	93.1	87.0	91.5	88.9	94.5	92.0	90.0	91.6	91.2
Ash, %	10.4	11.0	17.2	14.6	13.0	1.8	10.1	16.1	1.6
N, %	1.27	3.32	4.16	3.86	1.61	0.16	1.15	1.08	1.62
Crude Protein, %	**7.9**	**20.8**	**26.0**	**24.1**	**10.1**	**1.0**	**7.2**	**6.8**	**10.1**
Fat, %	6.8	1.1	1.3	2.8	3.1	0.1	0.8	2.1	4.6
CF, %	26.8	20.2	13.5	10.1	16.5	1.8	7.5	14.9	2.4
NDF, %	54.5	45.6	40.5	23.6	31.2	5.2	31.7	26.7	11.9
ADF, %	38.6	27.2	38.4	16.8	25.5	3.2	15.5	23.4	3.9
Amylose, %	5.24	<2.4	1.2	<1.7	4.25	21.67	18.0	9.0	12.28
Amylopectin, %	14.66	<1.0	<1.0	<1.0	1.65	60.03	24.05	4.21	53.42
Starch, %	**19.9**	**2.4**	**1.2**	**1.7**	**5.9**	**81.7**	**42.1**	**13.2**	**65.7**
GE, MJ/Kg*	18.89	17.95	17.68	17.38	16.43	16.94	16.42	14.86	18.67
GE, Mcal/kg	4.51	4.29	4.23	4.15	3.93	4.05	3.92	3.55	4.46
B-glucan, %	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ca, %	0.08	1.89	1.09	2.72	1.52	0.08	0.80	3.45	0.01
P, %	0.65	0.20	0.82	0.41	0.15	0.06	0.25	0.46	0.32
Amino acids, mg/g									
Aspartic acid	7.99	21.61	25.63	29.97	12.18	1.24	8.22	6.24	8.09
Threonine	2.12	6.82	10.24	8.25	3.74	0.32	2.33	1.96	2.97
Serine	2.52	6.58	9.17	8.19	3.76	0.35	3.09	2.20	3.91
Glutamic acid	11.25	20.11	26.55	23.21	14.38	2.14	9.43	8.78	23.42
Proline	3.39	9.58	11.98	10.56	4.70	0.38	2.43	2.46	7.69
Glycine	2.71	6.93	10.98	8.66	4.07	0.39	2.61	2.30	2.84
Alanine	4.47	10.15	12.53	11.49	6.59	0.76	4.26	3.91	8.16
Valine	3.00	7.56	10.38	9.28	4.60	0.45	3.07	2.43	3.90
isoLeucine	2.10	6.79	9.42	8.21	3.79	0.38	2.25	1.89	3.04
Leucine	4.13	12.03	16.60	14.46	7.08	0.64	4.24	3.35	10.84
Tyrosine	1.19	4.04	6.59	5.24	2.37	0.18	1.54	1.07	2.77
Phenylalanine	2.19	6.52	10.78	7.91	3.64	0.47	2.51	1.72	3.55
Lysine	**2.90**	**8.23**	**9.34**	**10.17**	**5.59**	**0.69**	**2.67**	**1.80**	**3.09**
Histidine	1.10	2.74	4.15	3.39	1.59	0.12	0.93	0.72	2.07
Arginine	3.44	7.71	11.05	9.39	4.51	0.35	3.28	2.00	3.73
Tryptophan	1.17	2.56	3.58	2.01	1.81	0.19	0.82	0.80	0.77
Cystine	1.35	1.71	3.01	3.00	1.08	2.13	1.72	0.94	2.35
Methionine	1.11	2.80	5.61	4.33	1.78	3.32	1.25	0.89	2.35
Sum	58.11	144.46	197.59	177.71	87.26	14.50	56.64	45.47	95.54
Lysine/protein	0.37	0.40	0.36	0.42	0.56	0.69	0.37	0.27	0.31

1 *Stylosanthes guianensis*, [2] Crassocephalum crepidioides, [3] *Amorphophallus paeoniifolius,* [4] *Alocasia macrorrhiza*

The main feeds could be divided broadly into the categories of tubers, grains, rice bran and green feeds. High energy sources were tubers and grains, but rice bran and green feeds also contained moderate levels of energy (Table 16).

Table 16. Nutritive quality of common feeds

	Nutrient content			
Feed categories	Energy	Protein	Minerals	Fibre
Tubers (e.g. cassava, duk deua)	High	Very low	Very low	Very low
Grains (e.g. maize, broken rice)	High	Moderate	Low	Low
Rice bran (varying levels of rice husk and protein content)	Moderate	Low	Moderate	High
Green feeds (e.g. paper mulberry leaves, bon/taro, local herbs)	Moderate	High	High	High

Protein sources were green feeds (high) and grains (moderate) with rice bran containing low to moderate levels of protein. Most green feeds were a good source of minerals such as Calcium and Phosphorus.

The range of nutrient contents within feed categories was considerable; particularly the protein content of green feeds, which ranged from 6–36% (Figure 3). Some green feeds, such as pumpkin tops, had exceptionally high protein content (36%). Unfortunately, there is a limited supply and it is also used as human food. Rice bran and many of the green feeds contained a high level of fibre, but there were several green feeds, which had a moderate fibre content (Figure 4).

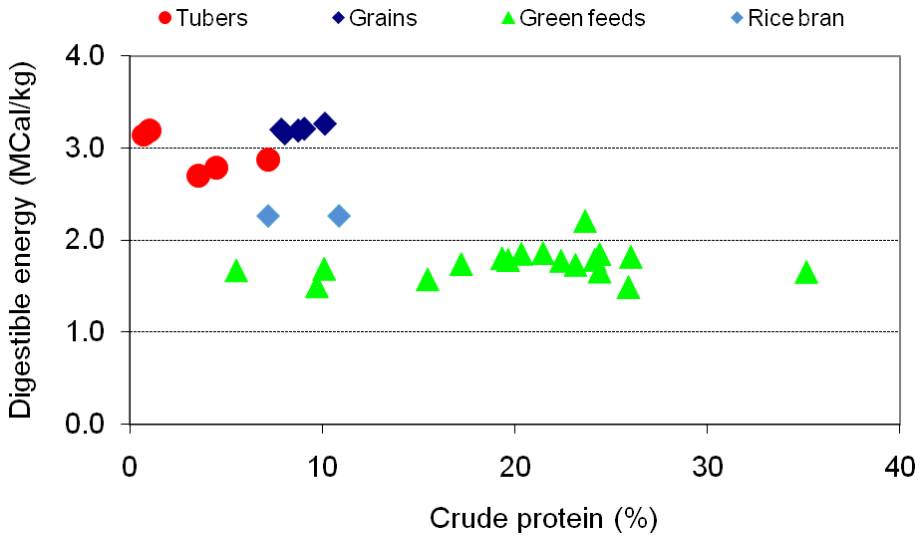

Figure 3. Digestible energy x protein content of local feeds

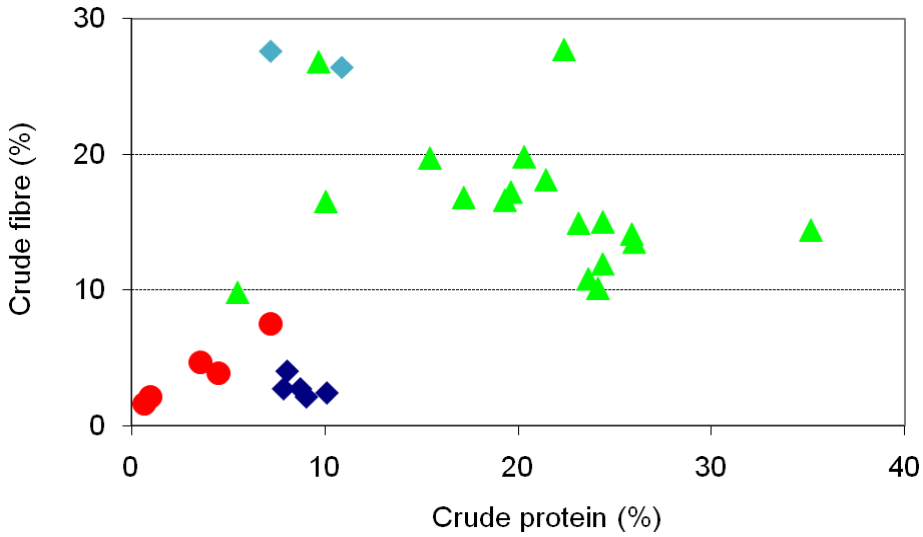

Figure 4. Crude fibre x protein content of local feeds

Nutritive quality of diets

Farmers in lowland systems (mainly Lao-loum people) fed mainly rice bran supplemented with local green feeds such as Bon (cf. section 8.1.1), with green feeds generally less than 10% of diet on a dry matter basis. This diet contained a moderate level of energy but was low in protein; probably in the range of 7-9%. It was also very high in fibre and thus low in nutrient digestibility (i.e. low nutrient density). Only farmers using broken rice, maize or distillers waste in addition to rice bran would have had a diet that was higher in protein and generally provided more nutrients to pigs.

Farmers in upland systems (mainly Hmong and Khmu people) had less rice bran available and used maize and cassava as a major ingredient in pig diets, in addition to locally available green feeds such as Ya Hua Bin. Upland diets tended to be higher in energy and lower in fibre than lowland diets, and thus had a higher nutrient density. Protein content was generally low to moderate, depending on the ingredients used at the time (7-10%). Cassava-based diets were very high in energy but severely deficient in protein while maize-based diets were high in energy and low-moderate in protein.

Animal requirements for growth and reproductive performance are well understood for exotic breeds such as large white but no information was available on local Moolath pigs. Assuming that Moolath pigs have a lower nutrient requirement than exotic pigs (based on experiences with unimproved breeds elsewhere), the diet quality offered to pigs in Laos may have been suitable for older pigs (e.g. fatteners, boars and dry sows) but was clearly deficient in protein for young and productive pig classes such as weaners, young growers and lactating sows. Weaners, in particular, require a diet that is high in protein (probably more than 15%) and essential amino acids (such as lysine) in order to grow well. They also need a diet that is nutrient-dense as they have limited gut capacity. This is not possible with high-fibre feeds. The diet provided would also be marginal for growers in pig fattening systems.

The general conclusion was that local diets were severely deficient in protein, particularly for younger animals, while energy may have been sufficient for moderate growth. The high-fibre content of many local feeds may also have been limiting productivity of younger pigs, although the local breed(s) were likely to cope better with high-fibre diets than exotic breeds.

Feed quantity provided to pigs in villages

The project team suspected that one of the reasons for the low live weight gain of village pigs may have been related to insufficient amounts of feed provided to pigs. Surveys were unable to capture this information since feeds given between farms and times varied tremendously, and farmers fed feeds with varying dry matter contents. For example, rice bran was fed as dry feed (approx. 10% moisture content); cassava roots were harvested fresh and boiled together with fresh green material. The project enlisted the help of three college students to stay in villages and record the types of feed provided, measure the amount of feed and water given to pigs, and feed spillage and refusals over a 5-day period. In total, the students collected data on 24 farms in 7 villages in Pek, Xieng Ngeun and Pak Ou districts.

The amount of feed provided to pigs varied considerably from sufficient to highly deficient (Figure 5).

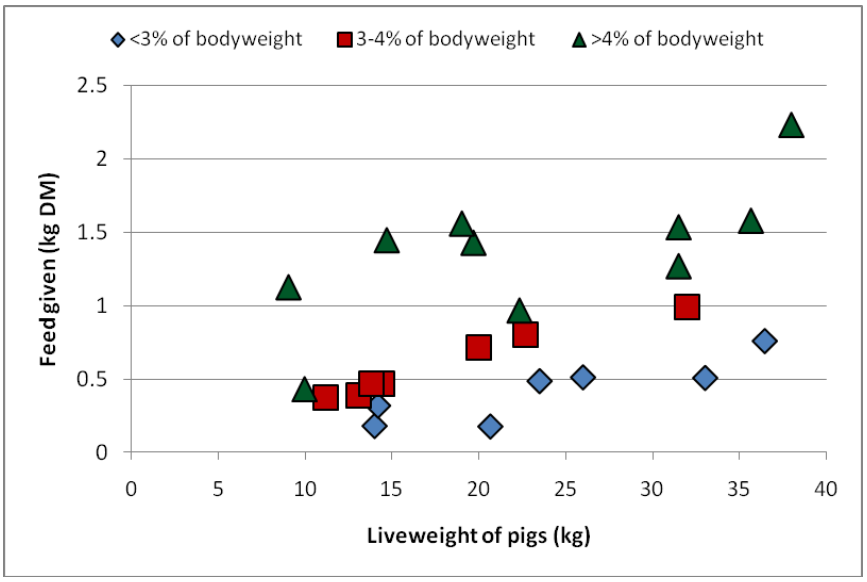

Figure 5. Amount of feed provided to growing pigs (markers divide data into feed given as % of bodyweight: <3%, 3-4% and >4%)

In the first experiment with Moolath pigs at LRC (see Section 8.1.3) young pigs (20kg bodyweight) consumed up to 6% of feed (expressed in % of bodyweight) and that this amount decreased to 4% once pigs reached a bodyweight of more than 40kg. Figure 5 shows that fewer than half of the farmers provided feed at a level of more than 4% to their pigs, with many farmers providing less that 3%. Farmers, who fed smaller amounts to their pigs compensated for the lack of feed by feeding a large proportion of green feed (Figure 6). This would have had the effect of filling the stomach of pigs but resulted in poor growth as the diet would have been very high in fibre and thus lacked nutrients.

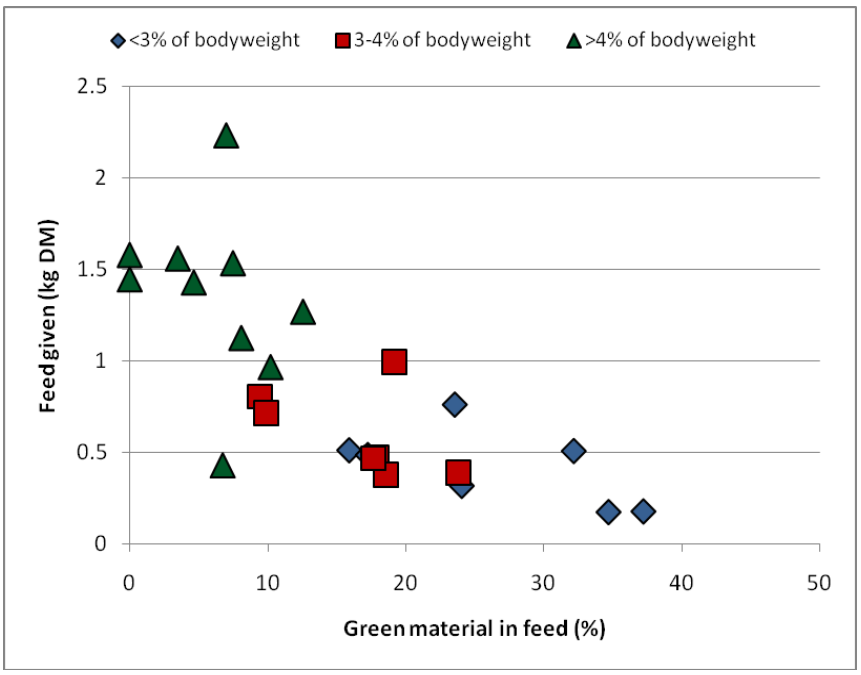

Figure 6. Amount of green feed in diet given to pigs (%)

In summary:

- Many farmers did not give enough feed to their pigs.
- All diets given to pigs were deficient in protein, with younger animals like weaners and young growers being most affected.
- Most farmers fed the same diet to all of their animals, regardless of age or needs.
- Many farmers fed all of their pigs together, regardless of age and size. Strong animals were therefore able to obtain more than their share and weaker animals lost out.

8.1.3 Growth and carcass composition of local Moolath pigs

At the inception workshop, the project team realised that a major gap in our knowledge was an understanding of the growth potential and nutrient requirements of local pigs in Laos. Was the reported growth rate of 100 g/day reasonable, given the genetic potential of the breed? What would be a reasonable growth rate for local pigs? Will local pigs be able to make use of more nutritious diets? To be able to answer these questions was crucial for the project and in 2006 we conducted an experiment at the Livestock Research Center, Nam Suang to determine the growth and carcass composition of Moolath growers fed a nutrient dense diet. A high quality commercial feed (diet) “Centaco” was used as this was most likely to contain a higher-than-required nutrient content for maximum growth of local pigs as the diet was designed for exotic breeds which have a higher nutrient requirement than local breeds. 30 young growers weighing approximately 20kg were fed one of 5 diet treatments consisting of different levels of feed intake. One treatment group of 6 pigs, chosen at random, was fed ad libitum and feed intake was measured. The other 4 treatment groups received the same diet, but at level corresponding to 90, 80, 70 and 60% of the average amount of feed ingested by the ad libitum treatment group. The feed on offer for each treatment group was revised every week to adjust for the increase in body weight of each treatment group. Pigs were fed these diets until they reached the usual slaughter weight for Moolath pigs of 60kg and they were then slaughtered and carcass composition was determined.

The average daily gain of pigs ranged from 558 to 346 g/day (Table 17). This growth rate compared to approximately 100 g/day in village conditions. The experiment showed that local Moolath pigs can grow well if fed a high-quality diet. Even at a restricted diet of 60%

of *ad. libitum* the quality of the diet still exceeded the feed provided by farmers in village situations.

Table 17. Average daily gain and feed conversion rate

	Treatment				
Parameter	100%	90%	80%	70%	60%
Feed intake, kg/day	1.98	1.83	1.64	1.35	1.19
Feed intake, %	100	92	83	68	60
Average Daily Gain (g)	558[a]	542[a]	523[a]	446[b]	346[c]
Feed Conversion Ratio	3.61[a]	3.39[ab]	3.23[b]	3.21[b]	3.44[ab]

Figures in rows followed by the different subscripts are significantly different (p=0.05)

The carcass composition date confirmed that the local Moolath breed is a high-fat type breed (Table 18). At slaughter, animals had deposited almost equal amounts of fat and meat. Diet treatments had a small effect on protein / fat deposition rates with the 60% restricted diet treatment resulting in less fat and more meat than less-restricted diets. This result showed that protein deposition of Moolath pigs can be influenced by diets and there may be scope for using higher protein / lower energy diets to further increase protein deposition rates.

Table 18. Carcass characteristics

	Treatment				
Parameter	100%	90%	80%	70%	60%
Back fat at P2 (cm	3.4	3.5	3.3	3.4	3.1
Carcass weight (kg)	42.7	42.7	41.8	42.1	42.3
Total fat (kg)	25.3[a]	24.2[ab]	23.5[ab]	22.3[bc]	20.3[c]
Fat %	59	57	56	53	48
Total lean meat (kg)	14.8[b]	14.5[b]	15.2[b]	15.0[b]	16.9[a]
Lean %	35	34	36	36	40

Figures in rows followed by the different subscripts are significantly different (p=0.05)

In many countries, native pig breed have been replaced with exotic breeds. Many factors have contributed to this change including a trend towards leaner meat, larger animals, higher growth rates and availability of exotic piglets for fattening through commercial companies. In Laos, this trend can also be observed in city markets like Vientiane and Luang Phabang. However, Moolath pigs have continued to be the main pork meat available in district and smaller provincial markets. This may be related to the remote nature of many rural areas in Laos where plant oil is not yet cheaply available and pig fat continues to be main source of fat / oil for cooking. It is likely, that native pig breeds will continue to play an important role in the nutrition and livelihood of rural people in Laos for some years.

This experiment showed that Moolath can grow well if fed a high-quality diet and that there is considerable scope for increasing pig productivity in villages by improving feeding. There was considerable variation in growth rate among pigs, which indicated that there is considerable scope for animal selection to improve performance.

8.1.4 The benefits of Stylo: a survey of early adopters

This survey was designed to provide an early estimate of the benefits of growing and supplementing Stylo in the diets of village pigs. The study was carried out in mid-2005 in 11 villages in two districts in Luang Phabang and Xieng Khuang provinces where farmers had already adopted Stylo for pig feeding (early adopters). The survey team preferentially selected farmers with long experience of using Stylo for pigs, and ensured that households from all the main ethnic groups engaged in pig production were included in the study (Lao-loum, Hmong and Khmu people). Two study methods – farmer focus group discussions and semi-structured interviews of randomly selected households - were used in the survey. Farmer focus meetings were organised in each village to gain a

general understanding of pig management in each village, experiences of utilisation of Stylo for feeding pigs and production and livelihood impacts. Household interviews were conducted immediately following each village meeting. A total of 30 households, including 7 households with women as the main respondent were interviewed. In all interviews, all family members were encouraged to contribute. The three main ethnic groups engaged in pig production in Laos: Hmong (4 households), Lao-loum (10 households) and Khmu (15 households) were represented.

The result of the study showed that there were two main impacts: (1) Improved growth rate of pigs, and (2) Time saving, as farmers (mostly women) no longer needed to collect naturally-occurring green feeds. Growth rates were estimated by asking respondents to estimate the initial and final sale weight of pigs kept in pens for fattening, and to recall the length of time taken from the start of the fattening period to sale of the animal. This information was used to calculate an average daily growth rate (ADG). The mean age and weight of piglets at the start of fattening was 4 month when piglets weighed 14-15 kg, and sale weight was approximately 65kg.

Using Stylo as a supplementary feed reduced the length of the fattening period from 18 to less than 9 months (Table 19). This effect was consistent across villages and meant that Stylo supplementation increased average daily gain (ADG) from 107g per day in traditional feeding system to 207g per day for pigs supplemented with Stylo. Clearly, there may be factors other than Stylo supplementation that also played a role (e.g. better management, Stylo being fed in addition to other feeds rather than as a substitute for other feeds) but the consistency and magnitude of the response showed that Stylo had had a major impact on pig productivity. The average area of Stylo grown per household was 320 m^2.

Table 19. Productivity of growing pigs supplemented with traditional green feeds or Stylo

	Traditional green feeds (no stylo)	Supplemented with fresh Stylo	SE
Duration of production cycle, months	18.0	8.7	0.95
Initial Weight, kg	14.0	15.0	0.4
Final Weight, kg	65.3	65.1	3.2
Calculated ADG, g/day	107	207	12.2

The second impact was the saving of time and labour for collecting and cooking pig feed. If farmers had plenty of Stylo 184, the time needed to feed pigs could be reduced from more than 3 hours to 1.5 hours (Table 20). Farmers feeding only rice bran and Stylo were able to reduce the time needed for feeding to 40 minutes a day, as they no longer needed to cook feed. Even farmers with small areas of Stylo saved almost one hour per day.

Table 20. Time needed to feed village pigs before and after adoption of Stylo

	------ Before -----		---------- Now (with Stylo) ----------			
Items	Time spent (min)	Who does the work?	Small Stylo area (not enough for feeding daily)	Large area of Stylo (enough to feed daily) Mixed feed + Stylo	Rice bran + Stylo	Who does the work?
Collecting feed	125	W/M	55	0	0	W/M
Cook	50	W	50	50	0	W
Feeding	20	W	20	20	20	W
Collecting Stylo	-	-	20	20	20	M
Total	195		145	90	40	

Feedback from farmers showed that this time saving was regarded as highly significant as labour during the crop growing season was in short supply. Villages engaging in shifting cultivation required a huge amount of labour for weeding crops (estimated at 136 person-days per hectare). Freeing labour at this time of year was valued tremendously. Farmers

invested the 'freed' time in other farm activities including better management and health care of pigs. Reducing labour requirements was an excellent entry point for working with pig farmers in upland areas of Laos.

This small impact study confirmed the benefits of supplementing Stylo to pigs (growers and fatteners): A doubling of growth rates from 100 to 200 g/day, and labour savings of 1.5 hours per day, which benefitted mainly women.

8.1.5 The growth and nutrient content of Stylo and other forage legumes

Farmer evaluations of forage legumes

Seventeen forage legumes with known adaptation to the environmental conditions of northern Laos, high digestibility and absence of known anti-nutritive factors were selected for farmer evaluation and chemical analysis. In 2007, these legumes were grown in small plots by farmer groups who already grew Stylo in Ban Phonesavanh, Xieng Ngeun, Luang Phabang and in Ban Khang Done, Pek, Xieng Khuang (Table 21). Farmers evaluated the suitability of legumes for pig feeding.

Table 21. The performance of legumes in village nurseries in Luang Phabang and Xieng Khuang

	Luang Phabang		Xieng Khuang	
	Establishment	Growth	Establishment	Growth
Aeschynomene histrix BRA 9690	VG[1]	G	G	VG
Arachis pintoi CIAT 18744	P	G	G	G
Centrosema acutifolium CIAT 5277	G	P	G	G
Centrosema pubescens Barinas	G	P	VG	G
Cratylia argentea	P	P	P	P
Clitoria ternatea Tehuana	G	G	G	G
Desmanthus virgatus Chaland	G	G	VG	G
Erythrina fusca	P	P	P	P
Lablab purpureus cv Rongai	G	G	G	G
Leucaena leucocephala K636	G	P	P	P
Leucaena collinsii OFI 52188	G	P	P	P
Stylosanthes guianensis CIAT 184	VG	VG	VG	VG
Stylosanthes guianensis Composite	VG	VG	VG	VG
Sesbania sesban Mt.Cotton	G	G	VG	G
Vigna unguiculata CIAT 9611	VG	G	VG	G
Vigna unguiculata CIAT 1069-6	VG	VG	VG	VG
Vigna unguiculata CIAT 10884	G	G	VG	G

[1] VG=very good; G=good; P=poor

Farmers at both sites selected *Vigna unguiculata* CIAT 10696, *Stylosanthes guianensis* 'composite' and 'Stylo 184' (control) and *Aeschynomene histrix* BRA9690 as having high potential for feeding to pigs (Table 22). In Luang Phabang, farmers also selected *Arachis pintoi* CIAT 18744. Selection was very much based on growth performance, ease of cutting and palatability to pigs. Samples of these legumes, as harvested by farmers for feeding to pigs, were collected and sent to Australia for chemical analysis.

Table 22. Farmers' preference on legume varieties in Xieng Khuang site

Preferred species	Ranking		Reason for selection
	Luang Phabang	Xieng Khuang	
Vigna unguiculata CIAT 10696	1	1	Very palatable Easy to cut Big and soft leaves Good regrowth
Stylosanthes guianensis CIAT 184	2	4	Palatable Easy to cut Very good regrowth; can be used often
Stylosanthes guianensis Composite	3	2	Palatable Easy to cut Very good regrowth; can be used often
Aeschynomene histrix BRA 9690	4	3	Palatable Easy to cut The top of plant is soft
Arachis pintoi CIAT 18744	5	-	Palatable

In 2008, seed of these 5 legume species were evaluated by more farmers on their own farms in several villages in Pek, Pak Ou and Xieng Ngeun districts. In this evaluation, farmers selected *Stylosanthes guianensis* 'composite', *Stylosanthes guianensis* CIAT 184 and *Aeschynomene histrix* BRA9690 as the most promising species. Farmers chose species that were: easy to plant, fast growing, easy to cut and palatable to pigs. The annual *Vigna unguiculata* was plagued by insect damage and only had a very short growing season.

This farmer evaluation showed that there were many legumes that may be used for pig feeding. The main criteria used by farmers when selecting plants for supplementary feeding, were related to plant growth and ability to fit into the existing farming system, rather than the quality of the feed. Quality difference among legumes may be important for young pigs and piglets, which have a small gut capacity and are less able to cope with more fibrous leguminous feeds.

The nutrient content of Stylo and other legumes

Stylo and other promising legumes were sent to DEEDI in Brisbane, Queensland for proximate and amino-acid analysis. Legumes were added to Figures 3 and 4 in Section 8.1.2, which presented the digestible energy, crude protein and fibre content of locally available feeds (Figures 7 and 8).

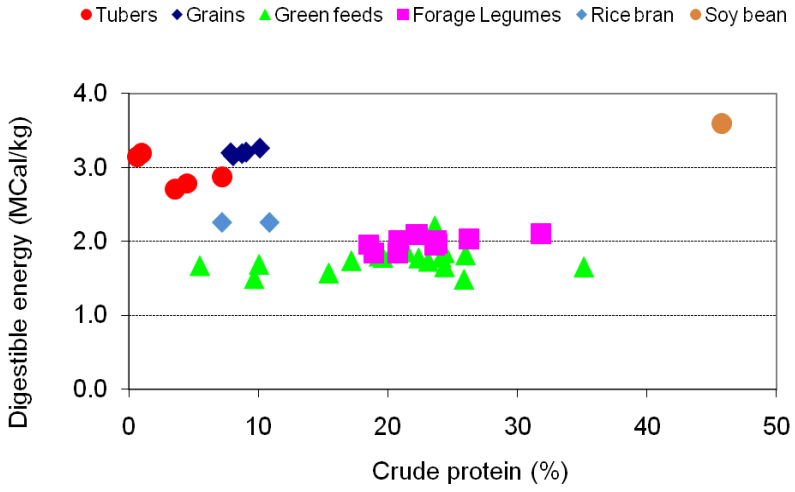

Figure 7. Digestible energy x crude protein of forage legumes, soy bean and local feeds

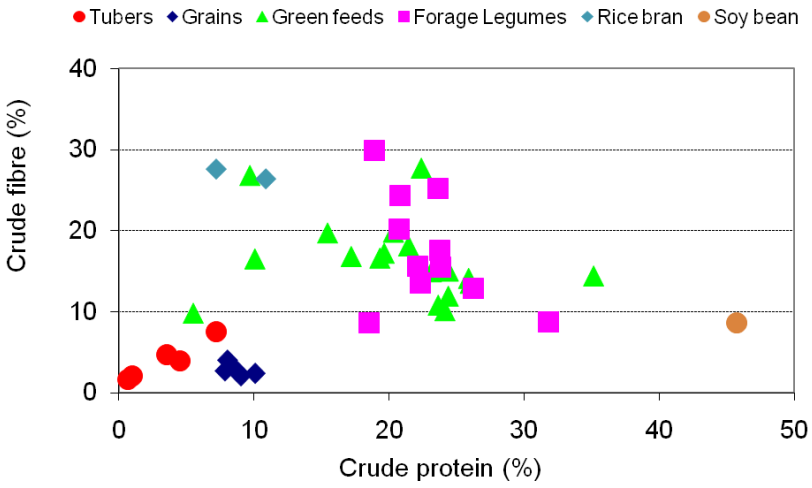

Figure 8. Crude protein x crude fibre of forage legumes, soy bean and local feeds

The energy content of forage legumes were at the upper end of locally available green feeds but had similar protein contents to the majority of green feeds (Figure 7). Crude fibre content varied tremendously among legumes and green feed (Figure 8). Soy bean meal was also analysed and was the only protein source with much higher protein content than green feeds and leaves of legumes.

In summary, forage legumes (leaf and shoots) did not have a significantly higher protein and /or lower crude fibre content than the best local green feeds. The benefits of legumes appeared to be related to their high yields, ease of harvesting and high palatability rather than their chemical characteristics.

8.1.6 Energy and protein digestibility of Stylo

In a pig metabolism study, the digestible energy (DE) value of dried stylo cut and harvested at different times (early cut, late cut, recut) post-planting was assessed at the Pig Research Facility at DEEDI in Brisbane, Queensland in 2007. The research was carried out by John Kopinski and Soukanh Keonouchanh from the NAFRI Livestock Research Center. *Stylosanthes guianensis* CIAT 184 was grown from seed at a DEEDI Research Station at Walkamin in northern Queensland. A half portion of the stylo crop was cut and collected twelve weeks post-planting (early cut) and dried at a low temperature in a fan-forced oven. At 18 weeks post-planting the other half of the original crop was harvested (late cut) and similarly dried. Also at 18 weeks post-planting the section of the crop which had been harvested at 12 weeks (6 weeks of regrowth) was recut (recut) and dried. The dried material was hammer milled and incorporated in a sorghum basal digestibility diet. Treatment diets consisted primarily of 65% sorghum, and a 10% basal component consisting of casein, vitamins, minerals, lysine and oil. To this was added 25% of one of the three cuts of dried stylo meals or in the case of the basal control diet another 25% sorghum inclusion. Diets were fed as a meal to pigs. Representative samples of the diets were analysed for DM, Ash, N and GE. 16 entire male Large White pigs (~22kg) were housed individually in metabolism crates. Total faecal collections were carried out over 5 days following an initial eight day pre-collection diet adaptation period. Ferric oxide was added to the diet as a faecal dye to indicate the start and end of collection. There were four replicates for each experimental diet.

The results of chemical analysis of sorghum and the three stylo cuts are presented in Table 23 and the digestibility results of the four diets in Table 24. The early cut stylo had a higher starch content and lower fibre fraction content than late and recut stylo. As a result the faecal digestible energy content was higher for the early cut stylo than for the subsequent cut stylo material which had become woody, as indicated by the higher NDF

and ADF content. The overall energy digestibility coefficient of the diet was observed to be less for the different stylo cuts (0.72-0.78) compared to the basal sorghum diet (0.88).

Table 23. Composition of main dietary ingredients

Parameter	Sorghum	Early cut Stylo	Late cut Stylo	Recut Stylo
DM, %	88.5	90.2	90.7	89.9
Ash, %	1.5	7.6	7.7	8.3
Nitrogen, %	1.78	3.41	3.11	3.60
Protein (Nx6.25), %	11.13	21.31	19.44	22.50
Fat, %	3.8	2.2	1.7	1.9
Crude fibre, %	1.2	12.4	21.3	18.0
Neutral Detergent Fibre, %	5.9	25.6	34.5	29.6
Acid Detergent Fibre, %	3.5	16.9	26.8	22.1
Starch, %	70.5	9.8	3.0	2.5
GE, MJ/kg	18.79	18.55	18.53	18.6
Calcium, %	<0.1	1.05	1.18	1.19
Phosphorus, %	0.33	0.21	0.20	0.23
Aspartic Acid, g/kg	7.28	19.89	21.30	22.13
Threonine, g/kg	3.44	8.53	7.49	8.40
Serine, g/kg	4.81	8.48	7.66	8.69
Glutamic Acid, g/kg	23.40	20.89	18.16	19.99
Proline, g/kg	8.73	9.67	9.62	10.83
Glycine, g/kg	3.39	9.81	8.71	9.68
Alanine, g/kg	9.74	10.73	9.33	10.25
Valine, g/kg	5.08	9.90	8.81	9.86
isoLeucine, g/kg	4.05	8.42	7.32	8.35
Leucine, g/kg	13.78	15.44	13.40	15.12
Tyrosine, g/kg	4.15	6.74	5.72	6.49
Phenylalanine, g/kg	5.17	9.92	8.80	9.79
Lysine, g/kg	2.34	10.54	9.45	10.40
Histidine, g/kg	2.48	4.59	4.11	4.54
Arginine, g/kg	4.98	12.31	10.37	11.62
Tryptophan, g/kg	1.38	3.23	2.82	3.38
Cystine, g/kg	2.17	2.71	1.93	2.69
Methionine, g/kg	1.82	4.73	3.07	4.01
Total amino acids, g/kg	108.19	158.06	176.53	176.22
Amino acid protein	0.97	0.74	0.78	0.91

The nitrogen data indicate that stylo inclusion provided a higher overall nitrogen intake as expected and also an increased faecal excretion of nitrogen. In the case of the early cut stylo the results show an increase in nitrogen digested compared with other diets although there was only a trend for higher retention of N. Overall nitrogen digestibility of diets was reduced with increasing fibre levels of the stylo, although the overall nitrogen retention was less affected. The results show that feeding of stylo meal does provide some nutritive value to the pig with increased nitrogen supply and some energy, with a portion of the nitrogen presented being retained by the pig.

Table 24. The apparent digestibility of dry matter, energy, nitrogen, and nitrogen retention of stylo experimental diets.

	Diet 1 Basal sorghum	Diet 3 Early cut stylo	Diet 2 Late cut stylo	Diet 4 Recut stylo
Dry Matter digestibility	0.87[a]	0.79[c]	0.75[b]	0.73[d]
Gross energy, MJ/kg DM	18.4	18.3	18.3	18.3
Digestible Energy, MJ/kg DM	16.1[a]	14.2[b]	13.7[c]	13.2[d]
Digestible Energy, MJ/kg As Is	14.6[a]	13.0[b]	12.5[c]	12.1[d]
Energy digestibility	0.88[a]	0.78[b]	0.74[c]	0.72[d]
Metabolisable Energy, MJ/kg DM	15.8[a]	13.9[b]	13.3[c]	12.8[d]
Intake Nitrogen, g/d	30.6[b]	35.5[a]	34.1[a]	35.9[a]
Faeces Nitrogen, g/d	6.8[c]	9.6[b]	10.5[ab]	11.7[a]
Urinary Nitrogen, g/d	5.5	5.4	5.4	6.0
Total N excreted, g/d	12.3[b]	15.1[ab]	15.9[a]	17.7[a]
Nitrogen digested, g/d	23.8[b]	25.9[a]	23.6[b]	24.2[b]
Nitrogen retained, g/d	18.3	20.5	18.2	18.2
Nitrogen retention	0.77	0.79	0.77	0.75
Nitrogen digestibility	0.78[a]	0.73[b]	0.69[bc]	0.67[c]

Figures within rows followed by different superscripts are significantly different (P=0.05)

Further studies will examine the growth performance response of pigs to stylo feeding. However, the digestibility results so far suggest that the field responses reported by farmers are to some degree a reflection of some nutrient supply from stylo to the pig. Nutrient digestibility was higher for younger Stylo than older Stylo and this will have practical implications for harvesting regimes of Stylo.

Further work is required to assess whether the field observations of a halving of the time to pig market weight with the use of stylo feeding in Lao is a response to either additional energy or protein nutrient supply from stylo alone. Alternatively it could also be partially a response to an increased total feed intake as a result of increased feed supply through the addition of the available stylo. For Australia, as intensive pig industries move from stall housing of dry sows into group housing, due to legislative changes in response to welfare concerns, the bulkiness and fibre level of stylo could be a viable option to develop new feeding regimes and diets enabling increased sow satiety without over-supplying nutrients to the dry sow.

8.1.7 Stylo supplementation to improve growth of pigs grown and fattened in pens (growers and fatteners)

Feeding value of Stylo for growers and fatteners: experimental results

The third in-vivo experiment investigated the effect of Stylo 184 supplementation rates (0% Stylo control, 10% fresh Stylo, and 10, 20 and 30% Stylo leaf meal) on feed intake and growth of Moolath pigs fed a rice bran based diet at the Livestock Research Center (LRC), Nam Suang in 2008. Thirty Moolath piglets (15 castrated males and 15 females) weighing approximately 15 kg each were used in the experiment. Purchasing sufficient numbers of piglets of approximately the same age, weight and condition was very difficult as most villages only had a small number of suitable piglets for sale at most times. Piglets were vaccinated to protect animals against Classical Swine Fever, treated for internal parasites and fed a rice bran diets for 15 days to allow them to adapt to the environment at Nam Suang. At the start of the experiment, piglets were weighed and randomly

allocated to 5 treatment groups ensuring that each group consisted of 3 male and 3 female piglets. Rice bran was purchased every two weeks from the local market. *Stylosanthes guianensis* CIAT 184 (stylo) was grown at LRC, harvested prior to the experiment, sun dried, chopped and ground to produce stylo leaf meal. During the experiment, fresh stylo was harvested daily, chopped into 3-5cm pieces and fed to the 10 % fresh stylo treatment. Pigs were housed in individual pens and each pen had a water nipple which ensured that pigs had access to water at all times. Diet treatments consisted of 100% rice bran, 90% rice bran + 10% fresh stylo, 90% rice bran + 10% stylo leaf meal, 80% rice bran + 20% stylo leaf meal, and 70% rice bran + 30% stylo leaf meal. The diet treatments were fed for 12 weeks and live weight gain and feed intake were measured.

The chemical analysis results of the ingredients and diet treatments (except for the fresh Stylo treatment) is shown in Table 25 and the average daily weight gains, intake and feed conversion ratios are shown in Table 26. The rice bran used for the experiment was of relatively high quality with an average protein content of 8.7%, however, the stylo leaf meal was of relatively low quality with 13.4% protein content and very high fibre content as shown by the NDF and ADF results. Stylo for leaf meal production was harvested when Stylo was already mature and stemmy as it had been left to ensure that sufficient material was available for the experiment. Young Stylo would have had a protein content of at least 20% and a much lower fibre content which is generally lower than for rice bran (see Table 15, Section 8.1.2). During the experiment, the Stylo field used for collecting fresh Stylo started to flower and insufficient Stylo could be collected to amount to 10% of the diet and the Stylo had few leaves as it produced mainly flowers at that time. This would have resulted in a relatively poor Stylo feed.

Table 25. Chemical analysis of ingredients and diets

	Ingredients and diets				
Parameters	Rice bran	Stylo leaf meal	Rice bran + 10% Stylo leaf meal	Rice bran + 20% Stylo leaf meal	Rice bran + 30% Stylo leaf meal
Protein, %	8.7	13.4	9.4	10.9	11.5
Crude fibre, %	25.3	37.0	28.3	26.5	28.1
NDF, %	44.6	58.3	46.0	45.0	46.9
ADF, %	30.1	43.7	32.7	31.0	34.1
Starch, %	14.2	<1	13.5	13.1	10.3
GE, MJ/kg	18.7	18.6	18.1	18.3	18.1
Ca, %	<0.1	0.75	0.15	0.24	0.31
P, %	0.93	0.24	0.84	0.84	0.73
Lysine, mg/g	2.79	6.01	3.63	4.77	4.55

Weaners fed fresh Stylo and those fed 10% Stylo leaf meal had higher weights at the end of the experiment than pigs fed rice bran only and those that were fed 20% or 30% Stylo diets (Table 26). This result was unexpected as we had hypothesised that the higher rate of Stylo inclusion would result in higher weight gains. This result was most likely related to the relatively poor-quality of the Stylo leaf meal (low protein and high fibre) and the relatively young weaners which would have found it difficult to cope with the higher fibre diets.

Table 26. Growth, feed intake and feed conversion ratio of weaners

Parameters	Treatments				
	Rice bran	Rice bran + 10% fresh stylo	Rice bran + 10% stylo leaf meal	Rice bran + 20% stylo leaf meal	Rice bran + 30% stylo leaf meal
Initial weight, kg	16.5	16.8	16.6	16.2	16.3
Final weight, kg	27.2	31.0	31.4	26.9	25.6
Average daily gain, g/day	117[a]	156[b]	163[b]	118[a]	109[a]
Total feed Intake, g/day	932	1063	993	893	858
Feed conversion ratio	8.9[a]	7.5[b]	6.6[b]	8.3[ab]	8.5[ab]

Figures within rows followed by different superscripts are significantly different (P=0.05)

In summary, while the inclusion of Stylo leaf meal increased protein content of diets, the level of fibre in the diet also increased and this limited the benefits of Stylo inclusion, particularly for young pigs. This experiment showed that Stylo must be harvest and fed when young and leafy.

Feeding value of Stylo: feedback from project and alliance partners

Feedback from farmers and alliance partners consistently reported that growth rates of pigs in village situation was low and usually in the range of 80-100 g/day for pigs fattened in pens. They also reported consistently that Stylo supplementation increased growth rates to 200-300 g/day, and saved time (1-2 hours each day) of mainly women and children as they now had a ready source of green feed close at hand. Farmers also reported that Stylo supplementation provided only limited benefits if fed to young piglets and weaners; leading to a recommendation that Stylo should only be fed to pigs weighing at least 15 kg. This finding highlighted the importance of needing to find alternative protein sources for creep feeding and young weaners. Farmers also reported that the benefits of Stylo supplementation were larger when Stylo was harvested young and leafy.

Numerous village learning activities (VLA) investigating Stylo supplementation, de-worming, and other pig feeding and husbandry interventions were conducted by project and alliance partners, and the results were shared at alliance workshops. VLA were designed as a learning tool for farmers and extension workers to enable them to evaluate new technologies and compare these with current practice. They were not intended as a research tool to provide statistical evidence on particular treatments. Nevertheless, the sheer number of VLA conducted and the consistency of results made them a powerful feedback mechanism to the researchers on the project. Some typical examples are presented below.

Stylo supplementation given to growers weighing more than 15 kg increased average daily gain (Table 27).

Table 27. VLA on supplementation of fresh Stylo for growers, Ban Phonexay, Xieng Ngeun.

	Traditional diet	Traditional diet, supplemented with fresh Stylo (approx. 10%)
Initial weight, kg	18.7	19.5
Final weight, kg	20.5	26.2
Average daily gain, g/day	62	225

Note: 5 pigs per diet; duration of VLA = 30 days.

When Stylo was fed to weaners weighing only 7-8 kg (which is the typical weaning weight of Moolath piglets), there was little benefit of Stylo supplementation (Table 2). Farmer feedback showed that young weaners often grew very poorly and it was not uncommon to hear of daily growth rates of 10-20 g/day for the first few months after weaning. Underfeeding at this critical stage of growth would have led to weakness and increased

susceptibility to diseases. Stylo supplementation was not able to provide sufficient protein/lysine for this stage of growth (Table 28).

Table 28. VLA on supplementation of fresh Stylo for weaners

	Traditional diet	Traditional diet, supplemented with fresh Stylo (approx. 10%)
Initial weight, kg	7.5	7.3
Final weight, kg	8.9	9.2
Average daily gain, g/day	47	60

Note: Duration of VLA = 30 days.

Farmers also reported that pigs did not like Stylo once it was old and stemmy. They observed that pigs chewed old Stylo and then spat out the fibrous material. Farmers recommended to feed only young Stylo, and suggested a regrowth period of 12-14 days. At this stage, Stylo is very leafy and the stems are still soft.

Farmers also experimented with producing leaf meal from Stylo. The main reason was that fresh Stylo was only available during the growing period (April – November) and produced very little feed from December – March. They cut young Stylo during the wet season, chopped it into short pieces and dried it in the sun for several days. Once dry, they processed the dried Stylo pieces by grinding it in a rice mill (same intake as for grinding maize and other grains) to produce a fine powder and then stored the leaf meal in plastic bags. Feeding Stylo leaf meal to pigs produced good results. Farmers found that they could add a larger amount of leaf meal than when they used fresh Stylo. Generally, the amount of fresh Stylo pigs would eat happily was about 10% (dry matter basis) of the total diet. As the Stylo was supplied fresh, it made up approximately 50% of a rice bran-Stylo diet on a fresh weight basis. In experiments, up to 30% of Stylo leaf meal was fed and eaten by growers. Farmers found that feeding Stylo leaf meal resulted in higher liveweight gains than feeding fresh Stylo (Table 29). This was likely due to higher amounts of Stylo fed when supplied as leaf meal.

Table 29. VLA on supplementation of fresh Stylo and Stylo leaf meal, Ban Hadkham, Pak Ou

	Traditional diet	Traditional diet with Fresh Stylo	Traditional diet with Stylo leaf meal
Initial weight, kg	16.5	18.5	19.3
Final weight, kg	19.0	25.0	29.0
Average daily gain, g/day	83	217	322

Note: 6 pigs per diet; duration of VLA = 30 days.

The labour saving and improved growth of pigs fed Stylo prompted many farmers to place greater emphasis on pig production, and became interested in improving their pig pens, improving animal husbandry and health. One of the suggested improved animal health practices was to deworm growers as they were purchased and put into the fattening pen. Mostly, deworming had a beneficial effect on growth rates (Table 30).

Table 30. VLA on de-worming, Ban Phoukhua, Xieng Ngeun.

	De-worming	No de-worming
Initial weight, kg	6.5	7.5
Final weight, kg	10.0	10.0
Average daily gain, g/day	117	89

Note: 5 pigs per treatment; duration of VLA = 30 days.

Other husbandry improvements included increased amounts of feed given, supply of 24 hour drinking water, improved feed troughs, and vaccination.

8.1.8 Stylo supplementation to improve performance of lactating sows and their piglets

The emphasis of the extension phase of the project was on productivity of sow-piglet system. One of the options identified for improving the growth of piglets prior to weaning as well as the productivity of sows was improved feeding during lactation. It was hypothesised that improved nutrition during lactation would benefit sows by reducing the weight losses during lactation and faster return to oestrus after weaning, and benefit piglets with improved milk supply during the suckling period.

An experiment was conducted at LRC, Nam Suang that investigated the effect of 3 levels of protein supplementation during lactation of 12 Moolath sows on growth of piglets and body condition of sows. 14 Moolath gilts and 2 boars, weighing 20 - 30kg, were purchased from three villages in Luang Phabang and Xieng Khuang, and an additional two Moolath gilts were bought from a local market and brought to LRC. The pigs were vaccinated and treated for parasites, and fed a quality diet consisting of rice bran (40%), maize (40%) and soy bean (or concentrate; 20%) diet. Once animals reached a body weight of 40-50 kg the diet changed to rice bran (75%) and maize (25%). Gilts and boars grew at 300-400 g/day during this period. Once gilts reached a weight of 50 kg and had shown at least two oestrus cycles, they were joined with one of the boars.

12 pregnant gilts were randomly allocated to one of three diet treatments. These were: (1) control diet consisting of rice bran and maize (75:25); (2) control diet mixed with high-quality Stylo leaf meal (80:20); (3) control diet mixed with soy bean meal (80:20). Treatment diets were fed at a slightly restricted level of 2.5kg per day from 2 weeks prior to expected farrowing until weaning of piglets at 8 weeks.

Unfortunately, the results of the experiment were inconclusive as half of the sows developed hind leg lameness 2-3 weeks prior to farrowing and could no longer get up and move around the pen. We suspect that the condition was femoral head epiphysiolysis, which may have been caused by a combination of the relatively high growth rates of gilts, their relatively heavy weight prior to farrowing (too fat), their relatively young age at first farrowing and concrete floors in pens at LRC.

Insufficient number of sows and piglets, and high animal variability resulted in statistically inconclusive results. Briefly, sows with leg problems had reduced intake and many of their piglets were born dead; those that were alive had a very low birth weight (300-400 g). Piglets born to healthy sows had a birth weight of 600-800g. The average number of piglets born (alive + dead) was 8.2. The mean growth rate (birth – weaning) of surviving piglets of healthy sows was 71 g/day for the control diet group, 77 g/day for the Stylo group and 86 g/day for the soy bean group. All of the healthy sows lost weight during lactation ranging from 6 – 42 kg. While the lowest weight loss (6 kg) was for the only sow left in the soy bean diet treatment, variability among other healthy sows was high (14 – 42 kg) and no conclusions could be drawn.

In summary, diets had relatively small effect on growth rates of piglets. This may have been related to the very good body condition of sows at farrowing, which allowed them to use body reserves to supply milk to their piglets. This situation would be different in villages where often sows are thin at farrowing, have limited body reserves and may thus not be able to supply sufficient milk to their offspring. The experiment also showed the enormous difficulty in implementing sow-piglet experiments in sufficient numbers to be able to draw conclusive results. An alternative may be to conduct farmer evaluations of improved sow nutrition on piglet growth and sow fertility.

8.1.9 Improved protein nutrition for weaners

Based on previous experiments and feedback from project and Alliance partners, the project team reached the conclusion that Stylo and other green feeds did not supply sufficient protein (lysine and other essential amino acids) for good growth to weaners, and

that poor nutrition was a key factor in the high mortality and observed poor growth of weaners in village situations. Further, it was hypothesised that the high fibre content of Stylo and other green feeds contributed to the poor response of piglets to Stylo supplementation.

The objective of this experiment was to determine the effect of protein and fibre content on the growth rate of weaned piglets. The experiment was conducted at the Livestock Research Centre (LRC), Nam Suang from March to June 2010, and was partially funded by a LARF grant to Mr Ammaly Phengvilaisouk. 24 Moolath male and female weaners weighing 6.5±2.1 kg were used for this experiment. Prior to the start of the experiment, the weaners were given access to creep-feed (rice bran, maize, soy bean; 45:45:10) to adapt weaners to solid feeds. Weaners were vaccinated (CSF), treated for internal parasites (Ivomectin) and given a vitamin injection (AD_3E-500 consisting of Vitamin A at 500.000 I.U; Vitamin D3 at 75,000 I.U; Vitamin E at 50 I. U). Six weaners (3 male and 3 female piglets) were randomly allocated to four diet treatments, and each treatment group was housed in a group pen. The four diet treatments consisted of combinations of high/low protein and high/low fibre content (Table 31).

Table 31. Weaner diets and projected[1] chemical composition[2]

Ingredients / parameters	Diet 1 High fibre / high protein	Diet 2 High fibre / low protein	Diet 3 Low fibre / high protein	Diet 4 Low fibre / low protein
	---------- Ratio, % ----------			
Rice bran,	65	70	20	25
Maize	10	30	60	75
Soy bean	25	0	20	0
	---------- Chemical composition, % ----------			
CP, %	15.7	7.3	15.3	8.5
Lysine, g/kg	7.5	2.0	6.5	2.1
Digestible Energy, Mcal	2.9	2.7	3.3	3.2
CF,%	20.6	20.5	8.5	8.7
Ca, %	0.14	0.07	0.09	0.03
P, %	0.36	0.29	0.35	0.29

[1] Chemical analysis results were not yet available at the time of writing this report.
[2] Diets also contained approximately 20g salt per weaner per day.

The chemical analysis shown in Table 1 is based on results of similar samples in previous experiment. Representative samples of the actual ingredients were taken and sent for analysis, but results were not yet available at the time of writing. Rice bran, maize meal and soy bean meal were purchased from local markets. Diets were twice daily at a level close to ad. libitum and water was provided at all times. Body weight gains and feed intake were measured during the experimental period of 12 weeks.

Protein content had an overriding effect on growth of weaners (Table 32). Weaners on the high protein diets gained 100-120 g per day while those on the low protein diets grew by only 3-10 g/day. Fibre level had no significant effect on growth, although the low fibre – high protein treatment group consistently had a slightly higher growth rate (10-20%) than the high fibre – high protein treatment throughout the experiment. Feed intake of weaners on the low protein diets was depressed, while high fibre appeared to stimulate intake of both the high and low protein diet. The feed conversion ratios of the high protein diets were slightly higher than those recorded in the first experiment of the project feeding a commercial diet to growers and finishers, which ranged from 3.2 to 3.6 (see Section 8.1.3). This may indicate that the level of protein (lysine) supplied in the high protein diet treatment in this experiment may have been too low to achieve maximum growth or may be related to the younger age of weaners in this experiment.

Table 32. Mean growth rate, feed intake and feed conversion ratio

	Diet 1 High fibre / high protein	Diet 2 High fibre / low protein	Diet 3 Low fibre / high protein	Diet 4 Low fibre / low protein
Initial weight, kg	6.3	6.7	7.1	6.1
Final weight, kg	14.8[a]	7.5[b]	17.3[a]	6.3[b]
Average daily gain, g/day	100.0[a]	10.0[b]	120.0[a]	3.0[b]
Feed intake, DM g/day	467	233	400	150
Feed intake, in % of body weight	5.0	3.2	3.7	2.4
FCR	5.3	20.9	4.1	22.3

In conclusion, high protein diets containing soy bean meal as the main protein source resulted in high growth rate of Moolath weaners. Moolath weaners were able to cope with a relatively high fibre content (20%) in the diet, provided the diet had a high protein content. There was an indication that the high fibre level of the high protein diet started to limit growth of weaners in this treatment and a slightly lower fibre level in weaner diets may be appropriate. Fortification of village weaner diets using soy bean meal, or another highly digestible protein source, may be highly efficient in improving growth rates of weaners. It would also a cost-efficient option as the amount of soy bean / protein supplement needed for weaners is relatively small but the effect is considerable. In this experiment, the total amount of soybean meal fed in Diets 1 and 3 was approx. 8 kg per weaner; a total investment of Kip 40,000 (approx. AUD 5.70).

8.1.10 A diet calculator for formulating better diets and training of extension workers

A simple spreadsheet-based diet calculator was designed to assist in formulating diets using locally available feed ingredients to better provide the nutrients needed by the different classes of pigs (weaners, growers, etc.). The diet calculator has been useful in formulating example diets, as a training tool for extension workers and in highlighting gaps in our knowledge to effectively formulate diets for native Lao pigs.

Several essential data are needed for diet formulation. These are: (1) The chemical composition of each feed ingredient, (2) the digestibility or availability of nutrients in each feed ingredient, and (3) the nutrient requirements of each type of pig, which depends on the breed (i.e. native, exotic) and the class of pig (i.e. weaner, grower, finisher, dry sows, lactating sows).

The diet calculator uses data (direct or derived) from proximate and amino acid analysis of the commonly used feeds in northern Laos, forage legumes and other protein sources such as soy beans. Only a limited number of commonly available ingredients have been included in the calculator but more can be added as needed. The values in the diet calculator are based on an as-fed basis (ie air dry values not dry matter values). The availability of ingredients in Lao for use in pig diets varies throughout the year which means that mixing balanced diets can sometimes be difficult. Formulating diets with farm-grown ingredients is easier for Finisher diets than it is for Weaner diets as many of the commonly used ingredients are too low in protein (and particularly the availability of lysine, the most limiting amino acid in pig diets) or they contain a lot of fibre. Some high-protein seeds such as soy bean are necessary to balance diets for piglets and young pigs. We used soy bean as it is used widely in commercial pig, poultry and fish diets but many other legume seeds, such as cowpea, contain similar amounts of protein and can also be used.

In this version of the diet calculator there are still many unknowns, which have had to be included as assumptions, based on our experience and published information from elsewhere. These unknowns / assumptions are the:

- Chemical analysis data of many of the local feeds. There were based on only a few samples so we know that there will be a lot more variation than documented here.
- Nutritional requirements of Moolath and other Lao native pig breeds at different stages of growth. We have some information from our experiments, field experience and feedback from project and Alliance partners, but there is a need for more accurate information on the energy and protein (lysine) requirements of these animals.
- Nutritive value (digestibility or availability) of the nutrients in the various feeds. Availability values currently included are based on published reports of related feed ingredients. Experimental data using Moolath pigs are needed to improve these values. The digestibility and availability values of ingredients have a big influence on the quality of the resulting diet!

Table 33 shows the types of recommended diets and specifications for Moolath pigs. The data and assumptions used in the diet calculator will need to be updated and improved as more information and results become available.

Table 33. Nutritive characteristics of diets and recommended specification for Lao native pigs

Diets	Used for	Diet description	Key nutrient composition			
			Crude protein	Available lysine	Digestible energy	Crude fibre
Weaner diet	1. Creep feeding piglets from 2 weeks onwards. 2. Feed for piglets after weaning until they reach 20 kg.	• Very high protein • High energy • Low fibre	>18 %	>9.1 g/kg	>3.0 Mcal/kg (>12.5 MJ/kg)	<5 %
Grower diet	1. For growing and fattening pigs from 20 - 40 kg. 2. For lactating sows. 3. Boars used daily.	• High protein • Moderate energy • Moderate fibre	>14 %	>6.6 g/kg	>2.9 Mcal/kg (>12 MJ/kg)	<12 %
Finisher diet	1. Growing and fattening pigs from 40 kg until slaughter. 2. Dry sows (not suckling piglets). 3. Boars not used every day.	• Moderate protein • Moderate energy • High fibre	>10 %	>4.7 g/kg	>2.5 Mcal/kg (>10.5 MJ/kg)	<20 %

The DIET CALCULATOR includes several sheets including an ingredient list and a main page where the user can change the amount of different available ingredients in the diet until the desired specifications are satisfied. A slightly modified screen shot is shown in Table 34, and example diets for Weaners, Growers and Finishers are shown in Table 35.

Table 34. Screen shot (modified to fit document) of DIET CALCULATOR main page

Ingredient	Amount in diet %	Crude protein %	Available lysine g/kg	Digestible Energy mcal	Crude Fibre %	Ca %	P %
Rice bran – poor quality	0	0.00	0.00	0.00	0.00	0.00	0.00
Rice bran – good quality	0	0.00	0.00	0.00	0.00	0.00	0.00
Maize grain	60	5.54	1.35	2.08	1.31	0.01	0.18
Soybean seed (not extruded)	20	8.48	4.84	0.78	1.59	0.06	0.11
Rice grain - broken	20	1.47	0.37	0.67	0.73	0.02	0.02
Cassava root	0	0.00	0.00	0.00	0.00	0.00	0.00
Stylo 184 – young	0	0.00	0.00	0.00	0.00	0.00	0.00
Stylo 184 – old	0	0.00	0.00	0.00	0.00	0.00	0.00
Paper mulberry - young	0	0.00	0.00	0.00	0.00	0.00	0.00
Banana stem	0	0.00	0.00	0.00	0.00	0.00	0.00
Pumpkin tops	0	0.00	0.00	0.00	0.00	0.00	0.00
Sweet potato vine - young	0	0.00	0.00	0.00	0.00	0.00	0.00
	100	**15.49**	**6.57**	**3.52**	**3.64**	**0.09**	**0.31**

Table 35. Examples of a Weaner, Grower and Finisher diet.

Weaner Diet: cassava, maize and soy bean

Ingredient	Amount in diet (DM) %	Crude protein %	Available lysine g/kg	Digestible Energy Mcal	Crude Fibre %	Ca %	P %
Rice bran - poor quality	0	0.0	0.00	0.00	0.0	0.00	0.00
Rice bran - good quality	0	0.0	0.00	0.00	0.0	0.00	0.00
Maize grain	35	3.2	0.79	1.21	0.8	0.00	0.10
Soybean seed (not extruded)	35	14.8	8.47	1.36	2.8	0.11	0.20
Rice grain - broken	0	0.0	0.00	0.00	0.0	0.00	0.00
Cassava root	30	0.3	0.17	1.01	0.5	0.02	0.02
Stylo 184 - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Stylo 184 - old	0	0.0	0.00	0.00	0.0	0.00	0.00
Paper mulberry - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Banana stem	0	0.0	0.00	0.00	0.0	0.00	0.00
Pumpkin tops	0	0.0	0.00	0.00	0.0	0.00	0.00
Sweet potato vine - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Total	**100**	**18.4**	**9.4**	**3.6**	**4.1**	**0.14**	**0.32**
Weaner diet specifications:		>18.0	>9.1	>3.0	<5.0		

Grower Diet: rice bran, cassava, maize, soy bean and Stylo

Ingredient	Amount in diet (DM) %	Crude protein %	Available lysine g/kg	Digestible Energy Mcal	Crude Fibre %	Ca %	P %
Rice bran - poor quality	0	0.0	0.00	0.00	0.0	0.00	0.00
Rice bran - good quality	30	2.2	0.81	0.70	6.9	0.02	0.19
Maize grain	20	1.8	0.45	0.69	0.4	0.00	0.06
Soybean seed (not extruded)	20	8.5	4.84	0.78	1.6	0.06	0.11
Rice grain - broken	0	0.0	0.00	0.00	0.0	0.00	0.00
Cassava root	20	0.2	0.11	0.67	0.3	0.01	0.01
Stylo 184 - young	10	1.8	0.29	0.19	1.8	0.16	0.02
Stylo 184 - old	0	0.0	0.00	0.00	0.0	0.00	0.00
Paper mulberry - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Banana stem	0	0.0	0.00	0.00	0.0	0.00	0.00
Pumpkin tops	0	0.0	0.00	0.00	0.0	0.00	0.00
Sweet potato vine - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Total	**100**	**14.5**	**6.5**	**3.0**	**11.1**	**0.26**	**0.39**
Grower diet specifications:		>14.0	>6.6	>2.9	<12.0		

Finisher Diet: rice bran, cassava, maize, soy bean and Stylo

Ingredient	Amount in diet (DM) %	Crude protein %	Available lysine g/kg	Digestible Energy Mcal	Crude Fibre %	Ca %	P %
Rice bran - poor quality	40	2.6	0.78	0.99	11.3	0.04	0.12
Rice bran - good quality	0	0.0	0.00	0.00	0.0	0.00	0.00
Maize grain	25	2.3	0.56	0.86	0.5	0.00	0.07
Soybean seed (not extruded)	5	2.1	1.21	0.19	0.4	0.02	0.03
Rice grain - broken	0	0.0	0.00	0.00	0.0	0.00	0.00
Cassava root	10	0.1	0.06	0.34	0.2	0.01	0.01
Stylo 184 - young	10	1.8	0.29	0.19	1.8	0.16	0.02
Stylo 184 - old	10	1.8	0.33	0.21	2.2	0.10	0.02
Paper mulberry - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Banana stem	0	0.0	0.00	0.00	0.0	0.00	0.00
Pumpkin tops	0	0.0	0.00	0.00	0.0	0.00	0.00
Sweet potato vine - young	0	0.0	0.00	0.00	0.0	0.00	0.00
Total	**100**	**10.8**	**3.2**	**2.8**	**16.5**	**0.33**	**0.26**
Finisher diet specifications:		>10.0	>4.7	>2.5	<20.0		

8.2 The scaling out component: Facilitating a Learning Alliance with multiple development partners.

The objective for setting up a pig production learning alliance with NGOs and other development projects was to provide a platform for scaling out results of the research component of the project. This approach was adopted as previous attempts to 'hand-over' research results to development partners by holding one-off workshops and/or field days had not resulted in extensive uptake of new technologies. The Learning Alliance (the 'Alliance') provided a way of (1) building capacity of Alliance partners through frequent interactions, cross visits, training and mentoring; (2) achieving widespread adoption of research results, and (3) providing an avenue for feedback on practical implementation problems to the research component.

8.2.1 Formation and activities of the alliance

The project first compiled a list of all NGOs, development projects and government extension services with interest in livestock development in northern Laos. A short list of potential Learning Alliance participants was prepared on the basis of their experience of, and commitment to, development of smallholder livestock systems, a commitment to working with smallholder farmers, enthusiasm for linking with a research project, and a willingness to contribute their own resources to participate in the Learning Alliance. Representatives of these organisations and projects were invited to a field day and workshop on 19–20 June 2006. On the first day, participants visited several villages where farmers were growing and using Stylo as a feed supplement for pigs, and had an opportunity to interact with farmers and question them about their experiences with growing and feeding Stylo to pigs. On the second day, each organisation or project was given an opportunity to present their activities and experiences with livestock production in a workshop setting. The project presented a review of pig systems in Laos, and the results of the impact study of early adopters that showed that supplementary feeding of Stylo provided a simple entry point for improving pig production, as it could double pig productivity and cut the time women spent in feeding pigs by half.

Following presentations, the proposal for forming a Pig Production Learning Alliance (the 'Alliance'), the activities of such an alliance and responsibilities of participating partners were discussed. The workshop agreed to form an alliance and carry out the following activities: Alliance partners would meet twice a year in a workshop: in March to review results and experiences and to develop plans for the following wet season (May–November); and in the middle of the wet season in September to review progress and assist each other with implementation issues. At these workshops, each Alliance partner

organisation would present its results and impacts, share experiences with implementation and develop plans for field work for the following period. The workshops would also provide an opportunity for developing plans for joint activities or setting up cross visits. The project agreed to supply up to 30 kg Stylo seed to each Alliance partner organisation to support scaling out, and support Alliance partners with research findings, information material, training on issues identified by Alliance partners, facilitation of cross visits to villages where improved practices had produced significant impacts, and facilitating mentoring by linking NGO staff with experienced extension workers from government extension services involved in the research project. The project agreed to facilitate Alliance workshops and training courses, but each Alliance partner organisation would have to pay its own costs for participating in workshops, cross visits and training courses.

8.2.2 Participation in the Alliance

The Alliance consisted of researchers from CIAT and NAFRI, extension workers and development practitioners from NGOs, NAFES and large development projects. Enthusiasm for participating in the Alliance was high and more partners joined the Alliance over the years (Table36).

Table 36. Number of organizations participating in the learning alliance from 2006 to 2010

Organizations[1]	2006	2007	2008	2009	2010
Government	3	3	3	4	4
Non-government	3	4	6	8	8
Development projects	3	3	3	2	2
International	1	1	1	1	1
Total	10	11	13	15	15

[1] Government organizations: NAFRI, PAFO, DAFO, NAFES (ASEM 2005/124 project)
Non-government organizations: World vision, CRWRC, GAA, CARE, GtZ, CESVI, CCL and ADRA.
Development projects: CIAT/DLF Capacity Building for Livestock Development project (ADB-funded), DLF -LAO-EU Livestock Development project (EU-funded), CIAT Participatory Research and Development in the Upland project (IFAD-funded), DLF Northern Region Sustainable Livelihoods Through Livestock Development Project (LDP).
International organisations: CIAT

In several cases, more than one project managed by NGOs participated in the Alliance. Examples include WorldVison with projects in Xieng Ngeun and Pou Khoun districts, and GAA with projects in Phongsaly and Oudomxay. In fact, it tended to be projects that participated rather than the organisation although country managers of some NGOs participated in some of the Alliance workshops. The only partners who stopped participating in the Alliance were those whose projects were complete. From 2006 to 2008, 1 NGO and 2 development projects were completed and three new NGO projects joined the Alliance. In three cases, NGO staff moving to a new project with a different NGO brought their new projects into the Learning Alliance.

8.2.3 Geographical reach and adoption of Stylo supplementation

Engaging with NGOs and other development organisations resulted in a much greater geographical reach than would have been possible working only with government extension services at the three project sites where the project worked directly with DAFO extension staff (Figure 9). These project sites were located in three districts in two provinces. By working with Learning Alliance partners, the project was able to extend its reach to more than 100 villages in 16 districts in 8 Northern provinces and 1district in central Laos.

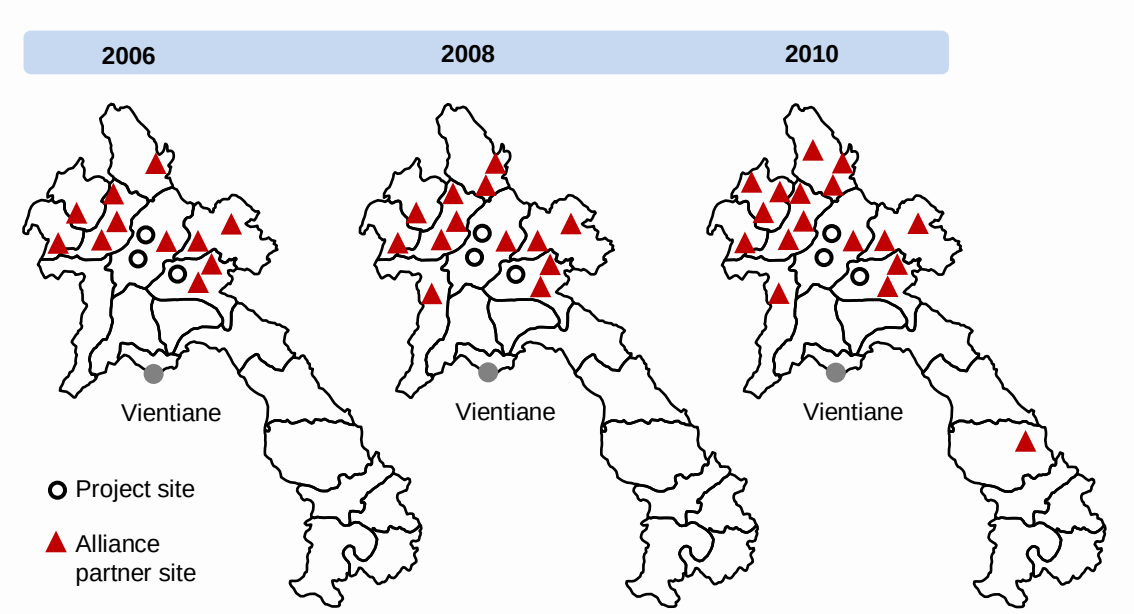

Figure 9. Project and Learning Alliance partner sites, 2006 - 2010

Figure 10 shows the number of households that had adopted Stylo supplementation and other improved pig feeding and husbandry techniques from 2005 to 2010. The number of adopters in 2005 represents the number of households that were already feeding Stylo to pigs in northern Laos. By 2007, the number of households growing and using Stylo for pig feed had increased to almost 1200 households and most of these were located in Alliance project areas (Figure 2).

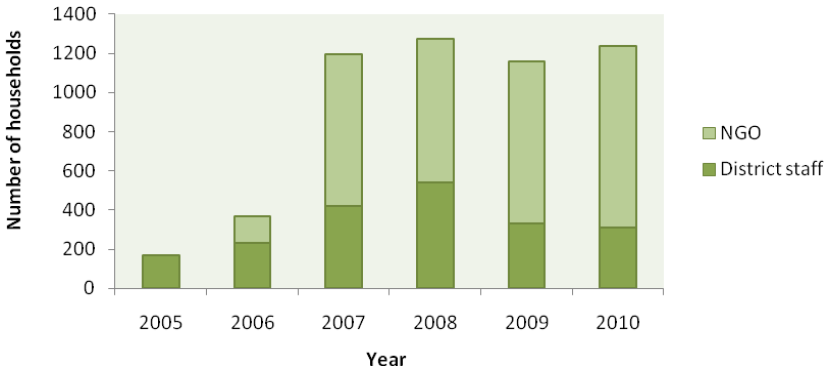

Figure 10. Adoption of Stylo supplementation and other improved feeding and husbandry techniques, 2005-2010.

From 2007 onwards the number of adopters remained relatively stable. In 2009, the number of households growing Stylo decreased slightly. There were several contributing factors to this decline. In several villages where farmers had been most enthusiastic about Stylo supplementation, farmers had intensified their pig production and were now using commercial concentrates (or soybean which was introduced as an alternative to commercial concentrates) as supplements (e.g. Ban Fai, Pak Ou district). They no longer had a need for Stylo as they were able to purchase protein inputs. Another reason for the decline was related to the high price of maize in 2008, which encouraged many farmers to reduce pig production, stop planting Stylo and instead plant maize. When the maize price collapsed in 2009, many farmers returned to pig production and there were many farmers who requested seed for planting Stylo in the 2010 wet season. This situation is likely to occur again when prices of a particular cash crop is high and entices farmers to concentrate on producing these crops. A third reason for the decline was related to the natural life cycle of Stylo. Stylo plants usually produce good yields for 3 years and then

production from individual plants starts to decline and they eventually die. At this stage, farmers need to replant Stylo from seed, ideally in a new field. Many farmers did not realise this and suddenly found that their Stylo crop was no longer productive. Farmers, who had planted Stylo in 2006 and some who planted in 2007 would have been in this situation by 2009. The project tried to address this issue during the project by raising this issue and encouraging farmer seed production so they would be ready to replant, but for many farmers (and extension and development workers) 2009 was the first time that they experienced this situation on their farms. While the project discussed seed production and supply, and held several training sessions on simple ways for farmers to produce their own Stylo, few farmers produced their own seed. To a large extent this may have been due to the supply of free seed offered by many development projects and NGOs. Although the supply was somewhat erratic, this free supply of seed would have counteracted the need for farmers to produce their own seed (despite it being a relatively easy process).

Adoption of Stylo is likely to be wider than recorded by the project. Some large development projects such as the LDP Development Project were also promoting the use of Stylo for pigs but no adoption figures were available. Also, many NGO development workers moved to new projects but were not able to participate in the Alliance.

It is expected that adoption will continue to spread as extension / development workers use their improved skills in pig production and demonstrate the benefits of Stylo supplementation to more farmers. It is also expected that adoption will slowly spread from farmer to farmer at each of the sites where is has already been adopted.

8.2.4 Building capacity of Alliance staff

The project arranged two review and planning workshops each year during which participants could share their results and experiences, and raise problems encountered with and during implementation of activities. Fellow participants were often able to assist with the problems raised, and the project arranged training session on topics suggested by Alliance partners to assist them with implementation of improved pig production systems. In the last two years of the project, training course were also offered outside the regular workshops and so provided an additional opportunity for interaction among Alliance partner staff. A list of training courses held during the project is shown in Table 37.

Table 37. Training courses offered and participation by Alliance staff, 2006-2010

Topic of training course	Year (number of participants)				
	2006	2007	2008	2009	2010
Stylo planting and management	22				
Stylo utilization and processing	22				
Village pig management and feeding	25				
Local available feeds, nutritive value and feed formulation		35			
Pig management		37			
Practical aspects of pig health and vaccination in smallholder systems		37			
Livestock marketing			22		
Pig nutrition and health			27		
Nutrition and management of pigs in sow-piglet production systems				40	
Nutrition and management of lactating sow and weaners					37
Pig nutrition and feed formulation					24
Nutrition and management of pigs in sow-piglet production systems					25

In addition to technical training, many of the discussions at workshops centred on extension methodology and tools, and project implementation issues. Village learning activities (participatory evaluation of new interventions and group learning), how to work effectively with different ethnic groups and how to work with women within their cultural settings were some of the extension issues discussed during workshops. Other foci of workshops were reporting of progress with activities and interventions, impact assessment and planning of activities for the next six months.

8.2.5 Feedback from Alliance partners

In July 2008, ACIAR project ASEM 2005/124 'Extension Approaches to Scaling out Livestock Production in Northern Lao PDR' conducted a review of the Alliance (Stelling and Millar, 2008). The following section is based on this report and contains excerpts from this report and resulting publications[1].

Respondents noted that prior to joining the Alliance they had worked in isolation; now they now enjoyed a supportive network of professionals, with access to much more technical information and a far broader range of experiences. Lack of understanding, isolation and wariness between government extension staff and NGOs had been replaced by a desire to share, learn together and strive towards common goals. Major feedback themes common to all participants were the technology itself, the provision of supporting materials, the extension methodology, and the creation of a strong network.

Respondents stated that the Stylo technology and other pig production improvements provided substantial, immediate benefits to farmers by reducing labour inputs, improving pig productivity and increasing income from pig production. The technologies were easy to implement and provided an inspiration for field staff who saw the successes of Stylo in their villages. Field staff from the government extension service and NGOs staff found the combination of CIAT's training courses and workshops, along with cross visits, highly valuable. They greatly appreciated the deliberate cycle of participatory planning, taking action, followed by discussion and evaluation of the actions, in which their experiences and concerns were truly valued. All participants identified farmer-to-farmer learning activities, such as cross visits, combined with the Village Learning Activities as major factors in the success of the project. Field staff from NGOs learnt both technical and extension skills and now feel better equipped to work with and support farmers. They stated that they were now confident that they could continue to scale out Stylo and other pig production technologies using these methods, supported by district government extension staff. NGO project leaders said that the project opened the eyes of their staff to a whole new technology, and gave them greater confidence in their role and a willingness to take on more responsibility within their programme. NGO leaders also felt that the Alliance has increased their staff's understanding of how government extension staff work and, conversely, increased the understanding of government extension staff about how NGOs work. The project also provided a platform for the exchange of experiences at the management level, with NGO leaders becoming involved with the network by attending workshops and planning sessions. One project leader noted the pleasures of interacting with other project leaders with a Lao focus, the excitement of seeing the project operating in other places in Laos, and learning how other NGOs operate.

All Alliance participants commented on, and appreciated, the strong informal network created by the project. Workshops created a forum for sharing knowledge between participants ranging from highly experienced participants to younger and newer ones. They learnt from the positive experiences of others, shared and discussed problems, and planned together. Importantly, participants felt their contributions were welcomed and they

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[1] *Stür W, Phengsavanh P, Stelling A, Millar J. and Lefroy R. (2009). Facilitating a multi-stakeholder learning alliance: a case study describing the activities, outputs and impact of the Pig Systems Development Alliance in Lao PDR. Paper presented at the Innovation Asia Pacific Symposium, 4-7 May 2009, Kathmandu, Nepal.*

developed friendships with colleagues whom they may otherwise never have met. The Alliance resulted in participants' trust in their newfound network partners. NGO staff felt happy to call local District or Provincial staff, could approach CIAT for help, and also felt confident in calling on staff from other NGOs. The enhanced understanding by all partners of each other's institutional culture, and seeing the advantages of working together were two of the most significant impacts of the Alliance. NAFRI, CIAT and NGO respondents commented on the strong network that has developed between government extension staff and NGO field staff. Functional evidence of the network was found in the now regular meetings between the NGO staff and their government district extension counterparts, where they shared experience and knowledge, and planed cross visits and other extension activities. NGO staff also appreciated the opportunity to share experiences with staff from other NGOs.

Synergies among Alliance partners by far outweighed the difficulties of working together. None of those interviewed for the Alliance evaluation had previously experienced a partnership, such as the Pig Systems Learning Alliance, between research, the government extension service and NGOs. All participants were appreciative of the complementary qualities project partners brought to the Alliance. NGOs were seen by other participants as focused, committed and keen for new experiences, but lacking technical knowledge. They brought different ideas and methodologies on how to work with communities. The NGO approach was seen as valuable for the impact of the project, as NGOs demonstrated to government staff that it was possible to achieve much quickly, with a concentrated effort. NGOs focused on poor communities and poor farmers, and used a range of tools and activities to work with them. Government field staff noted two NGO strategies of particular benefit to the project: livestock assistance programmes and micro-credit systems, both of which enabled poor farmers to participate in livestock raising. Government field staff were seen as providing much needed technical knowledge, a legal status and good understanding of government policy, a district-wide understanding of agriculture and competing land uses. In turn, government extension workers appreciated the enthusiasm, dedication and eagerness of the NGO staff. They felt that, once NGO staff were trained in Stylo and improved pig production, they were competent, confident and capable of expanding the technology. Importantly, they felt that NGO staff were keen to work with them, citing instances where staff had asked for help with technical issues. On a practical level, field staff pointed out that working together took advantage of the different skills and knowledge of NGO and government staff; they could discuss local issues together and solve problems in different ways.

Project participants at all levels agreed that the benefits of working together went beyond what individual partners could bring to the project. There were efficiency gains made through mutual planning and budget allocations for activities. During the course of the project, the relationships within the Alliance changed; while initially researchers provided most of the inputs and ideas for improvements, soon development partners started to experiment with new ideas and technologies and provided feedback on their results to all partners. This feedback and sharing helped both development practitioners and researchers with their work.

9 Impacts

The aim of the project was to identify, develop and extend interventions which improved pig productivity, household income and livelihood of resource-poor smallholder pig producers in northern Laos. The project achieved this by conducting applied on-station and on-farm research, adapting promising interventions to the needs of target communities, selecting successful interventions and strengthening the capacity of development partners to extend these successful interventions to farmers in their project areas.

The main impact pathway of the project has been the strengthening of the capacity of interested extension workers and development practitioners from NGOs, rural development projects and government extension service to introduce improved pig feeding and husbandry practices to smallholder farmers. The project also facilitated the development of an informal network of extension workers through a Learning Alliance platform which is likely to provide continued support for scaling out.

9.1 Scientific impacts – now and in 5 years

The project demonstrated the growth potential of the native Moolath pig by showing that local pigs could gain more than 500g/day, provided they were fed a good-quality diet. This result challenged the conventional view that local pigs could not grow more than 100 g/day, and created interest in research on local pig breeds. It also stimulated discussions within NAFRI and the Lao Government on the future of local breeds which, if not addressed, would be under threat of being replaced by imports of exotic breeds. In its most recent 5-year Development Plan (2011-2015) the Lao Government prioritised local pig breeds as a focus for research and development. One example of the interest in local breeds is a new collaborative project between Hungary and Laos, in which crossbred piglets (Moolath x Duroc) are fattened in Laos.

The project encouraged local and international researchers to conduct studies on use of forage legumes for pig feeding. At a local level, three Lao PhD students, enrolled at the Swedish University of Agricultural Science (SLU), are currently conducting nutritional research with local pigs. One of the students is determining the energy and protein requirements of the local Moolath breed, which has been identified by the project as a major gap in knowledge. This information on nutritional requirements of the local breeds can be integrated into the DIET CALCULATOR, which was designed by the project, and improve its functionality. Other studies are evaluating the protein availability to local pigs in in-vivo studies. There are also several final year students enrolled at Lao Agricultural Colleges and Universities who have been and are conducting experiments on the utilization of legumes as pig feed in Laos. The ACIAR-funded LARF small research grant scheme has also supporting several research projects on this topic. Internationally, researchers in Cambodia and Vietnam have started to conduct research on feeding legumes to pigs. Close collaboration with many of these scientists has ensured that these research endeavours complement the research and experiences conducted by the project.

The project identified the relatively high fibre content of forage legume material as a potential limitation to their use, especially for piglets and young weaners. This finding has stimulated scientific interest and precipitated searches by scientists at CIAT and its partners for alternative protein sources, such as farm-grown multi-purpose grain legumes.

In 5 years from now, the results of many of these studies on local pig breeds and the use of forage legumes for village pigs will be available and are likely to be used to further improve the interventions developed by the project. They are also likely to further

stimulate debate on the importance of local pig breeds for Laos and lead to increased investment in research and development of local pig breeds.

9.2 Capacity impacts – now and in 5 years

Capacity building was a major component of the project and has been the main pathway for achieving sustainable impact.

The project has strengthened the capacity of NAFRI, PAFO and DAFO staff involved directly in the project and of staff of participating agencies in the Pig Systems Development Alliance to conduct animal nutrition research (NAFRI staff), initiate and facilitate Village Learning Activities (VLA) to evaluate and share new pig feeding and management technologies with farmers, and scale out successful technologies. Through the learning alliance, it has creating an informal network of committed staff and so improved the capacity of partner staff to access information and expertise from other researchers, and extension and development staff working in a diverse range of organisations. These impacts were described in detail in the report of the evaluation of the alliance by Anne Stelling and Joanne Millar, ACIAR Project 'Extension approaches to scaling out livestock production in northern Lao PDR' in October 2008 (Stelling and Millar, 2008).

Capacity strengthening of Alliance partners has been achieved through training workshops, 6-monthly review and planning meetings and mentoring by experienced extension workers. Training was needs-based and covered a wide range of topics related to improving pig production, including legume agronomy and supplementation, pig diet formulation, improved pen designs, animal health and quarantine, and animal husbandry, as well as sessions on participatory extension and scaling out. Providing information on all of these topics was a challenge for project staff, but has been extremely rewarding in terms of uptake of technologies and the impacts experienced by farmers.

By 2010, NAFRI had successfully conducted several feeding experiments, and project and Alliance partners were routinely using VLA and skills learnt in training courses routinely. They had scaled out Stylo supplementation to more than 1,200 households in their project areas, which clearly demonstrates their skills in carrying out these tasks. By the end of the project, there were at least

- Six researchers at the Livestock Research Center, NAFRI who were competent in planning and conducting in-vivo feeding experiments with pigs. This was the result of 'learning by doing' with mentoring and supervision from experienced scientists from DEEDI and CIAT.
- 18 research and development practitioners who were competent in designing and implementing VLA with farmer groups. They were comfortable working and learning with farmers, discussing pig production constraints and opportunities, exploring potential technologies with them, and stimulating interest in evaluating new ideas and technologies.
- 30 development practitioners who were capable of scaling out Stylo supplementation and other pig production improvements in their project areas.

The strengthened capacity of researchers and development practitioners will ensure that the scaling out of Stylo supplementation will continue beyond the life of the project. Several other factors also contribute to the sustainability of project outcomes. These are:

- The informal network of researchers and development practitioners that has been created by the Learning Alliance approach. Alliance participants, using mobile phones, communicate frequently with each other to resolve questions and issues concerning pig production and forage legume supplementation.

- Institutional knowledge. NGOs and development projects have integrated the information and extension material on improved village pig production technologies into their activity plans and 'lessons learnt' knowledge depositories.
- Mobility of NGO development workers. Staff of NGOs, in particular, involved in the development alliance have moved to new NGOs or new projects, and have carried with them the skills needed to scale out improved pig production. They are using these skills in their new projects and thus spreading improved pig production technologies beyond the actual development alliance. Several development workers have requested that their new NGO / project be allowed to join the alliance. Government extension workers involved in the project and alliance will also move to new projects and bring the skills learnt to these projects.

9.3 Community impacts – now and in 5 years

9.3.1 Economic impacts

Pig production has always been an important source of cash income and part of the livelihood risk mitigation strategy (capital reserves) of households in remote upland villages. They relied on the income from pig production to pay for household expenses such as children's schooling, medicines, home improvements, seeds and other agricultural inputs. Generating reliable income from traditional pig production systems has not been easy as sows had a poor reproduction rate, piglet mortality was high, and it took a long time to grow and fatten the surviving pigs until they could be sold. Further, the risk of production was high as occasionally disease epidemics swept the villages and killed many of the pigs within a village. The project has been able to address some of these issues.

Improved growth of pigs fattened for sale (growers and fatteners)

Using Stylo as a supplement to local diets decreased the time needed to grow and fatten pigs (growers and fatteners) from a starting weight of 15-20 kg to a slaughter weight of 60-65 kg from 18 to 9 months, thus doubling average growth rates from approx. 100 to 200 g/day. This information was collected in the initial impact survey and confirmed numerous times in VLA results and feedback by Alliance partners (see key results for details). Briefly, partners were asked to report on the impact of Stylo supplementation in their projects. They reported that farmers benefited in several ways by feeding Stylo to pigs. The main benefit was improved pig growth; at least a doubling of growth rates, with many reporting increased growth rates from approximately 100 g/day to up to 300 g/day. Another benefit was easy and fast access to green feed near their village. Consequently, many farmers had been able to increase the number of pigs they fattened at any one time, often increasing from 2 to 4 pigs. Also, as the pigs grew faster, farmers were able to increase the number of fattening cycle per year. Overall, Stylo supplementation meant that farmers could sell more pigs each year and so made more income from pig production. They estimated that the increased income from pig production was 2-3 times higher than previously when farmers did not have Stylo.

In summary, the use of Stylo and the increased growth rate of growers (Moolath pigs weighing 20-40kg) and fatteners (40-60kg) had several benefits:

- Lower production cost. Farmers achieved a doubling of the growth rate with the same daily amount of feed given to the animals (+Stylo), which reduced their production costs.
- Producing income faster. Farmers were able to sell fattened pigs in half the time (every 6-9 months instead of 12-18 months) and so received income much sooner than before.

- Reducing risk. Taking only half the normal time for fattening meant that pigs were sold sooner and so were exposed to the risk of a disease epidemic for shorter times.
- Greater throughput (or off-take). Farmers could fatten two batches of pigs in the time that they previously took to fatten one batch at almost the same production cost that they previously needed to produce one batch. Not all farmers took this opportunity but there were many (25% of total adopters) who 'intensified' their pig production to take advantage of this opportunity.
- Higher labour productivity, especially for women (increased returns to labour). Women responsible for pig production saved 1–1.5 hours each day as they no longer needed to search for green feed for pigs, and this time was available for other activities. The reduction in labour inputs, combined with the shorter time needed to grow pigs for sale, resulted in an increase in productivity of women fattening pigs for sale.

The production cost of Stylo supplementation was relatively low. Firstly, only a small area of cropping land was required to grow sufficient Stylo to feed one grower/fattener (150-200 m^2 per animal). Many farmers grew 300-500 m^2 in total. Often, farmers grew Stylo on fallow land which was not used to grow crops at the time. Only when prices for particular annual crops like maize were very high in 2007-8 did some farmers replace Stylo with maize. In other years, fallow land was available for growing Stylo without competing with other crops. Secondly, households using Stylo saved 1-1.5 hours each day as they no longer needed to search for and collect naturally occurring green feeds for their animals. This time saving was a major factor driving initial adoption of Stylo and benefited mainly women who tended to be responsible for pig production. Inputs required to establish and maintain Stylo fields were small as only a very small area was needed, seed was supplied free (actual cost of seed to plant 500 m^2 were AUD 1.5-2.0), and only 1-2 weeding rounds were necessary before farmers could start harvesting Stylo. Most farmers weeded their Stylo fields as they harvested a small area of Stylo each day and would not have spent more than 5 minutes each day to do so.

Improving growth rate of weaners

During the extension phase, the project focussed on improving the growth of weaners from weaning (at 6-7kg) until they were sold as growers (at 15-20kg) to other farmers. Feedback from project and Alliance partners had shown that Stylo supplementation did not result in big improvements in the growth of weaners, and alternative protein sources (i.e. soybean) was fed in an attempt to overcome the poor growth of weaners.

Supplementing weaners with soybean meal increased growth rates from less than 3-10 g/day to 100-120g/day (see section 8.1.9). This massive increase in growth rate of weaners showed that the traditional diet was severely deficient in protein and even a small amount of protein, added to the diet in form of soybean meal, had a very significant effect on growth rates. The benefits were high while the financial investment was relatively low. Using the example of the weaner experiment only 8 kg of soybean meal was needed to grow a weaner from 7 to 17 kg in 85 days. This required an investment of $5.70 (price of soybean was Kip 5,000/kg). On the traditional diet, the same weaner would have taken at up to 1 year to reach a weight of 15kg, and would have required feeding for the whole year. Clearly, protein supplementation of weaners provided significant benefits to farmers.

Managing the risk of disease epidemics

This was not an area of research for the Project, however, some of the project outcomes may have led to a change to the risk of introducing and spreading disease epidemics.

Stylo supplementation and the higher returns from pig production stimulated many farmers to intensify production and improve their production system. In many villages, this led to a change in the way farmers raised pigs from free range scavenging to confined

production systems, with many constructing pens for pigs. This change would have had significant implications in terms of animal health (and potentially human health), and may have had the effect of reducing the risk of spread of diseases. Exploring these potential benefits was beyond the scope of this project.

Confining pigs in pens or enclosures posed enormous challenges to farmers who had previously practiced free scavenging systems where pigs were largely self-managed and fed. Farmers were now fully responsible for feeding and managing pigs. They needed to know what pigs ate and how much pigs needed to eat; how to grow feeds, process and mix pig diets for different animal classes; how to manage reproductive issues; how to ensure hygienic conditions; how to treat sick animals; and how to reduce the risk of disease and parasite infections. On the upside, increased confinement ensured that farmers had more opportunities to observe the condition of their animals and made it easier for them to apply animal health interventions such as de-worming and vaccination. Many farmers involved in the project have successfully risen to the challenges of this first step in intensification of pig production.

Another change that happened in some 'pig fattening' villages (villages where farmers traditionally purchased piglets from outside the village and fattened these for sale) was that farmers started to produce their own piglets. A major reason cited by farmers who made this change, was that this was an attempt to circumvent the risk of bringing disease epidemics into the village. Other factors such as high prices for piglets and interest in raising different breeds may also have played a role in this change, particularly in districts near provincial markets where demand for low-fat pork may have been growing. Farmers producing piglets in such villages reported that selling the piglets provided a higher income that fattening pigs. While this may have been a transient benefit, as prices for piglets varied greatly with time, the benefit of reducing production risks and being able to access preferred breeds remained.

Lastly, intensification of production and confining pigs in pens was likely to result in a different set of animal and human health issues from those encountered in more extensive systems.

In summary, supplementing growers and fatteners with Stylo and supplementing weaners with soybean or similar protein source were identified as priority interventions that could transform sow-piglet production in Laos.

9.3.2 Social impacts

Pig production has been predominantly the domain of women. Growing and using Stylo as a feed supplement, instead of using naturally occurring green feed, saved time and labour. The benefits were two-fold; firstly cutting Stylo near the pig pen and preparing it (chopping) to feed to pigs was relatively quick and easy. Secondly, unlike naturally occurring green feeds Stylo did not require cooking before being fed to pigs - they are happy to eat it fresh. For farmers, who fed rice bran plus traditional greens (e.g. Bon) that required cooking, the change to feeding fresh Stylo eliminated the need for cooking pig feed as all could be fed uncooked. The impact survey conducted early in the project found that the average time required to prepare pig feed was reduced from 195 to 90 minutes per day for households who had enough Stylo to feed it every day.

The early survey results were confirmed in the field by alliance partners, who also reported additional social benefits. NGO and other alliance partners were asked to report on the impact of Stylo supplementation in their projects at several Alliance workshops as part of monitoring and evaluation. They reported that women and children were major beneficiaries saving 1 - 1.5 hours each day as they no longer had to search for and prepare naturally-occurring green feed for their pigs. For example, the GAA project in Phongsaly reported that the main beneficiaries of Stylo supplementation were women and children (78% of households) who had previously been asked to collect green feeds from fallow fields and forest margins. They also reported that Stylo supplementation was

adopted by poor households, not only by households that are better off within a village. By introducing Stylo supplementation through Village Learning Activities, the benefits of this feeding practice quickly became obvious and poor households also became interested in supplementing Stylo to pigs. Several cases were reported where poor households, who did not raise pigs previously because of the production risks, started to raise pigs once Stylo supplementation had been introduced in a village. NGOs reported that the participation of poor households in the evaluation and adoption of Stylo supplementation increased from 10 to 30% as the benefits of this technology were proven. Another benefit was associated with the trend towards more confined production systems once Stylo had been introduced. With confinement, farmers solved the problem of damage to neighbours' field crops by scavenging pigs. This had been identified as a big problem in many villages as crop damage often created conflict and pig owners often had to pay for the damage.

In summary, households that adopted Stylo supplementation saved 1 -1.5 hours each day and the main beneficiaries of this time saving were women (and to a smaller extent children).

9.3.3 Environmental impacts

No major positive or negative environmental effects of growing the legume Stylo 184 were observed during the project duration. Being a legume, positive environmental effects may be expected in terms of soil improvements but these were not measured as the effect would only be small. Farmers were growing Stylo in small blocks of 200-500 m^2, with rows planted along the contour and no soil erosion was observed.

The project did not directly address the emerging issue of effluent management associated with more intensive pig production systems. In the majority of cases, production units were still too small to constitute a major hazard but clearly this will change as farmers produce more pigs, individual production units are sited adjacent to each other in a particular area of the village, or near waterways. Pig manure can be a valuable nutrient resource for on-farm use but may have animal health implications or need processing (e.g. composting or biogas production units). This is a topic that needs to be explored further in a future project.

9.4 Communication and dissemination activities

The main avenue for disseminating the results of the project to development practitioners was through the Learning Alliance. The usual research communication channels such as publications and presentations at relevant workshops were also used.

Through the Alliance, extension and training material reached a wide range of government and non-government staff committed to improving smallholder livestock production in Laos. The topics and content of extension and training material were based on the information and capacity strengthening needs of extension and development workers of Alliance partners. These included technical information, skills development and extension methodology. Many of the topics were developed upon request of Alliance partners, and the content was based on the results of research and on-farm experiences. The project produced a series of ‘Best Practice Guides’ extension leaflets on pig fattening and how to conduct Village Learning Activities. These provided technical information and a step-wise introduction of technologies to improve village pig production and introduced the concept of Village Learning Activities. The project also developed a simple DIET CALCULATOR and nutritional tables of common feeds and forage legumes.

The strategy for reaching other researchers and students was through publication as well as participation in workshops and conferences related to our project. Project staff presented project results in relevant regional and international workshops and conferences and the publications are listed in section11.2.

10 Conclusions and recommendations

10.1 Conclusions

The key learnings from the project were:

1. *Stylo supplementation - a stepping stone towards more market-oriented pig production*. Growing and feeding *Stylosanthes guianensis* CIAT 184 (Stylo) as a supplement to traditional pig diets provided major benefits to smallholder pig producers. Having Stylo saved considerable time for pig producers, who were mainly women, as they no longer had to collect native greens for their pigs and frequently doubled growth rates of pigs grown and fattened for sale. These benefits prompted many farmers to place increased emphasis on pig production as an income-generating farm enterprise; they became interested in improving nutrition, housing and animal husbandry. As farmers intensified production, some moved beyond Stylo and purchased protein supplement to further increase the growth rates of their pigs. Stylo had a key role in enabling this transition.
2. *Stylo, forage legumes and greens are good for pigs!* While Stylo remained the legume of choice for farmers, many other forage legumes and greens were equally effective as a protein supplement for pigs. Farmer's selection criteria for adoption of forage legumes (and other greens) were: easy to grow and harvest, high productivity and fast regrowth, and palatable for pigs – and Stylo ranked high on all of these criteria.
3. *Only a small area of Stylo was needed to provide significant benefits*. Stylo is a very productive forage legume and only a relatively small area of Stylo was needed to provide sufficient green material for pigs (100-150 m^2 per pig).
4. *Stylo needs to be fed when young and leafy*. Protein content and nutrient digestibility of forage legumes (and other greens) declines as plants mature. This increases fibre content and reduces the animal-available protein in the plants.
5. *Stylo is ideal for pigs weighing at least 15 kg*. Stylo was most effective as a supplement to local feeds for growers, fatteners, sows and boars. These animals had a larger, more mature gut than younger pigs and so were able to cope better with fibrous diets. Both rice bran and forage legumes (and other greens) were relatively high in fibre.
6. *Stylo should not be fed to piglets and young weaners*. To grow well, piglets and weaners need a diet that is very high in protein. The availability of protein content in leaves of forage legumes (and other green feeds) is too low to supply sufficient protein to these young animals, and other protein sources with higher protein availability, such as legume grains and/or fish meal, need to be used.
7. *Soybean supplementation of weaners provided very high returns for farmers*. Soybean meal (a grain legume), combined with local feeds, made excellent weaner diets resulting in high growth rates of weaners. It is likely that the same diet could also be used as creep feed for suckling piglets to assist in the transition to solid diets, supplementing milk supply from sows.
8. *Stylo leaf meal – a way of storing Stylo for the dry season.* Some farmers processed fresh Stylo into leaf meal as a way of storing Stylo for the dry season or use on days when they didn't have time to harvest fresh material. Clearly, considerable effort is required to dry and process Stylo, and only a limited number of farmers had adopted this strategy by the end of the project.
9. *Native Moolath pigs can grow well, if fed well.* Experiments showed that the native Moolath pigs could grow reasonably fast (>500 g/day) when fed a high quality diet.

Native pigs were able to cope with more fibrous diets than exotic pigs, which made them particularly suited to forage legume supplementation.

10. *Facilitating a Learning Alliance with NGOs and other development agencies led to sustainable scaling out of research results.* Providing a platform for sharing knowledge and experiences on village pig production was successful in linking researchers with multiple development partners. Researchers benefited from feedback from development partners, who in turn benefited from access to relevant information, training and experiences of other professionals. An informal network of practitioners emerged which is likely to provide continued support to former Alliance members. Strengthening capacity of development partners to scale out Stylo supplementation and other improved pig production interventions has been a successful strategy for scaling out.
11. *Successful facilitation of a Learning Alliance required effective facilitation skills.* Providing a neutral platform and effective facilitation were essential for bringing together a diverse range of partners. Creating an environment where all participants were happy to listen, freely shared their experiences and actively participated in the Alliance was essential and required excellent facilitation skills. Finding the 'right' facilitator was critical for the success of the Alliance.

10.2 Recommendations

While the project has made good progress towards understanding and addressing the nutritional constraints of village pig production, it also identified several research issues which, if addressed successfully, will amplify the impacts achieved already. It is recommended that these be considered for inclusion in the new, follow-on pig systems project 'Increased productivity of pig production and market chains for improved livelihoods in Laos':

- A better understanding of the nutritional requirements of local pig breeds. Several experiments working towards this goal are already being carried out by PhD students in Laos. Keeping in close contact with these students and filling critical gaps in the research will ensure that the results from this research can be used to improve the accuracy of the Diet Calculator and update nutritional recommendations and example diets.
- The protein/lysine digestibility of forage legumes (ie. availability of protein to the pig) for native Moolath pigs at different stages of growth. Results of the project and related literature indicated that, for exotic pigs, the digestibility of protein from leaves of forage legumes decreased sharply as legumes matured. These type of experiments need to be conducted with local pig breeds, which are better adapted to fibrous diets than exotic pigs, to be better able to predict the benefits of forage legumes for native pigs.
- Soybean meal was a very effective source of protein for supplementing weaners. Farmers reported that there were many agronomic issues with growing soybean (high incidence of insect damage and diseases) and the grains required accurate heat treatment to ensure that they were an effective protein source. It is recommended that the follow-on project evaluates (i) soybean varieties suitable for growing in northern Laos, and (ii) the suitability of alternative grain legumes such as cowpea, which may be easier to grow and process as a protein supplement for pig production.
- A better understanding of how much fresh Stylo (and other legumes and greens) can be fed to pigs when farmers use low-fibre basal feeds such as cassava and maize. Research indicated that pig diets (for pigs weighing more than 15kg) should only contain approx. 10% (on a dry matter basis) of fresh Stylo. If more fresh Stylo was added, voluntary intake decreased. This research was conducted

with rice bran as the main feed component which is very high in fibre. Using low-fibre basal feeds may allow the inclusion of higher proportion of fresh Stylo in the diet, resulting in higher growth rates.

- Finding practical options for farmers to use in their penned pig production systems: (i) modifications to pens to allow separation of different classes of pigs for feeding of specific diets (e.g. creep feeding of suckling piglets); (ii) ad libitum feeding and 24 hour water supply for pigs; (iii) improved hygiene in pens, feed troughs and watering points.

There are also some issues that could not be addressed fully in the current project but that have the potential to provide significant impacts. These include (i) simple treatment options of diarrhoea in piglets to improve survival of sick animals; (ii) feed conservation to allow farmers to store feeds such as maize and leaf meal throughout the year, (iii) labour saving options for producing legume leaf meals, and (iv) seed systems for Stylo and other forage legumes used by farmers.

As village pig production systems intensify, new research issues are likely to emerge. These include diseases associated with keeping more animals in a small space, and waste management issues.

Facilitating a Learning Alliance to link researchers with multiple development partners and so strengthening the capacity of their staff through workshops and training courses proved to be an effective way to develop and scale out improved pig production technologies, and should be continued.

Finally, it is recommended that the new project develops a working website where it makes publications and tools arising from the various ACIAR pig projects available to the wider research and development community. Additionally, finalised tools and publications should be shared with other practitioners through other existing livestock knowledge portals.

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11.3 Planned publications

Several publications of project results are in preparation:

- The Pig DIET CALCULATOR consisting of a manual with nutritional information, instructions, and a spreadsheet for formulating pig diets using local feeds. A working version is available, and a more descriptive version is in preparation for general use. This will be made available to the new pig systems project for distribution.
- A booklet presenting the nutrient composition of commonly used local feeds, forage legumes and selected grain legumes. This publication will include descriptions of feeds and their chemical composition. Some of the chemical analysis results are not yet available but it is hoped that the booklet can be completed by the end of 2010. It will be made available through the new project.
- Several scientific publications are planned by project partners. These include papers on (i) the energy and protein digestibility of *Stylosanthes guianensis*, (ii) growth potential and protein deposition of native Moolath pigs, (iii) nutritional value of local Lao feeds, and (iv) the effect of protein supplementation of Moolath weaners. There are several additional results from surveys and experiments, which cannot easily be published as individual papers but would provide valuable information of pig systems in Laos –maybe as part of a monograph on village pig production systems in Asia?

12 Appendix

Appendix 1: Best Practice Guide - How to conduct Village Learning Activities

See separate file: Best practice guide - How to do a Village Learning Activity.pdf

Appendix 2: Best Practice Guide - Pig Fattening

See separate file: Best practice guide - Pig fattening.pdf