EFFECTS OF FRESH OR SUN-DRIED CASSAVA FOLIAGE ON THE GROWTH PERFORMANCE OF GOATS FED BASAL DIETS OF GAMBA GRASS OR SUGAR CANE STALK

by

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Dedication

To my mother, Peng Kounnavongsa
All my brothers and sisters

Existing goat production in smallholder farming systems in the central regions of Laos

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Abstract

The overall aims of this thesis were to study existing goat production systems in lowland Laos, to investigate the potential to intensify goat production by using locally available feed resources, such as sugar cane, as the basal diet, and supplementing with fresh and sun-dried cassava foliage as the major protein source in view of the lack of information concerning the risk of toxicity from feeding the fresh cassava foliage.

Sixty goat farmers in four villages of Nongbok and Xe bangfai Districts in Khammuane Province were selected, and formal and informal interviews were used to get information about goat production systems. Information concerning problems and potential for goat production in each village was collected using participatory diagnosis. Data obtained included broad agricultural production systems, the importance of goats, number of goats per family, advantages and disadvantages of goat production, reproductive performances and farmers' experience to overcome the problems associated with keeping of goats.

The results showed that livestock plays an important role and is a major source of income for farmers. Each household has, on average, 2.2 ha of rice land. Cultivated land encompasses more than 45% of total area and includes irrigated paddy (7%), rain-fed paddy (34%) and other land such as upland crops. The number of family members per household varied from 4 to 12 persons with an average household size of 5.4 persons. Sex distribution was as 49% for males and 51% for females.

The average number of goats, cattle, buffaloes, pigs and poultry was 12, 7, 4, 2 and 15, respectively. Extensive systems were commonly found in all villages for ruminants, and were based on traditional management methods. Free range and semi-free range systems were found in the four selected villages. Animals were grazed freely on communal grazing areas for the whole day in the dry season, but kept confined or tethered during the crop production season. The feed resources were native grasses, tree leaves, shrubs, legumes and crop residues. Rice bran, broken rice, maize, cassava root and kitchen waste were the main feed sources for pigs and poultry. The average number of goats per family, and average body weight was 12 and 16 and 35 and 31kg for the free range system and semi-free range system, respectively. First kidding was at the age of 1 year, with an average of 1.5 kids per litter and 1.7 litters per year.

Foot and mouth disease and haemorrhagic septicaemia were the main problems which caused a high mortality rate. For ruminants including goats, Toxocara (roundworm infestation) was a major cause of the death of young calves. Swine fever and fowl cholera caused high mortality rates for pigs and poultry, respectively. Contagious Echthyma ("Orf") was found in goats. Internal parasites were the main constraint for goats, especially for the young kids. The main purpose of keeping ruminants is for sale, while pigs and poultry are used for home consumption and traditional ceremonies.

The growth experiment was conducted at the Livestock Research Center. Twenty local growing goats, including males and females, were arranged in a 2*2 factorial in a randomized complete block design (RCBD) with six replications. The daily live weight gain did not differ between sugar cane and Gamba grass but was higher for fresh than for sun-dried cassava foliage. In contrast, the DM feed intakes were lower for fresh versus dried cassava foliage and for sugar cane compared to Gamba grass. As a result, the feed conversion was better for fresh than for dried cassava foliage and for sugarcane than for Gamba grass. The inclusion of fresh cassava foliage resulted in 35% higher weight gain and 36% better feed conversion compared with the sun-dried form. Fresh or sun-dried cassava foliage is a valuable supplement for goats receiving low or medium quality diets, such as Gamba grass and sugarcane stalk.

Key words*: Extensive systems, Gamba grass, sugarcane, cassava foliage, intake, growth, local goats.*

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Appendix

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I. Bounthavone Kounnavongsa, Vanthong Phengvichith and T R Preston. Existing goat production systems in Khammouane Province, Laos

II. Bounthavone Kounnavongsa, Vanthong Phengvichith and T R Preston. Effects of fresh or sun-dried cassava foliage on growth performance of goats fed basal diets of Gamba grass or sugarcane stalk

List of abbreviations

ADB	Asian Development Bank
ADF	Acid detergent fiber
ADG	Average daily gain
AOAC	Association of Official Analytical Chemists
ANOVA	Analysis of variance
BW	Body weight
CP	Crude protein
DLF	Department of Livestock and Fisheries
DM	Dry matter
DMI	Dry matter intake
FAO	Food and Agriculture Organisation of the United Nations
FCR	Feed conversion ratio
GDP	Gross Domestic Product
GLM	General linear model
HCN	Hydrogen cyanide
LW	Live weight
N	Nitrogen
PAFO	Provincial Agriculture and Forestry Office
Prob.	Probability
RCBD	Randomized Complete Block Design
SEM	Standard Error Mean

Introduction

Laos is located in the central part of the Indochinese Peninsula. It is an inland state surrounded by China, Vietnam, Cambodia, Thailand and Myanmar. The land area is about 236,800 km^2, of which 80% is occupied by mountains and hilly regions. The agricultural land is limited to around 4% of the total. The population is approximately 6.5 million with an annual growth rate of 2.3% in 2006. There are three main ethnic categories of people: The Lao Loum constitute 68%, the Lao Theung 22% and the Lao Soung 9%. Laos is one of the least densely populated countries in Asia, with 23.3 people per km^2.

Agriculture generates about half the country's GDP, and rice and livestock products account for about 40% and more than 30% of the total agricultural production, respectively (STEA, 2003) The forests of Lao PDR have very high biodiversity, containing at least 10,000 species of mammals, reptiles, amphibians, birds, fish, and vascular plants. Laos ranks as one of the biologically richest countries in the region. Approximately 1.5% of the total land area has been set aside as National Biodiversity Conservation Areas (Linkham et al, no date). Approximately 80% of the population is engaged in subsistence farming, rather than commercial agriculture. Farming systems in Laos are mainly rice-based at subsistence level, where livestock production is a supplementary and complementary component of the systems. The lowland areas are predominantly occupied by Lao Lum, who cultivate paddy rice as their main occupation. The farm size averages about 1.9 ha per household with 2.24 tonnes of rice yield or an average of 344 kg of paddy per person per year. Apart from crop production, farmers also rear livestock, such as goats, cattle, buffaloes, pigs and poultry. They are reared mainly for monetary security and are an integral part of smallholder farming systems. Over 95% of the livestock is owned by smallholders. They are extremely important for the livelihood of smallholders as a sole means of accumulating assets, earning cash income, and providing draft power and manure for crops.

Goats play an important role in food production systems in almost all developing countries. Their great popularity can be explained by their good adaptation to many different climates and the many uses for which they can be kept. Goats are of high importance to people because of the many functions they provide: they serve as a bank account which can be drawn upon when cash money is needed. Furthermore goats provide milk and meat which are high-grade foodstuffs for people and contain high quality protein to balance diets based on cereal grains. Goats are much more resistant than cattle; they are small animals and cost less per animal. Each farmer usually owns a number of goats, and goat keeping therefore touches on many peoples lives.

Goats in Laos are of the local breed, with small body size, similar to the Katjang breed of goat, which are common throughout Southeast Asia. They reach a mature weight of about 40 kg and are raised for meat. The first kidding is usually at 12-18 months of age with a single kid. The does generally give birth twice a year, with a high incidence of twins. Goats are found more frequently in the upland areas than in the lowlands, with the largest concentrations in Oudomxay, Luangprabang, Huaphanh and Savannakhet provinces. Goats are allowed to graze freely all year round in small groups in forests, fallow cropland, natural grassland and communal land. The current production systems found are the free-range system, semi-rotational grazing system, semi-free range system and permanent grazing system, but most goats are produced in extensive production systems with low capital and other inputs. As goats are selective animals, farmers limit the number of goats they raise to avoid excessive damage to crops, for which the owner is held responsible. Lack of feed, especially in the dry season, high incidence of diseases and the expansion of crop production are major constraints.

There usually are good local and external markets for goat meat, which is one of the reasons for the increase in the goat population of around 8% per annum over the last 20 years.

Objectives

The aims of the present research were to:

- Study existing goat production systems in lowland Laos
- Investigate the potential to intensify goat production by feeding sugarcane as the basal diet.
- Compare fresh and sun-dried cassava foliage as the major protein source

General discussion

Livestock production systems in Laos

Agriculture is the mainstay of the economy in Laos. For the rural smallholders, who contribute most of the country's agricultural output, livestock keeping is often a vital source of cash income, a means to accumulate assets, and a provider of inputs to crop production. Cattle, buffaloes, pigs, chickens and goats are the most important livestock species in the country. Demand for meat is increasing, and there is a growing potential for exporting livestock and their products to neighboring countries. There is great potential to enable a dynamic development of the livestock and fisheries sub-sector. Relatively extensive land areas throughout the country are well suited to pasture and fodder production. An estimated 7 to 8 million hectares of grazing land and associated water resources are underutilized; comprising natural grasslands, forests, barren lands, inland water resources, and reservoirs, of which about two thirds are located in the uplands. It is estimated that in the future ruminant production in upland areas will increase and supply the demand of the lowland and urban areas, as intensification and mechanization in the lowland decreases land availability for grazing goats.

Livestock in Laos offer today one of the most promising opportunities for Lao farmers and foreign investors to commercialize, with high value products. According to the economic growth in the region, domestic and regional demand for livestock products is expected to increase.

Market demand for local consumption and export of goat meat is strong, the price per kg of live weight presently being about US$1.7 to 2.0 and goat meat is more expensive than cattle and buffalo meat, which sells at US$1.3 to 1.5 per kg. Recently, according to survey data, the price of live goats traded in Savannakhet province in June 2009 has increased to US$ 2.7 per kg live animal. This is one reason for the relatively high rate of increase in the goat population over the last 20 years (Stür et al., 2002). The government has adopted a livestock development plan to strengthen and promote animal production and enhance national food security.

Farmers raise animals predominantly by traditional methods based on low input and low output production systems, so the output per animal is not high. The animals are mainly indigenous and kept mostly under free range conditions; they feed themselves by grazing the natural grassland, in paddy fields after the harvest, on fallow land, in the communal land, and in the forest. The free range system means that there is often no selection of breeding animals. There is lack of information about livestock breeds and only pig breeds have been described in Laos (Table 2).

Feed resources are inadequate, and diseases and parasites are the main constraints on livestock production. The animal production systems have been changing recently in the lowland areas, particularly in the irrigated rice production areas, where instead of one rain-fed

rice crop the farmers now produce two rice crops a year. The grazing area for the buffalo and cattle is limited, which makes the traditional method of raising ruminants difficult. The main feed resources in all these systems are native grasses, shrubs, legumes and tree leaves that are available in these areas. Especially, goats are susceptible to seasonal parasite burdens under poor management conditions, resulting in high mortality rates of up to 50%. Native goats have high reproductive rates and are much cheaper than cattle and buffaloes, which make them very attractive and accessible to poor smallholder farmers.

A serious constraint to livestock production is the high animal mortality rate due to widespread incidence of animal diseases. More than 80% of chickens are said to die every year in upland villages; sporadic disease epidemics frequently kill many of the pigs, and the mortality rate of buffalo calves due to internal parasites is estimated at 30 to 40% (FAO, 2005)

Livestock production has often been identified as an ideal livelihood activity for Lao farmers who are looking for ways of moving out of shifting cultivation, especially in upland areas. The reasons for this have been presented elsewhere (Pravongviengkham, 1998; Hansen, 1998) but include:

- Livestock can be sold at any time in a market that has a relatively constant demand and relatively stable prices
- Ruminants such as goats, cattle and buffalo can walk for long distances to market
- Livestock provide manure to sustain yields of lowland rice and home gardens
- Livestock provide a relatively high return per unit of labor input
- Larger livestock use feed resources that cannot be utilized for any other purpose
- In many cases, livestock are the only means of capital accumulation available to farmers
- Livestock are less susceptible to the climatic cycles of drought and flood and, unlike crops, can be sold to when there are extreme conditions, like at times of severe floods.

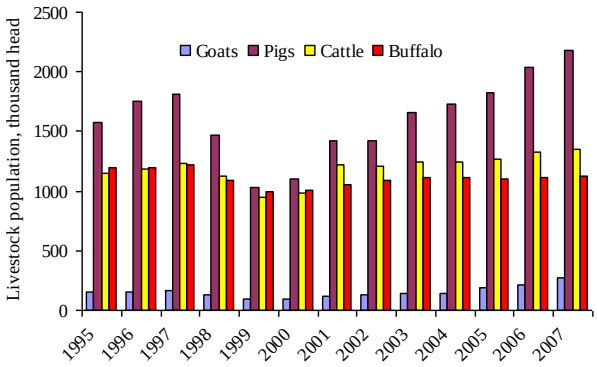

Figure 1: Livestock population in Laos

Table 1: Livestock population in Laos, thousand head

Type of animals	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Goats	153	159	165	132	94	100	123	126	138	139	191	211	268
Pigs	1580	1750	1813	1465	1036	1101	1427	1416	1655	1728	1827	2032	2186
Cattle	1146	1186	1228	1127	944	987	1218	1209	1245	1249	1272	1324	1353
Buffalo	1191	1197	1224	1093	992	1007	1052	1091	1113	1112	1097	1108	1123

Source: Ministry of Agriculture and Forestry, 2005

Table 2: Status of livestock breeds

Type	Breed	Population	Characteristics	Survey	Breeding program	Crossbreeding
Goats	Local	268,000	Not yet described	None	None	None
Buffalo	Swamp	1,123,000	Not yet described		None	None
Cattle	Yellow Asian	1,353,000	Described		None	None
Pigs	4 types	2,186,000	Described 4 types of indigenous pigs	Yes	None	None
Poultry	Indigenous	20,453,000	Not yet described	None	None	None

Source: Department of Livestock and Fisheries, 2007

Potential for goat improvement

Most goats in Laos are grazed freely all year round in small groups in the forest and fallow cropland. Health problems and lack of feed seem to restrict enlargement of the herd. Farmers also tend to restrict the herd size in order to avoid excessive damage to crops, for which the owner is held responsible (Stür et al., 2002). In recent years goat management practices have been changing (Phengsavanh 2003), and vary from site to site depending mostly on land availability, labor and community regulations. The existing production systems include free-range, semi-rotational grazing, semi- free range system, and permanent grazing and tethering. There is a comparative advantage for ruminant production in Laos because of the availability of large areas of suitable land.

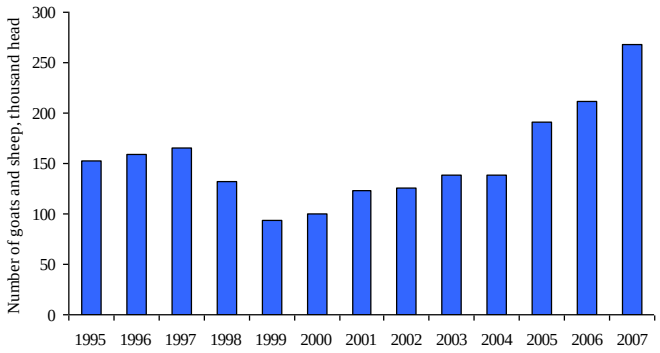

Figure 2: Goat population in Laos

Most goats are produced in extensive production systems with low capital and other inputs, particularly in hilly areas that are ideally suited to the breeding and supply of weaned goats. The local breeds have high reproductive rates and are much cheaper than cattle and buffaloes, which make them very attractive and accessible to poor smallholder farmers. For the small-scale farmer, the goat has a number of attractive properties. As they are small animals, compared to cows, their value is not very high, meaning that keeping goats involves less risk. It is easier to find feed for a small animal and even small children can control them and they are a quickly maturing animal with a high fertility. Animals are regularly available for sale or other uses so herd size restoration is also quickly done. Goats, especially can maintain themselves well in poor areas with long dry seasons, where other ruminants cannot. Goat rearing requires a low labor input compared to large ruminants and cropping (Carl et al, 2004).

Constraints and limitations on goat production

The results of the survey (Paper I), indicated that the constraints and limitations to goat production in Laos are:

- Due to the free grazing system, the high incidence of diseases and parasites is the main problem for smallholder goat production. These include internal parasitic infestation, especially in young kids after weaning. Heavy worm infestations are the cause of high mortality of kids, which can be up to 50 percent prior to weaning. Contagious ecthyma, an infectious dermatitis of goats that affects primarily the lips of young kids, is aother

problem. It can be treated with a little care at the time of an outbreak, but generally goats are severely affected and lose weight. Bloat is another concern and is a cause of mortality.

- Feed shortage in both dry and wet seasons, especially in the areas of intensive crop production, where grazing land becomes limited. The long dry season also affects the productivity of the grazing areas. Animals gain weight in the wet season and lose weight in the dry season, when they are susceptible to diseases.
- In many cases during the planting season, goats are tethered or confined in small areas where feed is limited, to avoid crop damage. In the dry season, the amount and quality of feed is low, and although goats are allowed to graze freely, they may have to walk long distances in search of feed
- All of these problems have a negative impact on the growth and productivity of goats
- Lack of extension capability to promote improved animal nutrition and husbandry
- Lack of capital: access to credit by smallholders is generally difficult and expensive

Possibilities for intensification of goat production in Laos

There are several reasons for promoting more intensive systems of goat production in Laos. The most important is the need to reduce the production of greenhouse gases, which are major contributors to global warming. Methane production from livestock is estimated to account for 37% of total anthropogenic emissions of this gas, two thirds of which arise from enteric fermentation in ruminant animals (FAO 2006). Two factors have to be considered. One is the productive rate of the animals, and this is specifically an issue in Laos as the extensive grazing systems support only low rates of animal productivity. It has been clearly demonstrated that the higher the growth rate the lower is the proportion of methane per unit of live weight gain (Leng 1991). This is an incentive for intensifying the present goat production systems. The second factor concerns the possibilities of modifying the rumen fermentation to reduce directly the proportion of the dietary energy converted to methane. In a review of the literature, Leng (2008) arrived at the conclusion that the presence of nitrate salts in the rumen will act as a sink for the hydrogen produced by fermentation of carbohydrate such that the hydrogen will be converted to ammonia rather than methane. Results of unpublished recent research in Australia and the Netherlands (Leng, personal communication) indicate that the proportion of methane in the rumen gases of cattle can be reduced by 50% by feeding sodium nitrate instead of urea as the nitrogen source in low-protein diets based on rice straw and sugarcane. According to Leng (2008), the dietary conditions which favour utilization of nitrate to lower the production of methane are: a source of easily fermentable carbohydrate, a low content of soluble protein, an adequate level of sulphur and a source of bypass protein.

Sugarcane satisfies the need for a basal diet that is rapidly fermentable (contains 50% sugar in the DM) and is low in soluble protein (less than 1% in DM). It has been shown to support growth rates in cattle of over 700 g/day when supplemented with urea and rice polishing as a source of bypass nutrients (Preston et al 1976). The potential to grow sugar cane in Laos is very high and presently there are ongoing projects to establish several sugarcane factories in the central and northern regions of the country. It also is one of the highest biomass yielding plants

In the experiment reported in Paper II, there were no differences in growth rate between goats fed chopped whole sugarcane and those fed fresh Gamba grass; however, the DM feed conversion was much better on the sugarcane diet.

The foliage of cassava (*Manihot esculenta*, Crantz) is now considered to be one of the most appropriate sources of bypass protein in ruminant diets due to its content of condensed tannins that bind the leaf proteins in the processes of mastication (Wanapat 2008). Several recent studies have shown major increases in growth rate in cattle when low-protein basal diets were supplemented with cassava foliage, either in the fresh state (Ffoulkes and Preston 1978; Ho

Quang Do et al 2002; Seng Mom et al 2001), as sun-dried foliage (Keo Sath et al 2008) or as leaf meal (Ho Thanh Tham et al 2008). An additional benefit from feeding cassava foliage to goats is that the tannins appear to modify or control nematode infestations (Seng Sokerya and Rodriguez 2001).

There is some controversy as to the potential toxic effects of the hydrocyanogenic glucosides present in fresh cassava foliage and which can give rise to liberation of HCN. For this reason, sun-drying of the foliage has often been recommended as the preferred form of processing (Wanapat 2005). However, there are several reports (Ffoulkes and Preston 1978; Seng Sokerya et al 2001; Theng Kouch et al 2003; Seng Mom et al 2001) in which cassava foliage was fed in the fresh state and where there were no indications of toxicity. There appear to be no reports in the literature of toxicity resulting from the feeding of fresh cassava to ruminants.

The experiment reported in Paper II showed not only that there was no toxicity from feeding the fresh cassava foliage, but also that growth rate and feed conversion were better on the fresh than on the sun-dried foliage.

Conclusions

- There is considerable potential for increasing goat production in Laos as demand for meat is high both in local and export markets
- Present management systems support only low productivity and are constrained by reduced availability of grazing land due to competition from food and cash crops
- Future developments should consider the opportunities for intensification of the production systems, which would have dual benefits of improved meat quality resulting from faster growth rates and improvements to the environment through the potential for reduced emissions of methane.

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References

Carl J and Kees V D B 2004 Goat keeping in the tropics
http://www.eap.gov.et/content/files/Documents/EAP%20Documents/Agricultural%20Comodities/Livestock/Small%20Ruminants/Goat/Capacity%20Building/Goat%20keeping%20in%20the%20tropics.pdf

DLF 2007 Department of Livestock and Fisheries Ministry of Agriculture and Forestry Vientiane Laos
http://www.nsc.gov.la/Statistics/Selected%20Statistics/Agriculture/Lifestock.htm

FAO 2002 Food and Agriculture Development in Asia and Pacific
http://www.fao.org/docrep/004/ad452e/ad452e2e.htm

FAO Livestock sector brief 2005 Lao People's Democratic Republic Food and Agriculture Organization of the United Nations, Livestock Information, Sector Analysis and Policy Branch AGAL
http://www.fao.org/ag/againfo/resources/en/publications/sector_briefs/lsb_LAO.pdf

Ffoulkes D and Preston T R 1978 Cassava or sweet potato forage as combined sources of protein and roughage in molasses based diets: effect of supplementation with soybean meal Tropical Animal Production 3(3): 186-192
http://www.fao.org/ag/aga/agap/frg/tap33/3_3_1.pdf

Hansen P K 1998 Animal Husbandry in Shifting Cultivation Societies of Northern Laos. In Chapman, E.C., Bouahom, B. and P.K. Hansen (eds.) *Upland farming systems in Lao PDR: Problems and opportunities for livestock*. Proceedings of a workshop held in Vientiane, Lao PDR from 19-23 May 1997. ACIAR Proceedings Series 87:112-117. (ACIAR, Canberra).

Ho Quang Do, Vo Van Son, Bui Phan Thu Hang, Vuong Chan Tri and T R Preston 2002 Effect of supplementation of ammoniated rice straw with cassava leaves or grass on intake, digestibility and N retention by goats. . Livestock Research for Rural Development 14 (3) http://www.lrrd.org/lrrd14/3/do143b.htm

Horne P M and Stür W W 1999 Developing forage technologies with smallholder farmers-how to select the best varieties to offer farmers in Southeast Asia. ACIAR Monograph No. 62. 80 pp.

Kouch T, Preston T R and Ly J 2003 Studies on utilization of trees and shrubs as the sole feedstuff by growing goats; foliage preferences and nutrient utilization. Livestock Research for Rural Development 15 (7).
http://ftp.sunet.se/wmirror/www.cipav.org.co/lrrd/lrrd15/7/kouc157.htm

Leng R A 1991 Improving ruminant production and reducing methane emissions from ruminants by strategic supplementation. A Report prepared for the Environmental Protection Agency of the U.S.A. EPA/400/1-91/004

Leng R A 2008 Decline in available world resources; implications for livestock production systems in Asia. *Livestock Research for Rural Development. Volume 20, Article #8.* Retrieved June 30, 2010, from
http://www.lrrd.org/lrrd20/1/leng20008.htm

Linkham D and and Khamphou P Food Security and Biodiversity in the upland Lao PDR: A Review on Recent situation of Causes and Effect
http://www.trf.or.th/TRFGallery/Upload/Gallery/Documents/Files/1000000008.pdf

Ministry of Agriculture and Forestry, 2005
http://www.nsc.gov.la/Statistics/Selected%20Statistics/Agriculture/Lifestock.htm

Mom Seng, T R Preston, R A Leng and U ter Meulen 2001 Effect of a single drench of cooking oil on the rumen ecosystem and performance of young local "yellow" cattle fed rice straw and cassava foliage

http://www.lrrd.org/lrrd13/4/seng134.htm

Phengsavanh P 2003 Goat production in smallholder farming systems in Lao PDR and the possibility of improving the diet quality by using *Stylosanthes guianensis* CIAT 184 and *Andropogon gayanus* cv Kent. MSc. Thesis. Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden

Pravongviengkham P 1998 Swidden-Based Farm Economics in Northern Laos: Diversity, Constraints and Opportunities for Livestock. In Chapman, E.C., Bouahom, B. and P.K. Hansen (eds.) Upland farming systems in Lao PDR: Problems and opportunities for livestock. Proceedings of a workshop held in Vientiane, Lao PDR from 19-23 May 1997. ACIAR Proceedings Series 87:89-102. (ACIAR, Canberra).

Quang H D, Son V V and Preston T R 2002 Blocks or cakes of urea-molasses as supplements for Sindhi x Yellow growing cattle fed rice straw and cut grass or cassava foliage Livestock Research for Rural Development, Volume 14, Number 2, April 2002 http://www.lrrd.org/lrrd14/2/do142.htm

Sath K, Borin K and Preston T R 2008: Effect of levels of sun-dried cassava foliage on growth performance of cattle fed rice straw. *Livestock Research for Rural Development. Volume 20, supplement.* Retrieved June 30, 2010, from http://www.lrrd.org/lrrd20/supplement/sath2.htm

Seng S and Rodriguez L 2001 Foliage from cassava, *Flemingia macrophylla* and bananas compared with grasses as forage sources for goats: effects on growth rate and intestinal nematodes. Livestock Research for Rural Development 13 (2): http://www.lrrd.org/lrrd13/2/soke132.htm

STEA 2003 Biodiversity Country Report Ministry for Agriculture and Forestry (MAF) Science Technology and Environment Agency
http://www.undplao.org/newsroom/factsheets/publication/Biodiversitycountryreport.pdf

Stür W, Gray D and Bastin G 2002 Review of the Livestock Sector in the Lao People's Democratic Republic. http://webapp.ciat.cgiar.org/asia/pdf/adb_livestock_review.pdf

Takao N 2000 Report of the society for researches on native livestock No. 18 ISSN 0910-0784 p113

Tham H T, Man N V and Preston T R 2008: Performance of young cattle fed rice straw sprayed with mixture of urea and molasses supplemented with different levels of cassava leaf meal. *Livestock Research for Rural Development. Volume 20, supplement.* Retrieved June 30, 2010, from
http://www.lrrd.org/lrrd20/supplement/tham1.htm

Existing goat production systems in Khammouane Province, Laos

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Abstract

Interviews on goat production systems in Sebanfai and Nong Bok Districts, Khammuane Province, were conducted in four villages with 60 farmers to obtain information on livestock production in general and specifically on goat production, including growth performance, feed resources and availability, health care and possible solutions to overcome identified limitations within the present system .

The survey showed that goats, cattle, buffalo, pigs and poultry are the main livestock species kept by farmers using traditional production systems and management. Very few farmers vaccinated their animals. Feed shortage, especially in the dry season, was the main constraint for ruminants. In general the minimum input system resulted in high mortality rates and low growth performance. Goats were the species considered to best tolerate really low inputs, as they survived the long dry season better than other ruminants. More than 60% of small-holder farmers raise goats often because of lack of funds to buy large ruminants. Free range and semi-free range systems were found in the studied areas. Raising goats was considered to have a good future because of high market demand. The reproductive performance showed that the first kidding was at the age of 1.0 to 1.1 years, with 1.3 to 1.6 kids per litter and 1.6 to 1.9 litters per year. The average weight of mature males was from 32 to 33 kg while for the females it was 26 to 28 kg. The average number of goats per family was 12 heads, with the maximum number of 32 heads for the free range system, and 16 heads with the maximum of 40 heads for the semi-free range system.

The constraints in raising goats were high mortality rate for the young kids, lack of feeds, both in quantity and quality, and management difficulties inherent in free grazing systems. If these technical concerns could be improved, goat production in these areas could be a good source of income for smallholder farmers in the future.

***Key words**: farmer practice, growth performance, local goats,*

Introduction

Livestock are important elements of the pathway out of poverty for millions of the rural poor in Asia and the Pacific. Livestock have a special role to play in the conversion of feed that is unsuitable for humans into food and other useful products. Small livestock, especially goats, sheep, pigs and poultry are especially important for the poorest livestock keepers and for the landless, who could start to raise livestock. In Laos, livestock play a key role in the lives of poor, rural people, providing a major proportion of their cash income, capital assets, draught power, fuel and fertilizer. The sale of livestock accounts for more than 50% of the family cash income of smallholder farmers. Over 95% of all livestock is produced by smallholders and

there is only a small number of commercial pig and poultry enterprises near major cities. The livestock population has been increasing in the last decade, and in 2007 there were approximately 1.3 million cattle, 1.1 million buffalo, 2.1 million pigs, 268,000 sheep and goats and 20.4 million poultry (DLF, 2007). The average annual growth rate for the last decade is 4% for cattle, 2% for buffalo, 8% for goats, and 3% for pigs, and most are indigenous breeds. These indigenous animals contribute more than 90% of national meat consumption. Based on the strong demand for meat both in domestic markets and neighboring countries, there are considerable opportunities to increase the production of cattle, buffalo and goats. Relatively extensive land areas throughout the country are well suited to pasture and fodder production, with an estimated 7 to 8 million hectares of grazing land and associated water resources being underutilized. Livestock in Laos offer today one of the most promising opportunities for Lao farmers and foreign investors to commercialize with high value products. According to the economic growth in the region, domestic and regional demand for livestock products is expected to increase.

Goat production plays an important role in rural and remote areas, supplying cash income, meat and organic fertilizer. The shortage of feed in both quantity and quality, poor management and high incidence of diseases result in low productivity and poor reproduction (Phengsavanh 2003). Local breeds, which have a small body size, are well adapted to the local environment. Detailed information about goat breeds, performance and other characteristics is needed in order to improve production and productivity. Average body weights when mature are between 25 to 35 kg. Litter size is normally two kids per litter after the first kidding. Most goats are kept in free range systems where they graze freely all year round in small groups in forest, fallow land, flatland, roadsides and on communal land (Xaypha 2005). Goat production systems in smallholder farms in Laos are classified into four systems (Phimpachanhvongsod, 2001) according to management practices: free range systems, semi-rotational grazing system, semi-free range system and permanent grazing system. According to DLF (2007), 47% of the total goat population is found in the north or mountainous region, 42% in the central region and 11% in the southern region of the country.

Table 1: Average measurements of body parts in adult native goats of Laos

Body parts	Male	Female
Withers height	53.6	53.9
Hip height	53.5	55
Body length	55.6	59.95
Chest depth	26.5	26
Chest width	11.4	13.85
Hip width	12.3	12.9
Thurl width	13.6	13.9
Hucklebone	8.9	9.5
Foreskin circumference	6.9	6.8
Chest girth	63.8	67.85

Source: *Takao Namikawa, 2000*

The demand for goat meat is increasing. There is usually is a good local market demand for goat meat, which is one of the reasons for the relatively high rate of increase in the goat population, about 8% per annum over the last 20 years (Photo 2).

Table 2: Population and distribution of goats, 1999 to 2003, thousand head

Location	1999	2000	2001	2002	2003	Percentage
Northern	60	60	51	57	63	46
Central	43	58	61	59	58	43
Southern	9	9	12	12	15	11
Total	112	127	124	128	136	100

Source: *Department of Livestock and Fisheries, 2007*

The aim of this survey was to study the existing goat production systems, their productivity, constraints and possibilities to expand in the future. The survey was conducted in Xe Banfai and Nongbok districts, Khammuane Province.

Materials and methods

Site selection description

The country is divided into three regions: northern, central and southern. Khammuane province is located in the central part of Laos, approximately 350 km south of the capital Vientiane (Figure 1), sharing borders with Bolikhamxay and Savannakhet provinces, Vietnam in the East and Thailand in the West, and covering about 16,135 square kilometers, of which about 39% belongs to three interconnected National Protected Areas. One of these is considered to be one of the most biologically important areas in the world.

The province has a total population of 336,935 people (Population Census, 2005) comprising nine districts: Hinboun, Nakay, Ngommalat, Thakhek, Mahaxai, Boualapha, Nongbok, Xe Bangfai and Saibouathong. Nongbok and Xe Bangfai districts were selected and four villages (two in each district) were visited to obtain data, namely Ban Nong Bok, Ban Dong Houang, Ban Houay Xe, and Ban Ban Tung, respectively.

Khammuane province in the central region of Laos is subjected to a monsoonal climate comprised of distinct wet and dry seasons. The elevation ranges from 500 to 2,200 m. The rainy season is from May to September, and provides 87% of total annual rainfall. Highest rainfall occurs during July and August (240 to 330 mm/month) and lowest between November and January (<10 mm/month). The dry season lasts seven months, from October to April, and there is almost no rain between November and January. Khammuane is one of the central parts which suffers nearly every year from heavy flooding. The average annual temperature is 25.6ºC and pan evaporation is 1390 mm. (PAFO, 2010)

Figure 1: Map of site selection

Farmer selection

Sixty goat farmers in four villages were selected. Information about agriculture and livestock production was obtained from the village organizations. Individual farmers were interviewed separately about their general livestock production, type of farming system and socio-economic characteristics. Specific and detailed information about the role of goats, production system, management problems and potentials and how to overcome these problems were the main topics of the interviews.

Data collection

The formal survey was conducted using a semi-structured questionnaire. Information concerning problems and potential for goat production in each village was collected using participatory diagnosis. Data obtained included broad agricultural production systems, the importance of goats to the villagers, number of goats per family, advantages and disadvantages of goat production, reproductive performance and farmers' experiences in overcoming the problems associated with keeping goats.

Results

Household situation

Khammuane Province is considered as the main staple food production area in the central region of Laos due to its flat land. Each household has, on average, 2.2 ha of rice land. Cultivated land encompasses more than 45% of the total area and includes irrigated paddy (7%), rain fed paddy (34%) and other land, such as upland crops. The number of family members per household varied from 4 to 12 persons with an average household size of 5.4 persons. Sex distribution was as 49% male and 51% female. All selected farmers were Lao Loum, which is the major ethnic group in the country (accounting for 68% of the total population) and living along the Mekong River plain. Most of them are engaged in agriculture, especially rice production, livestock and crops mainly for home consumption.

Livestock production

Data obtained showed that livestock plays an important role and is a major source of income for farmers. Goats, cattle, buffaloes, pigs and chickens act as living 'banks' for most families; animals are raised and can be sold for cash during times of particular need, for family

consumption and to utilize the wastes from rice fields and home gardens. All mentioned species were found on the selected farms, with an average number of 12 goats, 7 cattle, 4 buffaloes, 2 pigs and some 15 chickens per household. Extensive systems were commonly found for ruminants, and were based on traditional management methods in these areas. Animals were grazed freely on communal grazing areas for the whole day in the dry season, but kept confined or tethered during the production season in the flatlands, forest land, on the roadside or scavenge around the village. The feed resources were native grasses, tree leaves, shrubs, legumes, and crop residues which are available according to the season. Rice bran, broken rice, maize, cassava root and kitchen waste were the main feed sources for pigs and poultry.

The lack of feed was found to be a major constraint for livestock production. Rice straw was stored without any treatment and fed to large ruminants mainly during the wet season when it was the only source of feed at the critical time of flooding. Animals were kept in pens at nighttime. Simple housing was found and was always close to the house due to security reasons and easy access.

The outbreak of disease was the other serious constraint. Foot and mouth disease and haemorrhagic septicaemia were the main problems, which cause high mortality rate. For large ruminants, Toxocara (round worm infestation) was a major cause of the death of young calves. As the territory is flat, when flooding occurs the incidence of disease is highest. High mortality rate of pigs and poultry was also found, particularly fowl cholera in poultry and swine fever in pigs. Contagious Echthyma ("Orf") was common in goats and occurred when the season changed. Internal parasites were the main constraint for goats, especially for the young kids.

Goat production systems

Farmers use local breeds which are well adapted to the local environment. Litter size was almost always a single kid at first kidding and twin kids per litter for the next and subsequent kiddings. Average number of goats per family varied, depending on the production system, management and family conditions. In the interviews, most of the farmers said that keeping goats had many advantages, such as the need for less labour, less space and less investment when buying the animals compared to other ruminants.

The main purpose was to produce meat and all the systems practiced were extensive. Farmers let their goats scavenge freely in the morning in the forest land, on the roadsides or on grassland all year round. The goats themselves come home in the evening and were kept in the shelter at night time. Tree leaves and some grasses were provided depending on how and when the farmers could find them (Photo 1). Salt was always provided in the shelter as almost all farmers believed that providing salt was the way to encourage the goats to return home by themselves.

There was no vaccination or de-worming programs for goats in the studied areas. Contagious echthyma was the main problem on goat production and farmers used traditional medicine to cure it. It was not an immediately serious problem, but affected animals took time to recover. The disease occurred every year, especially when the season changed, with almost all animals being affected.

The goats can breed all year round and some farmers keep their bucks for a long time, up to 5 to 6 years. As the free range system was practiced, inbreeding was also found to be a problem, with the farmers reporting it as a cause of weakness in the goats and susceptibility to diseases. Thefts and predators such as dogs were other problems for the farmers.

The grazing systems were free range and semi-free range. The free range system was found in all four villages selected. Goats were allowed to graze freely in the forest, on the roadsides, on grassland all year round, and come back to the homestead in the evening. No vaccination program against any disease as well as de-worming was found. Salt, in the surveyed areas was provided and goats were penned at night time. Farmers sometimes provided some tree leaves or legumes, according to availability. The semi-free range system was found in Ban Dong Houang, Ban Houay Xe and Ban Tung. In these areas, goats were allowed to graze freely in the dry season from October to April. Because of the difficulty in avoiding damage to crops in the rainy season, goats were herded by the owners, kept in confinement or tethered during the day and brought home in the evening. The problem was that in the rainy season, although feed, for example young green leaves, was abundant, the animals had no opportunity to eat. In contrast, in the dry season the animals had to walk further to find feed, and this also caused the loss of animals.

The main purposes of keeping goats are not for home consumption or for traditional ceremonies. Goat keepers rarely slaughter their own goats compared to other livestock species, and most are for sale (Table 3).

Table 3: Reasons for keeping livestock (60 farmers interviewed)

Type of livestock	Selling	Home consumption	Tradition ceremonies	Others
Goats	3	-	-	-
Buffalo	3	-	1	-
Cattle	3	-	1	-
Pigs	2	1	1	-
Poultry	2	1	1	-

 # 3 Most important. 2 Medium importance, 1 Least important

In the semi-free range system, the average number of goats per family is higher than in the free range system (Table 4). This is dependent on the production system and family conditions, but not on the availability of feed resources.

Table 4: Average number of goats per family

System	Farmers interviewed	No of goats		
		Mean	Min.	Max.
Free range system	37	12	2	32
Semi-free range system	23	16	6	40

The average weight of mature goats was similar for both systems (Table 5).

Table 5: Average mature goat weight (kg) in selected villages

System	Farmers interviewed	Male	Female	Mean	Min.	Max.
Free range system	37	33	28	35	25	46
Semi-free range system	23	32	26	31	22	40

Photo 1: Goat pen with some tree leaves being fed

Photo 2: Goat trade in Savannakhet, Laos

The goats were classified according to their sex and age (Table 6).

Table 6: Average flock composition

Systems	Number of interviewed farmers	Age, year										
		0-1		1-2		2-3		3-4		>4		Total
		M	F	M	F	M	F	M	F	M	F	
Free range system	37	2	4	-	5	1	1	-	-	-	-	13
Semi-free range system	23	4	4	1	4	1	4	-	-	-	-	18

The reproductive performance of goats shows that the first kidding is at around one year (Table 7).

Table 7: Goat reproductive performance

System	Farmers interviewed	Age at first kidding	Kidding rate/year	Number of kids/litter (year)
Free range system	37	1.0	1.3	1.6
Semi-free range system	23	1.1	1.6	1.9

There are several problems relating to the goat production, but the main ones are diseases and lack of feed (Table 8).

Table 8: Constraints in goat production using scoring# (ranking)

System	Farmers interviewed	Disease and parasites	Feed shortage	Lack of funds	Lack of labour	Predators	Lack of land
Free range system	37	2.1	3.0	-	-	1.1	1.2
Semi-free range system	23	4.0	2.9	2.0	2.0	1.0	1.4

 # Scoring 1-6, the lowest score is the most important constraint

Discussion

The four systems found in Laos (Phimphachamhvongsod, 2001) were free-range, semi-rotational grazing, semi free range, and permanent grazing and tethering. In the surveyed areas, the free-range and semi-free range systems were commonly practiced. Goat production and management practices have been changing, and vary from site to site due to the availability of land, labour and community rules and regulations. Goat population density is higher in the northern region than in the central and the southern regions: 46, 43 and 11%, respectively. The main reason for keeping goats is for sale rather than for other purposes. Goats are a good source of income compared to other livestock species. Farmers keep a certain number of goats that depends on the availability of labour and land. The number varied from 2 to 40 goats per household, slightly higher compared to the findings of Phimphachanhvongsod (2001), who found that the number of goats per household ranged from 2 to 30 heads. The weight of mature animals reaches up to 46 kg and the first kidding was approximately 1 year of age. This is similar to the findings of Stur et al (2002), that the mature goat weight was about 40 kg, that they are used for meat only and that they have their first kids at age 12-18 months. The latter number is slightly higher compared to the data from the surveyed areas.

The main constraints for goat production are diseases and parasites, and lack of feed. Because the goats are selective species so farmers tend to restrict the number they raise to avoid excessive damage to crops for which the owner of the goats is held responsible. The high market demand, both local and external, was one of the reasons for the high rate of increase in the goat population over the last 20 years compared to other livestock species.

Conclusions

- Goat production in the selected villages at the present time is based on traditional extensive systems with very low inputs.
- High incidence of diseases all year round and feed shortage are the main constraints.
- There is a high potential to increase the productivity of goats, if the technical and managerial constraints can be solved, such as reducing the mortality rate of young kids by using de-worming techniques and providing better quality feed.

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References

DLF 2007 Department of Livestock and Fisheries Ministry of Agriculture and Forestry Vientiane Laos http://www.nsc.gov.la/Statistics/Selected%20Statistics/Agriculture/Lifestock.htm

Phengsavanh P 2003 Goat production in smallholder farming systems in Lao PDR and the possibility of improving the diet quality by using *Stylosanthes guianensis* CIAT 184 and *Andropogon gayanus* cv Kent. MSc. Thesis. Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden

PAFO 2010 Provincial Agriculture and Forestry Office of Khammune Province.

Phimphachanhvongsod V 2001 The potential of Glircidia sepium as a feed for goats in smallholder farming systems in Laos. MSc. Thesis in Tropical Livestock Systems. SLU. Department of Animal Nutrition and Management, Uppsala, Sweden.

Stür W, Gray D and Bastin G 2002 Review of the Livestock Sector in the Lao People's Democratic Republic. http://webapp.ciat.cgiar.org/asia/pdf/adb_livestock_review.pdf

Xaypha S 2005 Goat production in smallholder farming systems in lowlands Lao PDR and an Evaluation of different forages for growing goats MSc. Thesis. Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden.
http:/www.mekarn.org/msc2003-05/theses05/sophacont.htm

Effects of fresh or sun-dried cassava foliage on growth performance of goats fed basal diets of Gamba grass or sugar cane stalk

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Abstract

A trial to measure the growth performance of young goats (*Capra spp*.) was carried out during a 3 month period at the experimental farm of the Livestock Research Center, Vientiane, Laos, to study the effect of feeding fresh cassava foliage or sun-dried cassava foliage in a diet based on Gamba grass and sugar cane stalks. Twenty four goats, of which twelve males and twelve females, with an average body weight of 10.3 kg and at an average age of 6 to 7 months were randomly allocated to four treatments of six animals according to weight and sex. The experimental feeds were Gamba grass (*Andropogon gayanus cv. Kent*) and sugar cane stalk (*Saccharum officinarum*) as basal diets, supplemented with fresh cassava foliage or sun-dried cassava foliage (*Manihot esculenta*, Crantz). Feeds were offered ad libitum of an expected daily dry matter (DM) intake of 3% of body weight (BW). The highest daily weight gain was 59 g/day for the treatment using Gamba grass with fresh cassava foliage, followed by 56, 45 and 41 g/day for treatments sugar cane with fresh cassava foliage, Gamba grass with sun-dried cassava foliage and sugar cane with sun-dried cassava foliage, respectively. Dry matter feed conversion and DM per live weight gain were 16, 9, 12 and 6 and 58, 47, 42 and 33 g/kg for the treatments Gamba grass with sun-dried cassava foliage, Gamba grass with fresh cassava foliage, sugar cane with sun-dried cassava foliage and sugar cane with fresh cassava foliage, respectively. In conclusion, the daily weight gain was higher when using Gamba grass as basal diet supplemented with fresh cassava foliage and DM feed conversion was better for the treatment sugar cane supplemented with fresh cassava foliage.

***Key words**: Gamba grass, sugar cane, cassava foliage, intake, growth, local goats.*

Introduction

Livestock are an important component of smallholder farming systems in Laos, with sales which account for more than 50% of the family cash income. Livestock provide great benefits to farmers such as high nutritive value food, generating income and manure which is very important for maintaining soil fertility. They also provide draught power for transportation and crop production. They serve as financial assets so livestock offer an alternative for storing savings or accumulated capital as a "living savings account". Keeping livestock is considered as an alternative form of insurance; they also enhance family status because the value of livestock can be an indicator of social importance. Over 95% of all livestock is produced by smallholders. The goat population in Laos is estimated to be about 268,900 heads (DLF 2007). It is relatively small compared to neighboring countries in the region. However, the

population is increasing, with an annual growth rate of 8%. Most goats are native breeds, with small body size and low growth rates. Goats are generally allowed to graze freely all year round in small groups in the forest, fallow cropland and roadside. According to Phengsavanh and Ledin (2003) a major constraint to livestock production in Lao PDR is feed shortage, in both quality and quantity, and especially protein sources. The main feed resources are native grasses, shrubs, legumes and tree leaves that are available in forests, grasslands, and fallow land and agricultural by-products. Parasitism is the main problem under low level management conditions with a mortality rate up to 50%. Goats are also less resistant to intestinal parasites compared to other ruminants

The great challenge is to make the goats become environmentally friendly through the changing of the free range farming system to the stall feeding system. Farmers tend to restrict their herds in order to avoid excessive damage to crops, for which the owner is held responsible. In recent years (Phengsavanh at al 2003), goat management practices have been changing, and vary from site to site depending mostly on land availability, labor and community regulations. Goats are reared only for meat and they reach a mature weight of about 40 kg in 2-3 years under local conditions. First kidding is at 12-18 months of age, usually a single kid at the first litter and twin kids later.

Goats are browsers and highly selective, and they can withstand harsh conditions, such as seasonal shortages of feed, which means they are well adapted to the local environment. Because of their small body size, they need low capital investment, and need smaller areas to graze than cattle. Local goat breeds have high reproductive rates with a great genetic variability. However, little attention has been given to feeding, management and health, so small inputs will probably give good results.

The great potential in the development of goat production in Laos is the high market demand for goat meat for local consumption and export. This is an incentive to intensify goat production, as improved nutrition will lead to faster growth rates which will result in carcasses with higher content of meat.

Improved nutrition requires increasing the energy density of the diet, ensuring efficient rumen function and providing a complimentary source of bypass protein (Preston and Leng 1987). Sugar cane has a high content of soluble sugars and has been used successfully as the basis of an intensive system of fattening cattle (Preston et al 1976). The foliage of cassava (*Manihot esculenta*, Crantz) has been shown to be an effective source of bypass protein for fattening steers (Ffoulkes and Preston 1978; Wanapat et al 1997; Keo Sath et al 2008) and lactating dairy cows (Wanapat 2001). There is some controversy as to the potential toxic effects of the hydrocyanogenic glucosides present in fresh cassava foliage and which can give rise to liberation of HCN (Wanapat et al 1997). For this reason, sun-drying of the foliage has been recommended. However, there are several reports (Ffoulkes and Preston 1978; Seng Sokerya et al 2001; Theng Kouch et al 2003; Seng Mom et al 2001) in which cassava foliage was fed in the fresh state and where there were no indications of toxicity. There appear to be no reports in the literature of toxicity resulting from the feeding of fresh cassava to ruminants. There are also no reports where fresh and sun-dried cassava foliage have been compared in the same experiment.

Objectives

- The aims of the present research were therefore to investigate the potential to intensify goat production by feeding sugar cane as the basal diet.

- At the same time, a comparison was made of feeding fresh and sun-dried cassava foliage in view of the lack of information concerning the risk of toxicity from feeding the fresh foliage.

Materials and methods

Location and climate

The experiment was carried out at the Livestock Research Centre, National Agriculture and Forestry Research Institute, which is located about 40 km North of Vientiane Capital, Laos at an altitude of 150 m above sea level. The experiment was conducted during the months of October to December 2009. The climate is tropical monsoon, with a dry season from November to April (only about 1 to 2% of the annual rainfall occurs during this season) and a wet season from May to October. The average annual precipitation is about 1765 mm, ranging from 1500 mm to more than 2000 mm. The highest rainfall occurs in June to August. The maximum temperature ranges from 35^{o}C to 42^{o}C in March to May and the minimum temperature from 18^{o}C to 22^{o}C in December to February. The soils are generally sandy loams with low fertility and an average pH of 4.5.

Treatments and experimental design

The nutritional treatments applied to 24 growing goats were:

- GBFC = Gamba grass with fresh cassava foliage
- GBDC = Gamba grass with sun-dried cassava foliage
- SCFC = Sugar cane stalk with fresh cassava foliage
- SCDC = Sugar cane stalk with sun-dried cassava foliage

The treatments were arranged as a 2*2 factorial in a randomized complete block design (RCBD) with six replications. The animals were allocated to 6 blocks (Table 1) on the basis of sex (12 males and 12 females) and live weight.

Table 1: Experimental layout

Treatment	SCDC	GBDC	GBFC	GBDC	GBDC	SCFC
Pen No	1	2	3	4	5	6
Treatment	GBDC	GBDC	SCFC	SCDC	SCDC	GBFC
Pen No	7	8	9	10	11	12
Treatment	SCDC	SCFC	GBDC	GBFC	GBFC	SCDC
Pen No	13	14	15	16	17	18
Treatment	GBFC	SCFC	SCDC	SCFC	SCFC	GBFC
Pen No	19	20	21	22	23	24

Animals and management

Twenty-four local growing goats (*Capra spp.*) including 12 females and 12 males (non-castrated) weighing from 7.6 to 13.5 kg and about 6 to 7 months of age were housed in individual pens with raised slatted floors (Photo 5). The goats were bought from Savannakhet

province in the Central part of Laos, 500 km from Vientiane. They were treated against internal and external parasites with Ivomectin (1 ml/33 kg live weight), and then adapted to the pens and the trial feeds for 14 days before starting the experiment. The feeds were offered twice per day at 07:00h and 16:00h. The experiment lasted for 84 days, excluding adaptation and organizing periods.

Photo 1: Sugar cane stalk chopped

Photo 2: Gamba grass

Photo 3: Fresh cassava foliage

Photo 4: Partially sun-dried cassava foliage

Photo 5: Experimental pens

Experimental feeds

Gamba grass (*Andropogon gayanus cv. Kent)* and sugar cane stalk (*Saccharum officinarum*) were used as basal diets and fed ad libitum. They were supplemented with cassava foliage (*Manihot esculenta*, Crantz) offered ad libitum in the fresh state or after partial drying in the sun and, during periods of rain, under shade. Gamba grass was collected from an existing forage area in the Livestock Research Center. The forage area was divided into 6 plots, each providing enough feed for 7 days, which were harvested in a 40 to 45 day rotation. It was manually harvested twice per day in the morning and afternoon. After each cutting, urea was applied in the amount of 80 kg /ha. Sugar cane stalk was purchased from farmers nearby the center every 2 to 3 days. It was chopped into 2 to 3 cm lengths using a small hand-operated cutting machine. Cassava was grown in the Livestock Research Center, but there was not

always enough, so the rest was purchased from farmers. It was collected daily, morning and afternoon. The foliages, dry and fresh, were hung as whole branches above the feed trough. Mineral blocks and fresh water were offered ad libitum separately in each cage during the whole experiment period.

Measurements

Samples of each feed offered and refused were taken every two weeks to determine DM by micro-wave radiation (Undersander et al 1993). The dried samples were pooled over two weeks and stored for later analysis. The amounts of each feed offered and refused were recorded daily for individual animals. Live weights were recorded every 14 days. The dried feed samples were analysed for crude protein (CP) and ash according to standard methods (AOAC 1980). Crude protein was analyzed by the Kjeldahl method and was calculated as N x 6.25. Ash was calculated after incineration in a muffle furnace at 550^{o}C for 3 hours.

Statistical analysis

Data were analyzed using the GLM option in the ANOVA program of the Minitab 2000 software (Version 13.1). Sources of variation in the model were: forage, processing, interaction forage* processing and error.

Results

Chemical composition of the dietary components

The Gamba grass had higher levels of CP and ash than the sugar cane stalk (Table 2).

Table 2. Mean values for composition of the diet ingredients

	DM, %	CP	Ash	OM
		% in DM		
Gamba grass	27	9.6	7.2	92.8
Sugar cane stalk	22.5	6	1.6	98.4
Fresh cassava foliage	17.3	24.6	6.8	93.2
Sun-dried cassava foliage	34.2	25.4	5.7	94.3

Feed intake, growth rate and feed conversion

The daily live weight gain did not differ between sugar cane and Gamba grass but was higher for fresh than sun-dried cassava foliage (Tables 3 and 4 and Figures1 and 2). In contrast, the DM feed intakes were lower for fresh versus dried cassava foliage (Figure 3) and for sugar cane versus Gamba grass (Figure 4). As a result, the feed conversion was better for fresh than for dried cassava foliage (Figure 5), and for sugar cane rather than Gamba grass (Figure 6).

Table 3: Mean values (main effects) for change in live weight, feed intake and conversion for local goats supplemented with fresh or dried cassava foliage

	Basal diet			Cassava foliage			
Items	**Gamba grass**	**Sugar cane**	**Prob.**	**Dried**	**Fresh**	**Prob.**	**SEM**
Live weight, kg							
Initial	11	11		11	11		0.39
Final	13	13	0.94	13	14	0.28	0.36
Daily gain, g/day	55	52	0.485	46	62	0.006	3.35
DM intake, g/day							
Gamba grass	403			196	207		
Sugar cane		201		97	104		
Cassava foliage	201	239	0.014	282	158	0.001	10.0
Total	611	440	0.001	582	468	0.001	17.6
DMI, g/kg LW	52.5	37.1	0.001	50.0	39.6	0.001	1.66
CP intake, g/day	98.0	80.8	0.001	106	72.9	0.001	2.57
CP, % of DM	16.0	18.4		18.5	15.9	0.001	0.21
Cassava foliage intake/DMI	0.322	0.531	0.001	0.496	0.357	0.001	0.001
DM feed conversion	12.7	9.35	0.08	14.4	7.60	0.001	1.18
Cassava intake/Cassava offered	0.586	0.682	0.013	0.602	0.666	0.087	0.018

Table 4: Mean values for change in live weight, feed intake and conversion for local goats supplemented with fresh or dried cassava foliage

Items	**GBDC**	**GBFC**	**SCDC**	**SCFC**	**SE**	**Prob.**
Number of goats	6	6	6	6		
Live weight, kg						
Initial	10.7	11.4	11.5	10.7	0.55	0.54
Final	12.8	14.0	13.4	13.3	0.52	0.19
Daily LW gain, g/day	44.7^{a}	59.2^{b}	40.7^{a}	56.3^{b}	5.10	0.001
DM feed conversion	16.3	9.10	12.4	6.24	1.67	0.87
DM/LW, g/kg	58.3^{a}	46.7^{b}	41.7^{b}	32.6^{c}	2.34	0.001
Cassava foliage intake/DMI	0.376^{b}	0.268^{a}	0.616^{d}	0.446^{c}	0.0085	0.001

$^{a\ bc,d,}$ Main values within rows with different superscript are different at P<0.05

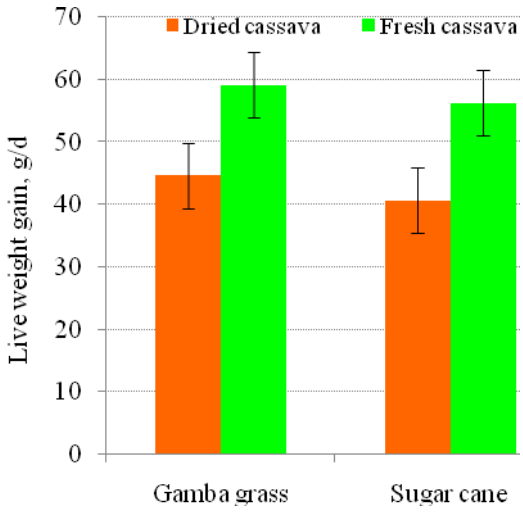

Figure 1: Contrasting effect of cassava foliage (dried or fresh) on growth rate of goats fed basal diets of Gamba grass and sugar cane

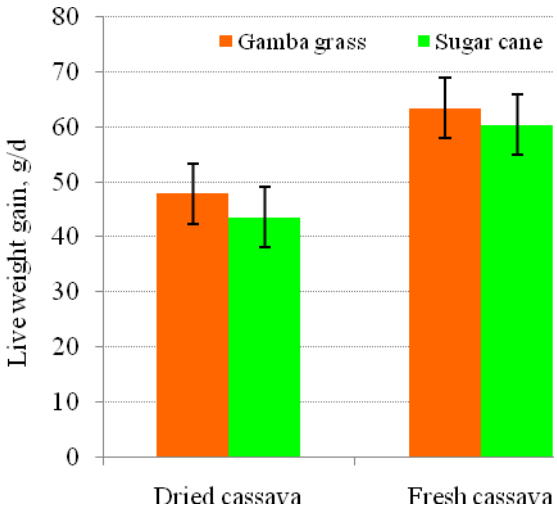

Figure 2: Contrasting effect of Gamba grass versus sugar cane on growth rate of goats fed dried or fresh cassava foliage

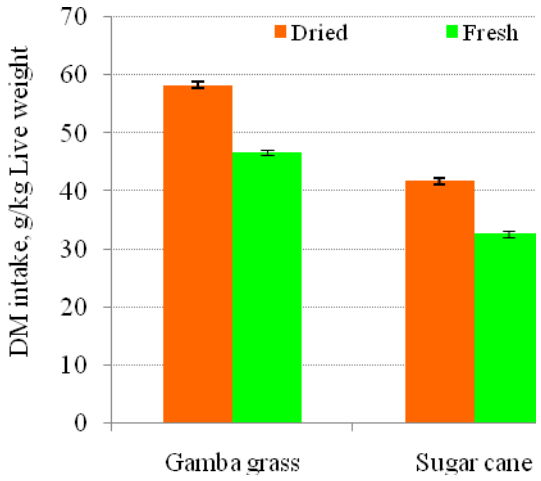

Figure 3: Contrasting effect of cassava foliage (dried or fresh) on feed intake of goats fed basal diets of Gamba grass and sugar cane

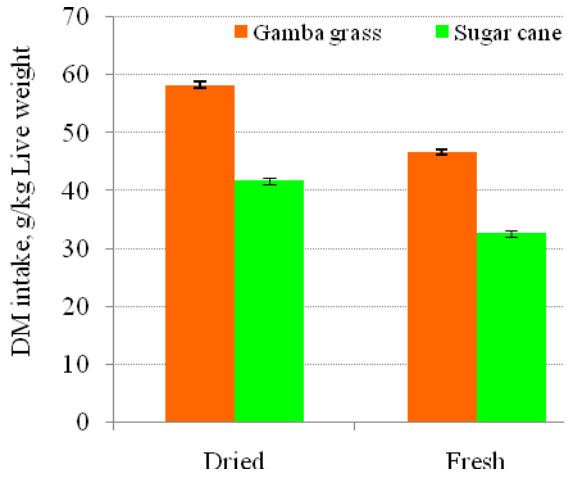

Figure 4: Contrasting effect of Gamba grass versus sugar cane on feed intake of goats fed dried or fresh cassava foliage

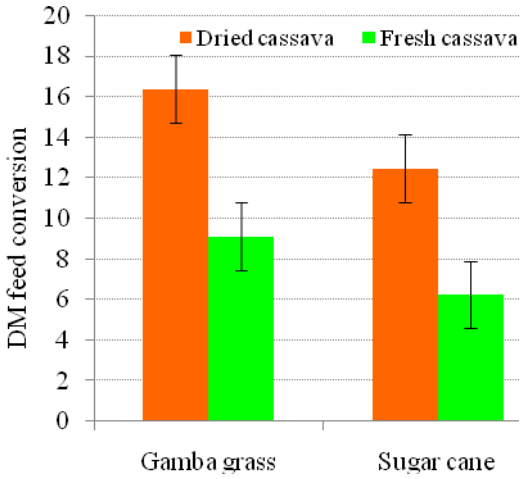

Figure 5: Contrasting effect of cassava foliage (dried or fresh) on feed conversion of goats fed basal diets of Gamba grass and sugar cane

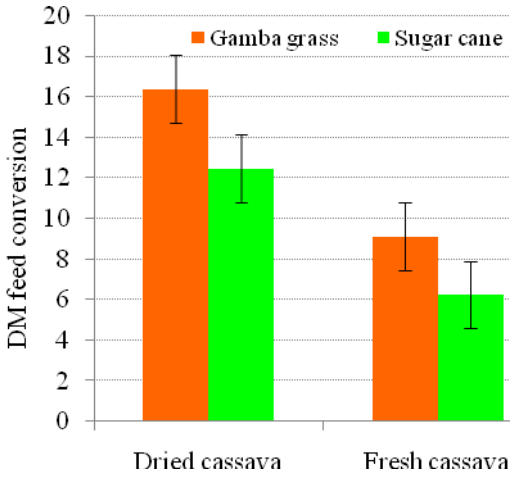

Figure 6: Contrasting effect of Gamba grass versus sugar cane on feed conversion of goats fed dried or fresh cassava foliage

Discussion

As far as the authors are aware the present study is the first to compare feeding goats with fresh and sun-dried cassava foliage derived from the same stand of cassava. The results showed clearly that the fresh foliage supported superior growth and feed conversion to the dried form, on both basal diets of Gamba grass and sugar cane. Moreover, the levels were very high, reaching 62% of the total DM intake when the dried cassava foliage was fed together with the sugar cane. The proportion of the diet as cassava foliage was higher on sugar cane than on Gamba grass and higher for dried versus fresh foliage. These contrasting results between the fresh and "partially" dried cassava foliage are difficult to explain. Total DM intakes were higher when Gamba grass was the basal diet. It may be that the goats found the "young" Gamba grass more palatable than the "mature" sugar cane and therefore compensated by eating more cassava foliage when sugar cane was the basal diet. The relatively large size of the pieces of chopped sugar cane may also have been a deterring

factor. The chopping machine had been designed to process fresh forages and did not perform adequately on the "tough" outer rind of the sugar cane, resulting in pieces of stalk of 2 to 3cm thickness. Practical experience in Mexico (Preston et al 1976) with cattle and with goats in Colombia (Lylian Rodriguez 2009, personal communication) indicated that fine grinding using a "high-speed" silage chopper resulted in higher intakes of sugar cane.

There is a wide range of recent literature showing the beneficial effects of cassava foliage on growth rates and feed conversion of cattle (Ffoulkes and Preston 1978, Ho Thanh Tham et al 2008, Keo Sath 2008, Mom Seng 2001) and goats (Seng Sokerya 2001, Ho Quang Do 2002, Ho Bunyeth 2004) and on milk yield in dairy cattle (Wanapat 2001). In these different experiments, the cassava foliage was prepared and fed in many different forms: fresh, wilted or ensiled. Wanapat et al (1997) recommended the drying of cassava foliage "not only to reduce moisture but also to decrease hydrocyanic acid to a safe level for ruminants". However, the implication that the precursors of hydrocyanic acid (HCN) are a constraint to the feeding of cassava foliage to ruminants has not been tested in the same experiment. Ffoulkes and Preston (1978) fed fresh cassava foliage as the sole source of roughage and protein in a diet of liquid molasses-urea, and reported growth rates of over 700 g/day in young cattle, similar to what was achieved with soybean meal. No health problems were observed that could have been caused by the presence of HCN precursors.

Conclusions

- Fresh cassava foliage resulted in 35% higher weight gain and 36% better feed conversion compared with the sun-dried form.
- Fresh or sun-dried cassava foliage is a valuable supplement for goats receiving low or medium quality diets such as Gamba grass and sugar cane stalk.

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References

AOAC 1990 Official methods of chemical analysis, Association of Official Agricultural Chemists (15th ed) Washington DC.

DLF 2007 Department of Livestock and Fisheries Ministry of Agriculture and Forestry Vientiane Laos http://www.nsc.gov.la/Statistics/Selected%20Statistics/Agriculture/Lifestock.htm

Ffoulkes D and Preston T R 1978 Cassava or sweet potato forage as combined sources of protein and roughage in molasses based diets: effect of supplementation with soybean meal Tropical Animal Production 3(3): http://www.fao.org/ag/aga/agap/frg/tap33/3_3_1.pdf

Ho Bunyeth and T R 2004 Preston Growth performance and parasite infestation of goats given cassava leaf silage (or sun-dried cassava leaves) as supplement to grazing in lowland and upland regions of Cambodia http://www.mekarn.org/procsr/buny.pdf

Ho Quang Do, Vo Van Son, Bui Phan Thu Hang, Vuong Chan Tri and T R Preston 2002 Effect of supplementation of ammoniated rice straw with cassava leaves or grass on intake, digestibility and N retention by goats. . Livestock Research for Rural Development 14 (3) http://www.lrrd.org/lrrd14/3/do143b.htm

Phengsavanh P 2003 Goat production in smallholder farming systems in Lao PDR and the possibility of improving the diet quality by using *Stylosanthes guianensis* CIAT 184 and *Andropogon gayanus* cv Kent. MSc. Thesis. Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden

Phengsavanh P and Ledin I 2003 Effect of Stylo 184 and Gamba grass in diet for growing goats. Goat production in smallholder farming system in Lao PDR and the possibility of improving the diet quality by using Stylo 184 and Andropogon gayanus cv Kent. MSc thesis, Dep. of Animal Nutrition and Management, SLU, Uppsala http://www.lrrd.org/lrrd15/10/seut1510.htm

Preston T R and Leng R A 1987 Matching ruminant production systems with available resources in the tropics and sub- tropics. Penambul Press: Armidale, Australia

Sath K, Borin K and Preston T R 2008: Effect of levels of sun-dried cassava foliage on growth performance of cattle fed rice straw. *Livestock Research for Rural Development. Volume 20, supplement.* Retrieved June 30, 2010, from http://www.lrrd.org/lrrd20/supplement/sath2.htm

Seng M, Preston T R, Leng R A and Meulen U ter 2001 Effect of a single drench of cooking oil on the rumen ecosystem and performance of young local "yellow" cattle fed rice straw and cassava foliage http://www.lrrd.org/lrrd13/4/seng134.htm

Seng S and Lylian R 2001 Foliage from cassava, Flemingia macrophylla and bananas compared with grasses as forage sources for goats: effects on growth rate and intestinal nematodes. Livestock Research for Rural Development, Volume 13, Number 2, April, 2001 http://www.lrrd.org/lrrd13/2/soke132.htm

Tham H T, Man N V and Preston T R 2008: Performance of young cattle fed rice straw sprayed with mixture of urea and molasses supplemented with different levels of cassava leaf meal. *Livestock Research for Rural Development. Volume 20, supplement.* Retrieved June 30, 2010, from http://www.lrrd.org/lrrd20/supplement/tham1.htm

Theng K, T R Preston and J Ly 2003 Studies on utilization of trees and shrubs as the sole feedstuff by growing goats; foliage preferences and nutrient utilization. Livestock Research for Rural Development 15 (7). http://www.lrrd.org/lrrd15/7/kouc157.htm

Undersander D, Mertens D R and Theix N 1993 Forage analysis procedures. National Forage Testing Association. Omaha pp 154

Wanapat M, Pimpa O, Petlum A and Boontao U 1997 Cassava hay: A new strategic feed for ruminants during the dry season, Livestock Research for Rural Development; 1997, Volume 9, Number 2 Metha92.htm

Wanapat M 2001 Role of cassava hay as animal feed in the tropics. http://www.mekarn.org/procKK/wana3.htm