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ORIGINAL RESEARCH

Feeding and performance of pigs in smallholder production systems in Northern Lao PDR

Phonepaseuth Phengsavanh · Brian Ogle · Werner Stür · Bodil E. Frankow-Lindberg · Jan Erik Lindberg

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Abstract A survey was carried out in the North of Lao PDR to study feeding systems and the performance of pigs in smallholder systems. A total of 341 farmers from five provinces were interviewed. To feed their pigs, farmers mainly rely on feedstuffs produced on the farm and collected from areas near the village. The feedstuffs used included by-products such as rice bran and distiller's waste, planted feeds, mainly maize and cassava, and various green plant materials. The feedstuffs used are usually high in energy and low in protein content, and the only readily available protein source is green plant material. This results in nutritionally imbalanced diets and as a result poor pig performance. The average growth rate of pigs in these systems was found to be only approximately 100 g/day. The reproductive performance of sows was found to be relatively low, as is the case of local breeds in the region, with an average litter size at birth of 6.8 piglets. The mortality of piglets was as high as 50% and was a main concern of farmers. In order to improve the productivity of pigs in smallholder systems, there is a need to find alternative feed resources to improve the nutritional feed quality, and to develop management systems which are suited to the needs and practices of smallholders.

Keywords Pig · Feed · Ethnic group · Growth rate · Reproductive performance

P. Phengsavanh
Livestock Research Center,
National Agriculture and Forestry Research Institute,
P. O. Box 7170, Vientiane, Lao People's Democratic Republic

B. Ogle · J. E. Lindberg (✉)
Department of Animal Nutrition and Management,
Swedish University of Agricultural Sciences,
P. O. Box 7024, 750 07 Uppsala, Sweden
e-mail: jan-eric.lindberg@huv.slu.se

W. Stür
International Center for Tropical Agriculture,
P. O. Box 783, Vientiane, Lao People's Democratic Republic

B. E. Frankow-Lindberg
Department of Crop Production Ecology,
Swedish University of Agricultural Sciences,
P. O. Box 7034, 750 07 Uppsala, Sweden

Introduction

Pigs are one of the most important animals for smallholders in the uplands of Lao PDR, particularly in areas where shifting cultivation is practiced. In these areas, farmers face a high risk of crop failure or low rice yields, resulting in too little food for their households (Phengsavanh and Stür 2006). Therefore, pigs play important roles as sources of income and as part of the household insurance system for smallholders. The income from pigs accounts for more than 50% of total family income in the remote areas of Northern Lao PDR. Pigs can be sold when cash is needed for buying rice and other foods, for paying school fees, or if a household member needs medical attention (Phengsavanh and Stür 2006).

In spite of pigs being very important for upland farmers' livelihoods, they are mostly still kept in traditional free- and semi-scavenging systems. Only recently have some farmers started to use more managed systems. The main traditional feed resources are agricultural by-products and vegetables, or weeds that grow naturally in the forests, along the banks of streams, and in cropping areas. Naturally occurring feeds, maize and cassava, are always boiled and subsequently mixed with rice bran before feeding. These feed resources are vulnerable to seasonal weather patterns. In the

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dry season, feed is always in short supply, and one of the main limitations of pig production is feed shortage. Feed is limited in both quantity and quality, which severely limits productivity in smallholder pig production systems (Thorne 2005). The growth rate of pigs in traditional systems in Lao PDR is very low, and it takes nearly 2 years for farmers to rear weaned pigs to a market weight of 60–70 kg (Phengsavanh and Stür 2007).

The aim of this study was to obtain information on pig production in smallholder systems: feeding systems practiced, productivity, and reproductive performance. It was hypothesized that pig feeding and management would be different among ethnic groups and would also be affected by the distance to the closest local market. The paper discusses the main constraints identified in the survey and options for possible improvement.

Materials and methods

Study area

The selected sites for the study were in the Northern provinces of Lao PDR (Fig. 1). In these Northern provinces, more than 80% of pig production is in low-input smallholder systems (Thorne 2005). The Northern region is characterized as a mountainous region and is the home of many ethnic groups, which are classified according to similarity of culture and dialect into four main groups: the Lao-Tai, Mon-Khmer, Hmong-Mien, and Tibeto-Burman (Messerli et al. 2008). The agricultural production systems are mainly shifting cultivation upland farming systems, with small areas of lowland paddy rice along the valleys.

Selection of provinces, districts, villages, and farmers

The selection of provinces was based on the importance of pig production in each province, based on the statistics of pig populations within each province. These figures were obtained from the national Department of Livestock and Fisheries. All Northern provinces were ranked according to the total number of pigs, and the five provinces with the highest pig populations were selected for the survey.

In each of the five selected province, one district was selected from the list of all districts, based on the same criterion as for the selection of province. Information on pig production in all districts of each province was collected from secondary information in the provincial livestock office, district agriculture and forestry office, and verified by provincial and district staff.

In the selected districts, all villages were grouped in clusters based on market accessibility, defined in terms of time needed to travel from the village to the district market. Information on accessibility came from the socio-economic atlas of Lao PDR (Messerli et al. 2008). Villages were grouped as follows: (1) less than 1 h, (2) 1 to 3 h, and (3) more than 3 h from the district market by car. Next, transects were randomly selected from those radiating out from each district town. Along this transect, two villages within each of the three clusters were randomly selected for the survey. In total, six villages within each of the five districts were included in the survey.

Fig. 1 Map indicating the location of the survey area. Source: Phengsavanh (1997)

In each survey village, 10 households, or a minimum of 10% of pig rearing farmers in the village, were randomly selected for group meetings and individual interviews to ensure a representative sample. The study team took the opportunity to interview more farmers in some villages when the opportunity arouse. In total, 341 respondents were interviewed. These included 110 Lao-Tai (Laoloum, Taidam, and Leu), 113 Mon-Khmer (Khmu and Pai), 78 Hmong-Mien, and 40 Tibeto-Burman (Ikor and Phounoi) households. The study was carried out from February to June 2009.

Methods used for the survey

Two methods were used to collect primary information. These were farmers' group meetings and a pig production household survey using a semi-structured questionnaire.

The focus group meeting was designed to obtain general information about the main agricultural and livestock activities, detailed information about the pig production systems practiced by farmers in the village, and to discuss issues associated with these pig production systems. The information from focus group meetings was used to complement and corroborate farmers' responses in the individual interviews.

The individual farmer interviews were used to collect details on management, productivity, problems, and benefits in raising pigs. This information, gathered through face-to-face interviews using a semi-structured questionnaire, was followed by probing questions to gain a deeper understanding of the issues. Before the start of the survey, the questionnaire was tested with farmers in several villages. After testing, the study teams, consisting of staff from Livestock Research Center, Provincial Agricultural and Forestry Office and District Agricultural and Forestry Office, met to discuss the need for modifications of the questionnaire and finalized it for the survey. The issues covered in the questionnaire included questions on experience in pig production (When and why did they start raising pigs), rearing and management systems (How do you keep and manage your pigs? Have you changed the way you raise pigs and why?), feed and feeding systems, production and reproductive performance, problems, and benefits in keeping pigs. The average growth rate was calculated from farmers' estimate of the time taken to grow individual pigs from the start of the fattening and the weight when the animals were sold. Farmers' estimate of pig weights were based either on measured weights using market balances or on the traditional technique of estimating live weight by measuring the heart girth of the animal. This method is commonly used in the more remote areas in Northern Laos, but so far, there are no calibrated weight bands in use. Based on this information, the approximate growth rate was calculated. Data on reproductive performance were collected based on information about the individual sows that the farmers owned at the time of the interview.

Data analysis

The data were entered into a spreadsheet and analyzed using PASW Statistics 18 (2009) for descriptive analysis of means, medians and ranges, frequency of distribution, and variation. The growth rate and reproductive performance were analyzed statistically by variance analysis (ANOVA) using the general linear model procedure of Minitab Statistical Software (Minitab 2007). When the differences between means were significant at the probability level of $p<0.05$, the means were compared using Tukey's pair-wise comparison test.

Results

Pig breed

All surveyed households raised indigenous native pigs. The Moo Lath and Moo Hmong were the two major indigenous pigs in the study area. These pigs are characterized by either completely black color or black with some white spots. The mature weight of Moo Lath and Moo Hmong pigs were very similar and ranged from 80 to 120 kg.

There were several reasons why farmers preferred raising local pigs. The main reason was a high local market demand for local pigs (65% of respondents), better adaptation to local environment and management conditions (54.9%), and tastier meat (11.0%).

Feed and feeding systems

Since it was difficult, or in some cases not possible, to measure feed intake in the questionnaire-based survey, the study was limited to determining the frequency of use of different feedstuffs and different practices of ethnic groups in the surveyed villages. Feed resources used for pigs in all study areas were similar and were mainly planted feeds (maize, cassava root, pumpkin fruit, and leaves) and other locally available feedstuffs, such as by-products (rice bran, broken rice, and local rice wine distiller's waste) and green plant material from crops or collected from native plants.

Rice bran was used by almost all the farmers surveyed (Table 1). Maize, cassava, a taro-type plant called *Bon* (*Colocasia esculenta*) and banana stems, were also commonly used. Other feeds, such as broken rice, pumpkin fruits, distiller's waste, and green plant material (leaves of *Yahuabin* (*Crassocephalum crepidioides*), *paper mulberry* (*Morus papyrifera*), *Phak hom* (*Amaranthus viridis*), pumpkin tops, and sweet potato leaves) were also used, depending on availability. Commercial feed was used by less than 7% of the interviewed farmers.

The availability of these feedstuffs varied throughout the year and depended mainly on seasonality, agricultural practices in the area, and the traditional experience of the different ethnic groups. The Lao-Tai group, who often had larger surpluses of rice, used more rice bran, broken rice, local alcohol distiller's waste, and various green plant materials. It was also found that almost all households that used any form of commercial feed were from the Lao-Tai group. The other three groups used mixtures of available feedstuffs, including rice bran, maize, cassava, and green plant material (Table 1).

This study did not collect and analyze feed samples for their nutritional value; however, this was done as part of another project, the CIAT "Forage legumes for supplementing village pigs in Lao PDR" project, which collected all of

Table 1 Frequency of feedstuff use by ethnic group

Feedstuff	Frequency (%)				
	Overall (n=341)	Ethnic group			
		Lao-Tai (n=110)	Mon-Khmer (n=113)	Hmong-Mien (n=78)	Tibeto-Burman (n=40)
By-products					
Rice bran	99.0	100.0	100.0	96.2	100.0
Broken rice	21.0	41.0	17	6.4	3.0
Distiller's waste	12.3	28.2	3.5	0.0	7.0
Planted feeds					
Maize	51.6	34.5	36.3	76.9	92.5
Cassava root	41.0	22.7	44.2	69.2	27.5
Pumpkin fruits	21.0	4.5	12.4	39.7	52.5
Pumpkin tops	9.0	2.7	6.2	25.6	0.0
Sweet potato leaves	6.5	11.0	5.3	1.3	7.5
Green plant material					
Bon[a]	46.0	65.5	41.6	6.4	32.0
Banana stems	41.0	41.0	28.3	51.3	57.5
Yahuabin[b]	30.0	33.6	9.7	70	0.0
Paper mulberry	17.6	15.5	29.2	9.0	3.0
Phak hom[c]	11.4	24.5	7.1	2.6	5.0
Commercial feed	6.7	20.0	1.0	0.0	0.0

[a] *Colocasia esculenta*

[b] *Crassocephalum crepidioides*

[c] *Amaranthus viridis*

the main feeds used by farmers in Northern Laos, and these samples were analyzed for their nutritive value by the Queensland Department of Primary Industry and Fishery in Australia. The analysis showed that the common feeds in smallholder pig systems such as rice bran, maize, and cassava had low crude protein (CP) content (8.2%, 9.7%, and 1.0%, respectively). The green plant materials used by farmers had a relatively high CP content ranging from 12% to 35%. However, these green materials also contained a high fiber level, with crude fiber ranging from 20% to 33%.

Most farmers fed their pigs twice a day, in the morning and afternoon. It was found that about 79% of farmers fed all their pigs together, while only 21% separated piglets from larger pigs and gave them better quality feeds. The provision of concentrate feed to pig was not common in the survey area: Only 6% of surveyed households provided concentrates, and 30% provided salt to their pigs.

Provision of water to pigs is another issue in smallholder pig production. Most of the surveyed farmers (93%) supplied water to their pigs only during feeding as a mixture with feed. Only around 7% of these farmers supplied extra water to the pigs during the day.

In general, women and children were found to be responsible for pig production in the family. The surveyed households reported that collection of feed, cooking feed, and feeding the pigs was mainly done by women and children (55%), by all family members (38%), and only to a limited extent by men (2%). It was found that there was a difference among ethnic groups. In the Lao-Tai group, 21% of women and children were involved in pig feeding activities, whereas this figure was 53%, 78%, and 90% for Mon-Khmer, Hmong-Mien, and Tibeto-Burman groups, respectively. The study also found that all of the tasks associated with feeding and collecting feed took 1.5 to 3 h/day and another 1.5 h to cook and feed pigs.

Productivity and reproductive performance

It was found that the growth rate of pigs differed among ethnic groups. The highest growth rate was in the Lao-Tai group and the lowest in the Mon-Khmer group (Table 2).

Pig growth rate also differed among households located at different clusters (i.e., at different distances from the district center) and also depended on access to feed resources. Pigs reared by households closer to the district center had higher growth rates (Table 3).

Reproductive performance was similar across all ethnic groups. The only significant difference was for the number of

Table 2 Estimated growth rates of pigs in smallholder systems by ethnicity based on farmers' responses (least-square means and standard error of the mean)

	Ethnic group				SEM
	Lao-Tai (n=108)	Mon-Khmer (n=76)	Hmong-Mien (n=55)	Tibeto-Burman (n=33)	
Fattening period, months	13.9 a	19.0 b	19.8 b	17.4 b	0.76
Initial weight, kg	11.1 a	8.9 b	17.15 c	10.3 a	1.30
Final weight, kg	64.7 a	61.6 a	82.8 b	65.6 a	1.96
Average daily gain, g	140 a	104 b	117 b	108 b	5.07

Means in a row followed by the same lowercase letters do not differ significantly (p>0.05)

live piglets per litter at weaning, which was highest in the Lao-Tai group and lowest in the Hmong-Mien group (Table 4). There were no differences in reproductive performance related to distance from the district center. However, the number of piglets surviving from birth to weaning was highest in the areas closest to the district center (73%) and lowest in the areas further away (53%). In the current study, around 66% of surveyed households reported that the main cause of mortality was disease, 34% reported diarrhea, and only 1% of surveyed farmers reported squashing of piglets as a cause of mortality.

Only 12% of the surveyed households kept boars to service their sows, and more than 90% of boars used were selected from their own herd. Around 95% of surveyed households reported that although boars were selected for breeding purpose, there were no special care for boars, and they were fed the same feed and received the same management as all other pigs. Ninety-eight percent of households mentioned that they did not control when the boars became sexually active for the first service, and this was usually as young as 5–7 months of age.

Discussion

Two native pigs, Moo Lat and Moo Hmong, were commonly kept in the study areas. These two types may be different "breeds," but at this stage, there is no genetic information available to treat these different types as separate breeds (Wilson 2007). These pig types are important for farmers in free-scavenging systems, as they are well adapted to scavenge a part of their nutritional needs in free-range conditions (Kennard et al. 1996). The local breeds are high-fat pigs, and pig fat is the main, often only, fat source used by smallholder farmers in cooking. This is one of the reasons why local farmers prefer to raise native pigs rather than the leaner exotic breeds.

Based on traditional knowledge, the surveyed smallholder farmers had developed production systems for pigs that made use of agricultural by-products and locally available green plant materials. This was in accordance with the finding by Kumaresan et al. (2007) in North Eastern India, who showed that farmers used all locally available materials for feeding pigs. Unfortunately, this practice may have led to the feeding of nutritionally imbalanced diets and to underfeeding due to the limited availability, and to nutritional limitations of the feedstuffs used. Traditional feedstuffs supply mainly energy, but their protein content is low (Ocampo et al. 2005). The quality of some of main feeds used in the survey was low. For example, local rice bran contained high levels of rice husks and most likely had a low CP content. The CP content of rice brans used by farmers in Northern Laos range from 6% to 8% (Keoboualaphet and Miklet 2003; Phonekhampheng et al. 2008). The main protein source was generally green plant material, which was abundant only in the wet season, while availability was low in the dry season. In addition, an important limitation of green plant material was its high fiber content, which reduce digestibility and feed intake, particularly in piglets. Leterme et al. (2006) reported that in piglets, the digestibility of a tree leaf meal decreased sharply when the incorporation level in the diet was

Table 3 Growth rates of pigs in smallholder systems by distance to district center (least-square means and standard error of the mean)

	Distance			SEM
	≤1h (n=97)	>1 but <3h (n=92)	>3h (n=83)	
Fattening period, month	16.4 a	16.1 a	20.0 b	0.64
Initial weight, kg	12.0 ab	13.8 a	9.7 b	1.09
Final weight, kg	70.4 a	67.8 a	67.9 a	1.61
Average daily gain, g	133 a	117 b	103 c	4.27

Means in rows followed by the same lowercase letters do not differ significantly (p>0.05)

Table 4 Reproductive performance of pigs by ethnicity of owners

	Ethnic group				SEM
	Lao-Tai (n=52)	Mon-Khmer (n=102)	Hmong-Mien (n=78)	Tibeto-Burman (n=28)	
No. of litters per year	1.5 a	1.1 b	1.3 c	1.4 ab	0.04
No. of piglets per litter	7.2 a	6.8 a	6.5 b	6.9 a	0.14
No. of surviving piglets	5.2 a	4.3 b	3.6 c	4.6 ab	0.22
Weaning age, months	3.1 a	3.3 a	3.9 b	3.6 b	0.30
Weaning weight, kg	7.4 a	5.6 b	7.4 a	6.5 a	0.12
Age at 1st service, months	8.1 a	9.0 a	7.7 b	8.4 a	0.25
Weight at 1st service, kg	37.3 a	31.3 b	27.6 c	34.1 a	1.21
Duration of using sow, years	2.7 a	2.7 a	3.7 b	3.2 a	0.12

Means in a row followed by the same lowercase letters do not differ significantly (p>0.05)

increased up to 20%. However, the authors found that even a level of inclusion of the tree leaf meal of up to 30% did not affect digestibility in large older pigs. All these factors influenced the quality of traditional diets and had an impact on the nutrient supply to the pigs.

Although there were several potential feed resources available, their seasonal availability varies throughout the year, and this forces the farmers to use these resources intermittently. Underfeeding was observed in many areas, as the collection of large amounts of green feed was time consuming and often taking up to 3 h/day for a normal household (Phengsavanh et al. 2008). In addition, the loss of feed through poor design of feed troughs and competition for feed within pens meant that smaller animals often did not get enough feed, contributing to the problem of underfeeding.

Water supply was another limitation, as most farmers provided water to pigs only in connection with feeding. This was related to the fact that almost all farmers in the Northern mountainous areas of Laos had difficulty in finding enough water for family consumption, particularly in the dry season. This made it difficult to also provide plenty of water to their animals. In this study, only farmers living close to rivers and streams provided extra water during the day to their animals. Water limitation can be one of the factors that negatively affect the growth and health status of pigs in smallholder systems.

The collection of feedstuffs and feeding were found to be the responsibility of women and children in most of the surveyed villages. This is in accordance with earlier data (Wilson 2007; Phengsavanh and Stür 2006) showing that women and children spent considerable time in collecting, preparing, and cooking feed for pigs.

The results of this study showed that growth rate of pigs was higher in the Lao-Tai ethnic communities and in areas closer to the town. This can be explained by the fact that the Lao-Tai ethic group, who tended to live in lowland areas and often had a surplus of rice, used more rice bran, broken rice, and local alcohol distiller's wastes to mix with green plant materials. Some had also started to use commercial feed. Despite this, the performance of pigs in smallholder systems was generally very poor, as it was affected negatively by nutritionally imbalanced diets and underfeeding. In the current study, few households provided any supplementary feeds and salt to their pigs. It was found that pigs generally took nearly 2 years to reach a marketable weight of 60 to 70 kg. This equated to an average of daily weight gain ranging from 100 to 140 g, which was in agreement with earlier data (Phengsavanh and Stür 2006). The low quality of diets was likely to also negatively affect the milk production of lactating sows and explain the poor body condition of sows observed in the survey. Farmers reported that it usually took more than 4 months for sows to return to good body condition after weaning.

The reproductive performance of sows in this survey was relatively low, as was the case with other local breeds in the region (Le Thi Thanh Huyen et al. 2005). The high mortality rate of piglets (up to 50%), usually occurring before weaning, was of major concern to smallholders. Disease outbreaks and diarrhea were the main causes of mortality. These may have been related to the observed poor hygiene, and lack of disease preventive measures as well as poor nutrition of sows during gestation and lactation. In a recent report by FAO (2010), several measures were suggested to address disease outbreaks in smallholder pig production systems. These measures were related to the segregation of animals such as pigs newly introduced to a village being quarantined until confirmed free from diseases, village quarantine systems, and movement of pigs around the areas. In the current study, there was few or no problem with squashing of piglets, as native sows were allowed to build nests prior to farrowing, which were soft and prevented squashing.

Another problem relating to reproduction is boar selection and management. In many villages, good quality boars are often sold for breeding or fattening, and therefore, farmers had to use the few remaining (unsold) boars in the village for breeding. In the last few years, service providers have offered to bring boars to some more accessible villages for mating. Their fee was one to two piglets per successful service. Many farmers preferred to select boars from their own herd and then sell these for slaughter at a later time. Boar management was clearly a problem with many being used for breeding at too young an age, and many were clearly underfed. Since the boar is selected from within the herd, this and the lack of knowledge of the provenances of individual animals within the village herd have led to inadvertent inbreeding and a failure to use the better animals for progressive improvement of breeding lines (Thorne 2005).

Conclusion

Smallholder pig farmers relied on feedstuffs available on and around the farm. These feedstuffs mainly provided energy and were low in protein, causing nutritionally imbalanced diets and resulting in poor growth performance and high piglet mortality. To improve pig productivity in smallholder systems, the problem of feed quality and quantity must be addressed. There is a need for prioritizing and finding the most practical options for farmers to overcome this major constraint to pig production.

There is also an urgent need to generate information on genetic variation and growth potential for local breeds in Laos, which would be useful in future studies on factors influencing the performance of local pigs.

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