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Impact of the use of exotic compared to local pig breeds on socio-economic development and biodiversity in Vietnam

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TABLE OF CONTENTS

List of tables	III
List of figures	III
Abbreviations	III
Executive summary	1
1 Introduction	3
2 Formation and distribution of local breeds	4
2.1 Delta areas, northern Vietnam	5
2.1.1 I pig	5
2.1.2 Mong Cai	6
2.1.3 Lang Hong	7
2.1.4 Thai Binh	7
2.1.5 Tap Na	7
2.2 Central and northern mountains of Vietnam	8
2.2.1 Meo	8
2.2.2 Muong Khuong	8
2.2.3 Co	9
2.2.4 Soc	9
2.2.5 Tuy Hoa	9
3 Formation and distribution of composite breeds	10
3.1 Thuoc Nhieu	10
3.2 Ba Xuyen	10
3.3 Trang Phu Khanh	11
3.4 DBI-81 and BSI-81	11
3.5 Improved Mong Cai	12
4 Introduction of high performance breeds and crossbreds	14
5 The pig breeding system and its stakeholders in Vietnam	20
6 Suitability of different breeds for different environmental conditions	22
6.1 Conditions of smallholder pig production in Vietnam	22
6.1.1 Feeding systems and management	22
6.1.2 Pig housing	23

6.1.3	Diseases	23
6.2	Productive and reproductive performance of different genotypes in different production systems	23
7	Impact of imports on biodiversity	28
8	Conclusions	31
9	References	33
10	Contact addresses	39

LIST OF TABLES

Table 1: Local pig breeds in Vietnam	4
Table 2: Chronology of creation of Ba Xuyen and Thuoc Nhieus pigs	11
Table 3: Import of exotic pig breeds to Vietnam	15
Table 4: Reproductive performance of different pig genotypes in Vietnam	25
Table 5: Live weight gain of different pig genotypes in Vietnam	26

LIST OF FIGURES

Figure 1: Distribution of major local breeds in Northern Vietnam	4
Figure 2: Distribution of major local breeds in Central Vietnam	5
Figure 3: Mong Cai sow	7
Figure 4: Ban sows	8
Figure 5: Pig population and liveweight of pigs in Vietnam from 1975 to 1999	18

ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
AI	Artificial insemination
IFAD	International Fund for Agricultural Development
LR	Landrace pig breed
LW	Large White pig
LW gain	Liveweight gain
MC	Mong Cai pig breed
NIAH	National Institute of Animal Husbandry, Vietnam
N Vietnam	North Vietnam
PIC	Pig Improvement Company
SIDA	Swedish International Development Cooperation Agency
SU	Soviet Union
S Vietnam	South Vietnam
VND	Vietnamese Dong
VSF	Vétérinaires sans Frontières

EXECUTIVE SUMMARY

This case study focuses on the formation and distribution of the main indigenous pig breeds and crossbreds in Vietnam, the introduction of high performance breeds and their impact on biodiversity, and the suitability of different breeds for different environmental conditions.

Vietnam owns a wide variety of local pig breeds across different regions of the country. The Lang Hong, Mong Cai and I breed are the product of a long deliberate breeding history, whereas other breeds, e.g. the Meo, Co, or Soc, were not systematically bred. In particular the I and later the Mong Cai were strongly promoted in Vietnam to replace lower yielding local breeds. In South Vietnam, the Thuoc Nhie, Ba Xuyen and Phu Khanh composite breeds developed from crossbreeding local with exotic pigs. The DBI-81 and BSI-81 were developed in North Vietnam from crossbreeding I sows with exotic boars, but did not become widespread in national pig production. Only the Mong Cai has become common, being now the major local sow line in Vietnam. Exotic pigs, including Large White, Landrace, Duroc and Berkshire, have been introduced to Vietnam from American and European countries since before the 1920s. Major driving forces were the French Colonial Rulers (before 1954), American forces (before 1973), the socialist government (since 1954), Vietnamese and foreign commercial companies (before 1954 and after 1986), and developmental projects (after 1986). Gene flow now and recently is mainly a net inflow of exotic pigs. Current development and poverty alleviation projects at village level usually promote exotics, and only occasionally improved Vietnamese breeds. Information on pig gene flow to and within Vietnam is limited, due to the restricted information policy of both international breeding companies and Vietnamese official sources, but also due to the decentralised nature of pig breed import and distribution.

At present, exotic and crossbred pigs dominate, while local pigs make up only 26% of the national pig herd, mostly in uplands, rural and remote areas. The decentralised structure of the Vietnamese breeding system, the less developed central coordination and the common use of AI have all supported the spread of exotic pigs in Vietnam, especially at the smallholder level which makes up 80 to 95% of Vietnamese pig production.

Smallholder pig production includes different intensity levels. In contrast with large-scale commercial pig production, they can be characterised as low-input systems. Local pigs yield lower reproductive and growth performances. Performance data in literature are rarely comparable, as local breeds were usually investigated in low-input extensive-farming conditions, while exotic pigs or crossbreds are often tested under improved conditions or on station. Mong Cai sows under smallholder conditions yield higher reproductive performances than exotic or crossbred pigs, implying better reproductive performance potential of local breeds. Additionally, favourable adaptation traits (regarding environmental/climatic factors, low input production conditions, and susceptibility to disease) and general robustness are described for local pig breeds, together with favourable meat quality traits. Other, less favourable traits of local pig breeds include a high fat content and low lean meat ratio, a low growth rate, and, apart from the Mong Cai, a low fertility, rendering them less suitable to respond to higher inputs, unless their special quality traits are rewarded by the consumer.

The influx of exotic breeds had a strong impact on local pig populations. Today, 10 of 14 local pig breeds are in vulnerable or critical state or face extinction, and all of them show declining populations. NIAH is the main Vietnamese institution conducting conservation

programs, but only for a limited number of pig breeds. The long-term sustainability of those programs is questionable.

The significant genetic distinctions both between Vietnamese breeds and between Vietnamese and European breeds have been shown. Local breeds are a source of promising alleles, which might be significant for future genetic improvement and of unpredictable economic value.

Local pig breeds are a significant component of the Vietnamese and worldwide biodiversity, and are still important for resource poor farmers in Vietnam, who depend on them to ensure their livelihoods. The dominance of high yielding exotic breeds will increase in intensified production systems. Local breeds will only contribute to worldwide biodiversity if their competitiveness to exotics is proved for production systems under development and/or if favourable adaptation traits are proved and the controlling alleles identified. Investigations are under way to define local pig breeds, characterise them, and compare their performances under standardised conditions.

1 INTRODUCTION

This case study focuses on the formation and distribution of the main indigenous pig breeds and crossbreeds in Vietnam, the introduction of high performance breeds and its impact on biodiversity, and the suitability of different breeds for different environmental conditions.

Livestock forms 25 percent of the agricultural output value in Vietnam and is almost entirely in the hands of small farmers. Traditional farming systems integrate crops, fish and livestock, mainly pigs and poultry (Ly, 1996). Industrial livestock production on state-run farms and large-scale private farms is developing, but is still only a minor part (Thong, 1996).

For a long time, animal production in Vietnam has been based on local genotypes (Lemke et al., 2000), which are well adapted to local climates and available inputs. However, their productivity under improved conditions is lower than that of exotic breeds (Ly, 1996), under low-input conditions it might be comparable or even higher than that of exotics, but both are rarely tested together under same low-input conditions. Thus, local breeds have been replaced or crossbred with imported high-yielding breeds to increase performance in recent decades, leading to a severe decrease in the number of indigenous breeds, which are an important part of Vietnam's biodiversity (Lemke et al., 2000).

In 2002, the Vietnamese pig population was 23 million head. Indigenous pigs accounted for 26% of the total, located mainly in uplands, rural and remote areas. Local breeds can utilize farm-grown feeds and by-products, survive and produce in low-input systems, and withstand hardships. In rural and mountainous areas, local pigs have a multitude of functions, including consumption, capital storage, use in weddings, funerals, religious celebrations, as gifts and as suppliers of manure (Country Report of Vietnam, 2003). That report mentions 14 indigenous Vietnamese pig breeds, five of them in vulnerable state, two in critical state, and three facing extinction. Disappearance of local breeds might put smallholders' food security and economies at risk, or might be just a consequence of a better suitability of exotic breeds to meet farmers demands.

Thuy (2004) showed that Vietnamese indigenous breeds were genetically distant to European breeds, had a higher number of alleles per gene locus, and were genetically more heterogeneous than European breeds. The large genetic distance between selected breeds can be exploited in crossbreeding, benefiting from heterosis and combination effects for performance and adaptation traits.

This case study describes the formation and distribution of local breeds (chapter 2) and of composite breeds (chapter 3), and the introduction and spread of exotic high performance breeds to Vietnam (chapter 4). Chapter 5 describes the pig breeding system and its stakeholders in Vietnam. Chapter 6 discusses the suitability of selected pig breeds under different environmental conditions met in Vietnam. Chapter 7 discusses the impact of importing exotic breeds on biodiversity. Conclusions are drawn from the presented results.

2 FORMATION AND DISTRIBUTION OF LOCAL BREEDS

According to ecological and economic conditions, Vietnam is divided into seven agro-ecological zones: Northern Mountainous and Middle Highlands, Red River Delta, Northern Central Coast, Southern Central Coast, Central Highlands, North-East of Southland and Mekong Delta (Ly, 1996). There are diverse local pig breeds in the different regions of Vietnam (Table 1).

Table 1: Local pig breeds in Vietnam

Northern Vietnam	Uplands, Central and Northern Vietnam	Southern Vietnam
I	Meo	Ba Tri
Mong Cai	Co	
Muong Khuong	Soc	
Lang Hong	Tuy Hoa	
Meo (Ban, H'mong)	Tau Pha	
Thai Binh	Nghia Binh	
Tap Na	Mini pig/ Quang Tri	
Tong Con		
Ha Bac		
Son Vi		

Source: compiled from: Molenat and Thong, 1991; Ly, 1999; Ly, 1999; FAO/DAD-IS, 2004; Thuy, 2004)

Figure 1 and Figure 2 depict the distribution of the major local pig breeds in Vietnam.

Figure 1: Distribution of major local breeds in Northern Vietnam



(Upper case letters mark distribution area of pig breeds: A = I pig, B = Mong Cai pig, C = Lang Hong pig)

Figure 2: Distribution of major local breeds in Central Vietnam



Upper case letters mark distribution area of pig breeds: A = Meo/Ban pig, B = Muong Khuong pig, C = Co pig, D = Soc pig

According to Lemke et al. (2000), the indigenous breeds Lang Hong, Mong Cai and I can be characterised as improved, higher-yielding breeds resulting from a longer systematic breeding period, compared to the Meo and Co indigenous breeds which have not been deliberately improved. Other local pig breeds include the Tong Con at the Chinese border, the white Nghia Binh pig (central Vietnam) and the Ha Bac, a small breed predominantly kept in the central region of northern Vietnam (Molenat and Thong, 1991). The Tau Pha breed predominates in smallholder scavenging systems in the mountainous regions of central Vietnam. In the central highlands, a black and white pig resembling the Mong Cai has been observed but whose breed has not yet been identified (Hot, 1982). Thuy (2004) mentions additionally the Son Vi pig (Phu Tho province) and the Mini pig of Quang Tri province.

2.1 Delta areas, northern Vietnam

2.1.1 I pig

The I pig originates from Nam Dinh province (nowadays Nam Ha), Red River Delta. It is a very small, black pig with potbelly and swayed back (Ly, 1999). Two sub-species can be distinguished (Khanh and Hien, 1963), namely the I-mo (or pure I pig) and the I-pha.

The I-mo is smaller than the I-pha with short legs and trunk, a big head with short snout bent upward and small, upright ears. In the extremely wrinkled face, the eyes seem to be closed. Most I-mo sows have 10 teats.

The I-pha is a cross of I-mo with various (unknown) local breeds, but is nowadays considered a distinct breed. It has longer legs, trunk and snout than the I-mo. The snout tapers. The potbelly is less pronounced and the face is only slightly wrinkled. The ears are bigger and stand horizontally. I-pha sows have 10 to 12 teats.

The I pig is characterized by early maturity, high fecundity and adaptation to a frequently flooded, muddy environment and poor, roughage-based diet. I pigs are said to be resistant to parasites (Tang and Cuong, 1994). In general, they are considered very robust. The I pig has a high fat and low lean meat proportion (Molenat and Thong, 1991).

Before 1970, the I pig was most common in North Vietnam. The province of origin (Nam Dinh, nowadays Nam Ha) had good access via roads and rivers to the other delta provinces, thus supporting the introduction of the I pig to Ha Nam, Ha Tay, Hung Yen, Hanoi, Vinh Phuc, Hai Duong, Thai Binh, Quang Ninh, Ninh Binh, Hai Phong and Thanh Hoa (Tang and Cuong, 1994).

1970-1989: The promotion and distribution of the higher-yielding Mong Cai (“Mong Cai-isation”) led to a parallel reduction of the I pig population. In 1989, only 463 sows were counted in the original breeding region (Hoang Hoa district). In this time, the National Institute of Animal Husbandry Hanoi (NIAH) started conservation measures to protect the breed from extinction (Lemke et al., 2000).

In 1989, 22 I-mo pigs (2 boars, 20 sows) were selected from the remaining I pig population of two villages to build a nucleus (Tang and Cuong, 1994). Due to internal problems, that conservation project was dissolved in 1994, and 20 sows and two boars from the nucleus were transferred to a new nucleus in Hoang Hoa. Since 1989 (start of conservation), the nucleus has slightly expanded; in 2000, the nucleus consisted of 36 sows and six boars (Lemke et al., 2000). No data exist on the current population size. There remain only few communes in Thanh Hoa province where I pigs are kept in small numbers outside the conservation program (Ly, 1999).

2.1.2 Mong Cai

The Mong Cai, today the main breed in North and central Vietnam, originated from North East Vietnam (Duyet and Duong, 1996), from the Red River delta, coastal provinces Hai Phong and Thai Binh (Thien et al., 1996). It has a small to medium body size, and small, upright ears. Head and body are black, with a white band running from one side of the abdomen over the shoulder to the other side of the abdomen, making a black saddle over the middle of the swayed back (Figure 3). The Mong Cai is characterised by high prolificacy. It is adapted to poor quality feed, and is in general robust. Disease resistance has been reported but not scientifically confirmed.

Figure 3: Mong Cai sow



Picture taken at smallholder households of ethnic Black Thai in Son La province, North West Vietnam (picture: Lemke)

Two types of Mong Cai have been described, a small-frame and a large-frame. The large-frame type is said to have a higher lean meat rate, a bigger litter size and a higher growth rate. However, piglet mortality in the large-frame type is also higher (Hai et al., 1979). The pure Mong Cai pig with a small body size originated from the sea shore region of Quang Ninh province (formerly Hai Ninh province), bordering Quang Dong province (China). The Tong Cuu pig of Quang Dong province resembles the Mong Cai pig (Doanh, 1994).

1960-1975: Since the 1960s, the Mong Cai has spread throughout the northern delta areas.

After 1975: Mong Cai pigs were introduced to Central and South Vietnam (Ly, 1999). The Mong Cai was frequently used to improve local breeds with lower performances. Thus, the number of pure Mong Cai pigs gradually declined, while the number of Mong Cai crossbreds (with other local or exotic breeds) increased (Doanh, 1994).

2.1.3 Lang Hong

The Lang Hong pig resembles the Mong Cai in appearance and performance. However, there has not yet been an attempt to assess any relation between the breeds. Compared to the latter, the Lang Hong has a shorter trunk, less pronounced potbelly and swayed back, a shorter snout, and smaller, upright ears. The forehead bears a white triangular mark.

Lang Hong pigs are mostly raised in Bac Ninh and Bac Giang provinces (North East Vietnam). At present, Lang Hong pigs are mostly crossed with Mong Cai (Ly, 1999).

2.1.4 Thai Binh

The Thai Binh breed originates from the Red River delta. It is a small pig of white colour with black marks, has a swayed back and a pronounced potbelly (Molenat and Thong, 1991).

2.1.5 Tap Na

The Tap Na has been found in Cao Bang province and neighbouring mountainous provinces (North East Vietnam), kept under low-input conditions. It is a black pig with six white marks (forehead, four feet, tip of the tail). The Tap Na shows some external features resembling the Mong Cai, but has a black belly and no white band at the shoulders like the latter one. The Tap Na has a straight head of medium size with stooping ears, the snout is not wrinkled. It has long legs like the Muong Khuong or Meo. Its back is straight and the belly does not touch the ground. It has 6 to 10 teats.

The Tap Na is well adapted to the ecological conditions where it is kept. It is said to be resistant to certain diseases, and to have a tasty meat. Daily weight gain and lean meat percentage are low and the feed conversion rate is high.

The number of Tap Na pigs is decreasing and it is at high risk of extinction. Nowadays, Tap Na pigs in villages near main roads are crossbreeds, and pure Tap Na are difficult to find (Duc et al., 2004).

2.2 Central and northern mountains of Vietnam

2.2.1 Meo

The Meo pig originated from the high mountainous areas of Truong Son. Meo pigs are mainly kept by ethnic Thai and H'mong people in North and North West Vietnam, who call their pigs by different names, e.g. Ban, Dan, Meo (with different diction) and H'mong. It remains to be investigated, whether these are different breeds, eco-types of the same breed, or one breed under different names (e.g. Hoa, forthcoming). In this study, the term Meo is used. Meo pigs have also spread to the mountainous areas of Nghe An province (Central Vietnam), an area populated by Thai farmers.

The Meo is well adapted to the local ecologies and socio-economies of the H'mong people (Ly, 1999). Meo pigs resemble wild boars. They have no potbelly and a straight back (Figure 4). Thai farmers describe three local varieties differing in size, appearance of white marks (snout, tip of the tail, legs), reproductive performance and growth rate (Lemke et al., 2000). For Meo pigs of the H'mong, six phenotypic groups have been described, which might represent sub- or eco-types (Huyen, 2004).

Figure 4: Ban sows



Pictures taken at smallholder households of ethnic Black Thai in Son La province, North West Vietnam (Lemke, 2002)

Meo sows are said to have less favourable mothering abilities. They reach maturity late (8 to 9 months). Under the husbandry conditions of H'mong farmers, litters are with 6 to 7 piglets small; the farrowing interval is high. About 60 to 70% of piglets survive until weaning. H'mong boars are sexually mature at four to five months age (To and Duc, 1967).

Meo boars have been mated with sows of other local breeds for commercial purposes (Ly, 1999).

2.2.2 Muong Khuong

The Muong Khuong pig closely resembles the Meo pig. It is kept by H'mong farmers in the mountainous areas of North Vietnam, particularly Lao Cai province. The Muong Khuong is a large pig and copes well with being kept as a scavenger. Due to similarities between Muong Khuong and Meo concerning performance, appearance, adaptation traits, and area of keeping, Vietnamese scientists have tried to identify whether they belong to the same breed (Ly,

1999). The development plans of Lao Cai province for the period 2001 to 2005 include a plan for conserving the Muong Khuong, mainly to preserve it as a sow line for crossbreeding (Thu, 2004).

2.2.3 Co

The Co pig is found in the Central Highlands of Vietnam. Its very small body size and low performance is most likely a result of inbreeding (Hot, 1982). Before 1960, Co pigs were common in the central provinces Nghe An, Ha Tinh and Binh Tri Thien, but were strongly reduced in numbers due to the spread of the Mong Cai to central provinces (Ly, 1999).

2.2.4 Soc

The Soc pig also originates from the Central Highlands. It is kept by the ethnic groups of E De, Gia Rai, Ba Na, and Mo Nong, in the provinces Lam Dong, Dak Lak, Gia Lai and Kon Tum. Soc pigs have a small body and resemble wild pigs. They are kept as scavengers, without supplemental feeding. Due to the introduction of higher-yielding pigs, the population of Soc pigs in the Central Highlands has strongly decreased (Ly, 1999).

2.2.5 Tuy Hoa

The Tuy Hoa originates from the Song Ba river delta. Tuy Hoa pigs have little hair and a white colour and are quite sensitive to insolation. They show a good growth performance under good feeding conditions (Molenat et Thong, 1991). Under smallholder conditions, Tuy Hoa pigs show a great variation in performance.

3 FORMATION AND DISTRIBUTION OF COMPOSITE BREEDS

In Vietnam, a number of composite breeds are known. However, breeding history and genetic make-up in some cases rather suggest that breed standardisation has not yet been accomplished. The Ba Xuyen and Thuoc Nhieu breeds (Mekong delta) and the Trang Phu Khanh (Central Vietnam), Thuoc Nhieu and Ba Xuyen breeds were formed from spontaneous natural mating between local sows and exotic boars in the 1920s (Doanh et al., 1985). They have widely spread since due to good adaptation to the local climate, high prolificacy, good mothering abilities and a high growth rate (Tjällden, 1999). More recent attempts of Vietnamese scientists to create synthetic breeds from I sows and exotic boars date back to the 1980s. Further, the improved Mong Cai with exotic influence in its genetic make-up can be distinguished from the original Mong Cai.

3.1 Thuoc Nhieu

The Thuoc Nhieu is a medium-sized pig (120 to 160 kg adult liveweight) of white colour. It has small upright ears, a medium-length snout, short legs and a long body with slightly swayed back. Growth rate and reproductive performance are moderate (litter size: 8 to 10 piglets/litter), the lean meat ratio is low and the fat percentage high (Molenat and Thong, 1991). The Thuoc Nhieu can cope with feedstuffs of low nutritional value and harsh keeping conditions (Tjällden, 1999).

In 1900, the Chinese imported pigs to the coastal areas around the Mekong delta. Vietnamese local black sows (probably Co) were mated with those Chinese Hainan boars. The resulting crossbreds (F1, called Tau Pha, black-and-white pigs) were mated with French Craonnais boars (imported by the French, now extinct). The resulting F2 crossbred (called Bo Xu) was then continuously crossed with imported Yorkshire Large White and Yorkshire Middle White, creating the Thuoc Nhieu pig, which stabilized after some decades (FAO, 1999). The Thuoc Nhieu was popular in the provinces Tien Giang and Long An and the vicinity of Ho Chi Minh City, and later spread to the provinces Vinh Long, Long An, Dong Nai, Binh Thuan, Can Tho, and Soc Trang (Mekong River Delta) (Ly, 1999).

The Mekong Delta is one of the most important pork-producing areas of Vietnam. To fulfil national policies and meet the increasing market demand, scientists of the Institute of Agricultural Science of South Vietnam carried out selection programs mainly between 1981 and 1989. In this period, the Thuoc Nhieu's growth and reproductive performance improved by over 10% compared to those in smallholder conditions, and the breed then stabilized compared to those kept under smallholder conditions. The improvements are due to both successful breeding practices and the higher input on station. Thuoc Nhieu pigs for breeding were selected from rural backyards in Tien Giang province based on body conformation, growth rate, litter performance (sows), semen quality and sired litter performance (boars). First-grade boars and sows of second grade and upwards were placed in state breeding farms of the province for inbreeding between lines for two or more generations with continuing selection. The results showed increases in weaned litter weight and litter size. Selected sows also showed good prolificacy, surpassing Yorkshire sows reared in Vietnam (Thong et al., 1996).

3.2 Ba Xuyen

Like the Thuoc Nhieu, the Ba Xuyen was created by mating Vietnamese native black sows (probably Co) with Chinese Hainan boars and mating the resulting F1 (Tau Pha) with French

Craonnais boars. Between 1932 and 1956, mating the F2 (Bo Xu) with American Berkshire boars yielded the Ba Xuyen, a black pig with white spots, appreciated by farmers (Hai, 1994). Ba Xuyen pigs were concentrated in Soc Trang province. At present, they are sporadically raised in the provinces Vinh Long, Can Tho, Tien Giang, Kien Giang, An Giang, Long An, and Dong Thap (Mekong River Delta) (Ly, 1999).

Table 2 summarises the creation of Ba Xuyen and Thuoc Nhieu pigs (Doanh et al., 1985).

Table 2: Chronology of creation of Ba Xuyen and Thuoc Nhieu pigs

Year	Formula of crossing
1900	Chinese Hainan (B) x Vietnamese local black (S)
	↓
1920	French Craonnaise (B) x F1 (S)
	↓
	F2 (Bo Xu)
1932-1956	American Berkshire (B) x F2/Bo Xu (S)
	↓
	Ba Xuyen pig
1936-1956	Yorkshire Large White (B) x F2/Bo Xu (S)
1957	Yorkshire Middle White (B) x F2/Bo Xu (S)
	↓
	Thuoc Nhieu pig

Abbr.: B = boar, S = sow

3.3 Trang Phu Khanh

The Trang Phu Khanh pig originates from Phu Khanh province (today provinces Khanh Hoa and Phu Yen, South Central Coast) as a crossbred between Yorkshire and local pigs. It is still kept in the area, being a common sow line (Duyet and Duong, 1996). A long period of crossbreeding and selection led to the development of the Trang Phu Khanh, resembling in performance and appearance the Yorkshire. The Trang Phu Khanh has been recognized as Vietnamese pig breed since 1989. However, breeding efforts were not well coordinated, and Trang Phu Khanh pigs increasingly mixed with other pig breeds (Ly, 1999). Trang Phu Khanh sows have a good fertility and mothering abilities (Duyet and Duong, 1996).

3.4 DBI-81 and BSI-81

In 1981, scientists of the National Institute for Animal Husbandry (NIAH) created two new pig types: the white-coloured DBI-81 from mating Vietnamese I sows with Soviet Large White boars, and the black-coloured BSI-81 from mating I sows with Berkshire boars. They intended to create pigs with higher lean meat ratio than the local pigs and higher robustness than the exotic breeds. DBI-81 and BSI-81 were employed to generate crossbred offspring from local I and Mong Cai sows for fattening, acceptable to farmers and suitable for husbandry conditions in Vietnam (Doanh and Thong, 1985). NIAH selected DBI-81 and BSI-81

boars and supplied them to the artificial insemination network in northern and central provinces (Thuong, 1985). The genotypes were most widely spread in Hanoi and the provinces Ha Son Binh, Ha Nam Ninh, Ha Bac, and Thanh Hoa (North Vietnam) (NIAH, 1985).

3.5 Improved Mong Cai

With comparatively favourable characteristics, particularly a high reproductive performance, the Mong Cai pig has been used to improve other local pig breeds with lower performances, especially in North and Central Vietnam. Mong Cai are mainly used as a sow line (Thien et al., 2002). Over time, the number of pure Mong Cai gradually declined, while the population of Mong Cai crossbreds (with local or exotic pigs) strongly increased (Doanh, 1994). Since 1959/60, many scientific studies have been conducted on the Mong Cai. Mong Cai underwent a breeding and selection process at the state breeding farms including Thanh To, Dong Trieu, and Tam Dao through activities such as breeding assessment, boar examination and creating the nucleus herds (Doanh et al., 1985). The following examples document the distribution process.

Since 1975, Mong Cai were exported to Central Vietnam by state breeding farms (Dong Trieu, Tam Dao, Thach Ngoc). Through selection and adaptation in this centre, the Mong Cai has been shown to have a good mothering ability, large litters, a good milk production, a high number of litters per year, and a large body size (Duyet and Duong, 1996). In 1975 and based on government policies, 300 Mong Cai sows from the provinces Tam Dao, Quang Ninh and Hai Phong (North Vietnam/Red River Delta) were brought to a state breeding farm in Hue (Central Vietnam) to replace local pigs of low production. However, this farm collapsed in 1980, and a number of sows were given to local farmers.

Between 1977 and 1987, pig breeding in Central Vietnam focussed on Mong Cai and Trang Phu Khanh. However, breeding efforts were limited to the government/state farms; there were no national policies concerning farmers. (Duyet and Duong, 1996).

Since the 1990s, Mong Cai and (Yorkshire x Mong Cai) sows have been imported to Thanh Hoa province (North Central Coast), as part of the province's developmental program, to increase the lean meat rate in the province's pig herd (Luong and Gian, 1999).

In Tuyen Quang province (North East Vietnam), Mong Cai sows have been introduced since 1992 (Minh, 2000; Dong and Tiep, 2002). The breeding program of Tuyen Quang province was an open nucleus breeding program carried out in two periods. From 1992 to 1994, 69 Mong Cai sows and two Mong Cai boars of associated farms were given to 69 smallholders in Son Duong district, which received additional funding. The associated farms ceased work in 1994, but from 1995 to 1998 the number of pure Mong Cai sows amongst the smallholders increased very quickly. The breeding program expanded to include many smallholders of other districts of Tuyen Quang province, reaching a breeding population of over 3 millions Mong Cai sows. This strong development was partly due to external support, as the program received funding e.g. from the IFAD project of the province (International Fund for Agricultural Development) and SIDA (Swedish International Development Cooperation Agency). Smallholders received credits from the project for keeping Mong Cai sows (1 mVND/sow/year, no interest rate). Further project activities included developing AI centres to distribute Mong Cai semen in 6 towns and districts of Tuyen Quang province, to create a pure Mong Cai herd of high quality.

Government policy in 1994 no longer included maintaining Cornwall pigs, but confirmed the importance of Mong Cai pigs for the national breeding strategy due to its good reproductive performance and adaptation traits. However, male Mong Cai yield very low prices due to their inferior fattening performance, and market demand is only for female Mong Cai for breeding. Thus, keeping a purebred Mong Cai population is not economically desirable for farmers (Rodríguez et al., 1996). For example, in Thua Thien/Hue province, only one private farm keeps one Mong Cai boar, and the whole province as well as farmers from other provinces depend on this Mong Cai boar. The availability of semen is low (2 doses each 3 days, at a price of VND 8,000 = US\$ 0.62/dose). Demand for Mong Cai in the provinces is considered to be very high.

4 INTRODUCTION OF HIGH PERFORMANCE BREEDS AND CROSSBREDS

The indigenous Vietnamese pig breeds are characterized by a low growth rate and high carcass fat (Xuan et al., 1995). Exotic breeds like Yorkshire, Berkshire, Cornwall and Landrace have been introduced as part of government strategies and to satisfy the growing demand for large lean carcasses. However, they are less adapted to the local environment and husbandry conditions than the native breeds, and so yield performances lower than their genetic potential (Singh et al., 1996). About 10% of the Vietnamese breeding herd consist of adapted exotic breeds, which have been kept a considerable time in Vietnam under local conditions, mainly in state farms and small-scale private farms, concentrated in South East Vietnam (Hai, 1996). From 1970 onwards, crossbreds of local sows and improved or exotic boars with hybrid vigour have been increasingly used (Quac et al., 1996).

Table 3 summarises the import of exotic breeds to Vietnam.

Table 3: Import of exotic pig breeds to Vietnam

Year	Pig breeds	Origin	Vietnamese organization facilitating the breed import
1920	Craonnais	France	Individual farms, S Vietnam
1932	Berkshire	USA	
1936	Yorkshire	USA	
1955	LW, Berkshire	France	Phat Ngan Animal Husbandry Corporation, S Vietnam
1957-1959	Yorkshire	Japan	
1964	LW, Berkshire	SU	NIAH, N Vietnam
1965-1966	Yorkshire, LW, Hampshire, Chester White, Duroc, LR, Poland China	USA	Phat Ngan Animal Husbandry Corporation, S Vietnam
1969	Yorkshire	USA	Phat Ngan Animal Husbandry Corporation, S Vietnam
1971	LW	SU	NIAH, N Vietnam
	Berkshire	China	
	Landrace	Cuba	
1976	Duroc	S Vietnam	Agricultural University No. I and III, N Vietnam
1977	Yorkshire, LR, Duroc	Cuba	NIAH, N Vietnam
1978	LW, Duroc	Cuba	NIAH, N Vietnam
1997	Yorkshire, LR, Pietrain	England	PIC, N Vietnam
2000	Duroc, LW	USA	NIAH, N Vietnam

Abbr.: LR = Landrace, LW = Large White, NIAH = National Institute of Animal Husbandry, PIC = Pig Improvement Company, SU = Soviet Union

Source: compiled after: Doanh (1985); Thien et al. (1992); Hai (1996); Truc et al. (2003)

Before 1954 (end of French colonisation), exotic breeds were imported by individual farms in South Vietnam. At that time, Ba Xuyen and Thuoc Nhie pig breeds were developed (see above) mostly to meet the domestic market demand, but also partly for export. After 1954, when US forces occupied South Vietnam, exotic breeds were mainly imported from the US to meet the demand of the US Army. As a result, pig production developed strongly, particularly from 1964 to 1967 (1964 to 1973 American War). Exotic pigs were imported through Phat Ngan Animal Husbandry Corporation, South Vietnam, and were then bred both pure and crossed, creating the so-called Yorkshire Phat Ngan pig. From 1965 to 1974, Yorkshire Phat Ngan had a great impact on South Vietnamese pig production. Industrial pig production developed with large and medium scale farms especially around Saigon (today Ho Chi Minh City). Several factories produced commercial feedstuffs; Phat Ngan Animal Husbandry Corporation supplied breeding animals, and a number of companies processed pork. After 1975 (end of the American war, reunification of Vietnam), Soviet Large White pigs were imported

through NIAH (11 boars, 87 sows) and brought to Lam Dong province (North East South) (Doanh, 1985). Between 1975 and 1986, French Landrace pigs were introduced to South Vietnam through the France Hybrid Company.

From 1964 to 1977, North Vietnamese state farms imported mainly exotic boars for mating with local sows. NIAH directly managed those imports. In 1976, Duroc pigs from the South were introduced to the North and raised in the research farms of Agricultural University No. I and III (Truc et al., 2003). Imported pigs were kept and tested in the breeding centres of NIAH and other state farms in Hanoi and Hai Hau under intensive conditions, in order to create parent stock to supply breeding animals and F1 crossbreds for farmers and commercial animal production (Doanh and Luan, 1985). Results showed that, in general, imported breeds could adapt to Vietnamese climatic and husbandry conditions. However, compared to pure parent stock in the countries of origin, the performance of animals kept in Vietnam declined by 20 to 30% due to lower nutritional levels and the tropical climate. For example, in imported Large White pigs the reproductive performance of sows declined. In contrast, the semen quality of Large White boars raised in Vietnam nearly equalled that of Large Whites in the Soviet Union. Large White pigs born and raised in Vietnam developed an outer appearance with thinner hair and a lighter body conformation. Large White boars were used to create DBI-81 pigs (see above). Imported Berkshire pigs also adapted to local climatic and husbandry conditions at state farms. They were very robust, and especially insusceptible to mange. Berkshire boars were used to mate I and Mong Cai sows. However the reproductive performance declined in the Berkshire sows as well. Imported Duroc yielded lower performances and had higher mortalities. Imported Yorkshire, Landrace and Duroc often developed respiratory or reproductive diseases during adaptation periods at state farms, but disease incidence has decreased over the years of raising exotic pigs in Vietnam (Doanh, 1985).

In 1997, the British PIC (Pig Improvement Company) introduced 480 great-grandparent pigs to North Vietnam (Tam Diep farm, Ninh Binh province) including the lines L11 (Yorkshire), L06 (Landrace), L64 (Pietrain) and the composed lines L19 (Duroc/Yorkshire) and L95 (Landrace/Chinese Meishan). In July 2001, all these lines were transferred to Vietnam through NIAH. At present, Tam Diep farm produces grandparent stock for Vietnamese breeding farms, which in turn raise parent stock for smallholders, which then raise and fatten the end products (Truc et al., 2003). Another farm with 600 great-grandparent sows was established by PIC Ltd. Vietnam in Dong Giao (Ninh Binh province) before 2000.

CP group supported Vietnam with the construction of a pig AI station for 50 exotic boars in Hung Yen province for Hung Yen and neighbouring provinces (Lich and Tuyen, 2001).

From 1995 to 2001, the Australian Centre for International Agricultural Research (ACIAR) funded a project on "Breeding and feeding pigs in Australia and Vietnam" (AS2/1994/023), involving collaboration between the Institute of Agricultural Sciences of South Vietnam and the Queensland Department of Primary Industries. About 40 Australian Large White and Duroc pigs were brought to Vietnam and crossed with Vietnamese breeds to produce lean pigs with higher growth rate. A system of performance testing and selection was implemented. ACIAR and the Australian Agency for International Development (AusAID) provided funding to support AI centres. In addition to the breeding-related activities, two 'least-cost' diets were formulated based on traditional and non-traditional ingredients (ACIAR, 2004).

Parallel to developing crossbreds, and based on governmental policy, Vietnamese scientists started to introduce AI from 1958 onwards (Thien, 2002). Since the 1980s, the advantages of AI have been increasingly recognized. Crossbred feeder pigs increased in number, reaching 60% of the total herd (Thong, 1996). The Yorkshire was considered as a base breed in the development of two-way and three-way crossbreds. These crossbreds help to increase pork production and carcass quality and fulfil consumer demand for meat. The use of exotic pigs and crossbreds and of advanced management techniques was supported by the Vietnamese research and education system, through the agricultural extension service (training and technical advice), and the mass media (radio, television). Networks of technical staff and demonstration farms have been established for appropriate feeding, rearing management and a supply of certified boars, plus AI services and disease management (Hai, 1996).

Previously, traders and farmers used to sporadically introduce exotic pigs from South Vietnam to the Central Highlands, including Large White, Yorkshire, Duroc and Landrace. Due to uncontrolled breeding and extensive management, exotic pigs intermingled with each other and with local pigs, leading to the great variety in the pig population found today. After 1975, exotic breeds (Cornwall, Large White, Yorkshire, Landrace) were imported to Central Vietnam (Duyet and Duong, 1996), and state breeding centres were established e.g. in Duc Trong (Large White) and Bao Loc and Buon Ma Thuot (Edelschwein). Among the breeds brought to the Central Highlands, the Cornwall seemed to adapt best to local conditions, but had a high carcass fat content, comparatively lower fertility and undesired colour, and thus did not get general approval for breeding. Large White, Yorkshire and Landrace were mainly used for AI service. The proportion of exotic blood in fatteners increased considerably. Crossbred fatteners now yield growth rates of 430 to 500g/day, a lean meat ratio of 50%, and have a low feed consumption. Large Whites have become more widespread than the other exotic breeds in the Central Highland (Hot, 1982).

From 1981 to 1989, the Institute of Agricultural Science of South Vietnam carried out a project of selective breeding to improve Yorkshire pigs in Ho Chi Minh City and neighbouring provinces (Thong et al., 1996). The breeding was based on pigs from commercial breeding farms (216 sows, 23 boars) and family farms (1050 sows, 40 boars). Selected pigs had higher performances than the population average (litter weight at birth: + 16%, litter size at weaning: + 9%, litter weight at weaning: + 17%). Further crossbreeding experiments were conducted between Thuoc Nhieu sows and Yorkshire and Landrace boars; 419 crossbred litters were performance tested. The F1 crossbred offspring had higher performances than the pure parental pig breeds (Thong et al., 1996).

The so-called Lean Meat Program was based on a governmental decision to increase, over a 10-year-period (1990 to 2000), the lean meat proportion in the Vietnamese pig herd. Extensive investigations between 1990 and 1994, e.g. at NIAH and Bac Thai experimental farm, proved that crossbreds between local and exotic pig breeds were well adapted to economic and ecological conditions in the Red River Delta. Particularly the three-way cross of (Landrace x (Large White x Mong Cai)) was chosen for widespread use in breeding programs in the Red River Delta Region in the following decade 2000 to 2010 (Thien et al., 1996).

The northern mountainous provinces received a large number of new pigs, including exotic imports and Mong Cai pigs. For example, the People's Committee Son La imported Russian Large White, Belgian Yorkshire, Hungarian Cornwall, American Duroc and Danish Landrace (source: Son La Department of Agricultural and Rural Development) through the state breeding centre and regional breeding centres of the province, agricultural extension centres

of province and districts, national development and poverty alleviation projects and private organisations of the province. Imported pigs were kept in regions near towns with comparatively good infrastructure and economic conditions.

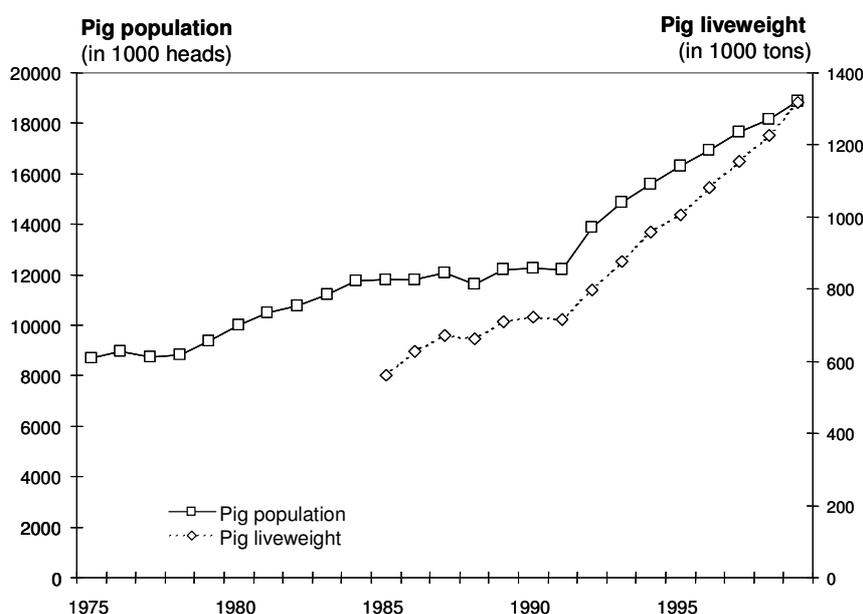
In 1994, 556 pigs (mainly Landrace, Yorkshire) were brought from South Vietnam to state farms in Thanh Hoa province (Huy et al, 1996).

In several pilot projects, exotic pigs were introduced to smallholder households, e.g. in 1988, the Vietnam Institute of Agricultural Science and Technique introduced Yorkshire sows to smallholders in Hai Duong province (Red River Delta) (Duy et al., 2001). Selected households were relatively well-off and located in regions with already strongly developed pig production. Contracts were made with the farmers to keep the exotic sows. The risk was shared between farmer and the research institute; no additional direct funding was involved. Interested non-project farmers were advised how to select, buy, keep and manage exotic sows. Results proved the adaptation abilities of Yorkshire to smallholder conditions; farmers yielded high outputs and an acceptable efficiency. In the following year, this model was applied widely in the province.

More breeds were introduced in 1995 and 1996. The Thuy Phuong pig research centre (NIAH) introduced pure Landrace and Yorkshire pigs to farmers in Red River Delta provinces (e.g. Ha Tay, Thai Binh) and investigated their performances under smallholder conditions. Smallholders tended to use extensive farming techniques even for the exotic pigs.

After more than 40 years of research a number of crossbreds have been identified that combine the favourable genetic characteristics of local and exotic breeds, in both state farms and smallholder farms and in different eco-systems. In particular, government research between 1990 and 1995 produced the crossbreds LR x (LW x MC), LW x (LW x MC), LR x (LR x (LW x MC)) and LR x (LR x (LR x MC)) for commercial production. In 2000, the crossbreds (Duroc x (LW x LR)) and Duroc x (LR x YR)) were introduced into pig production. The results of crossbreeding programs led to changes in the breeding strategies for both sows and fatteners (Thien, 2002).

Figure 5: Pig population and liveweight of pigs in Vietnam from 1975 to 1999



Source: General Statistical Office (2000)

The growth of the Vietnamese pig population increased markedly since 1992, probably reflecting the economic changes after 1986 (Figure 5).

The plot depicting the pig liveweight runs almost parallel to the plot depicting the population, indicating that a higher production output is mainly due to an increasing pig population. The rise in the pig liveweight and convergence of the two plots reflect the higher percentage of exotic and crossbred animals in the total population, especially in the last decade (see below, chapter 7).

5 THE PIG BREEDING SYSTEM AND ITS STAKEHOLDERS IN VIETNAM

The national pig breeding system of Vietnam has mainly been implemented at state farms (under government administration) and provincial farms (administered by the People's Committee of the province) (ASPS, 2002). Before 1995, Vietnam had 53 state breeding farms; almost all of them keeping Yorkshire, Landrace, Duroc and Mong Cai. The exotic pigs had been imported from France, Belgium and other European countries, Japan, Thailand and the US. These state breeding farms supply piglets for fattening, and produce boars for both natural mating and AI (Lich, 1996). The majority of breeding centres are involved in several levels of the breeding pyramid. Commercialisation has required many breeding centres (Decision 68/1998/QD-TTg, 1998) to change from breed development and dispersal of genetics to production and sale of commercial stock for fattening. The emphasis on short term commercial gain is at the expense of a long-term national vision of livestock improvement. Only a small number of breeding centres and research institutes keep local breeds for crossbreeding and conservation. The Vietnamese pig breeding is not centrally coordinated. Neither genetic improvement nor breed replacement and conservation are uniform across regions (ASPS, 2002). A certain amount of the breeding centres' output reaches farmers via the mass organisations (mainly Women's Union, Farmers' Association) and national development projects. For example, the national extension service runs a Breed Distribution Project, with the aim to supply one Large White boar to each village.

Almost all northern and central provinces have AI stations, each holding up to 20 breeding boars; individual AI stations keep as many as 30 to 100 boars. Insemination services in North Vietnam are more developed than in the South. Boars for AI are mainly of Yorkshire, Landrace and Duroc genotype and produce in total over 1 billion doses per year. However, many AI stations lack equipment for semen collection and processing, resulting in poor semen quality (Lich, 1996). In 2000, Vietnam had 265 district AI stations, 138 of them in the North (including independent AI stations). There were 10 state breeding farms with a total of 2,000 grandparent sows including indigenous, exotic and hybrid genotypes, 2 boar testing stations with a test capacity of 300 boars/year, and 10 provincial breeding farms keeping 1,500 breeding sows (Lich and Tuyen, 2001).

As an example, AI is most common in the Hue-Thua Thien province: farmers obtain semen from the AI centre in Hue city, and inseminate sows themselves. However the whole province has only 3 AI centres and this limits the availability of semen (Rodríguez et al., 1996). The state farm in Hue city has 8 boars (7 Large White, 1 Mong Cai). In total, 40 doses Large White/day (VND 6,000/dose = US\$ 0.46/dose) are distributed to four technicians in 4 districts, who distribute them further. Veterinarians and farmers conduct the insemination at village level. In Quang Phuoc village, a provincial breeding farm was rented to a farmer, who manages the farm himself, providing 25 doses/day (Large White). Another private farmer keeps a Yorkshire boar, supplying semen at VND 4,000/dose (US\$ 0.31). Renting AI stations to private persons and private boar ownership was also seen in Son La province and is probably widespread.

Since the late 1980s with the start of the open door policy in Vietnam, foreign governmental and non-governmental organisations have played a role in introducing and distributing higher-yielding pig genotypes in a large number of both big and small projects. Examples include the activities of ACIAR and AusAID (see above), the IFAD Country Program Vietnam (IFAD International Fund for Agricultural Development; Tuyen Quang province) or

SEDEC (Socio-Economic Development Center for Coastal Areas) in cooperation with Konrad-Adenauer-Stiftung (Binh Thuan province, 2001). With project activities starting in 2001, Vétérinaires sans Frontières have promoted Mong Cai sows in Phu Tho province (North East Vietnam), now extending their activities to other North Vietnamese provinces.

In the field of international companies and breeding organisations, active importers include PIC, CP Thailand, the Dutch TOPIGS (export via TOPIGS international in Canada and the US), the United Kingdom Pig Breeding Association (Nhien, 2004) and the Danish DanBred. It is assumed that a great number of other international traders are actively introducing exotic pigs to Vietnam, but information on those activities is scarce.

6 SUITABILITY OF DIFFERENT BREEDS FOR DIFFERENT ENVIRONMENTAL CONDITIONS

Today, Vietnam owns a number of indigenous pig breeds. Depending on the various climates, ecological and socio-economic conditions in the distribution areas, there is considerable variation in performance from one breed to another (Ly and Duyet, 2000). Each region has its own special conditions and over the generations different breeds have adapted to their unique environments as people create domestication and breeding processes to suit their own specific needs. As a result, breeds have been developed that produce even under extreme conditions, are robust, show low susceptibility or even resistance to disease, and can survive on limited nutritional resources (Tjällden, 1999). However, ecological and economic conditions are changing, and animals adapted to production systems that no longer exist will be replaced by those better suited to the new, prevailing systems.

Hai and Nguyen (1997) described three production systems in Vietnam: state run farms (4 to 5% of total pig production), private commercial farms (15%) and smallholders (80%). In 1998, around 95% of sows in Vietnam were kept in extensive households, while less than 5% were kept under intensive conditions (Pig International, 1998).

Lemke et al. (2002) and Valle Zárate et al. (2003) indicated that pig production in Son La province (North West Vietnam) showed different levels of production intensity. Lemke et al. (2002) described a semi-intensive system used in mountain valleys and near towns, where pig production is driven by generating income from the sale of pork. Introduced Mong Cai and Mong Cai crossbreds dominate. In the extensive systems found at hillsides and further away from town, pig production is driven by availability of resources. Local pig breeds prevail (Meo/Ban), serving various functions (consumption, income generation, social functions).

6.1 Conditions of smallholder pig production in Vietnam

Major constraints to livestock production in Vietnam concern animal nutrition, health, livestock genetic potential (FAO, 1999) and marketing (Lich and Tuyen, 2001; Vang, 2002).

6.1.1 Feeding systems and management

Smallholder pig production is mainly based on the utilisation of farm-produced feedstuffs and agricultural by-products, characterised by a high fibre content and low protein and energy contents (Loc et al., 1996). Feedstuffs for pigs include rice bran, broken rice, maize, vegetables, agricultural by-products like soybean cake, fish meal, salted fish waste, and commercial concentrates. Particular for lactating sows, farmers provide protein-rich feed supplements (Thong, 1996), however, at a limited amount (Rodríguez et al., 1996). Fishes and shrimps (fresh or dried) are used sporadically as protein supplements (Peters, 1998). Households with larger pig herds and engaging in activities like wine production, tofu processing or grain milling, can use by-products as pig feed; which has been observed in both lowlands and highlands (Tung, 1999). It has even been observed by the authors of this study that families started distilling and selling rice wine in order to make fermented rice as pig feed. At smallholder households in Son La, pig feeding was based on maize, rice bran and cassava. Comparing Thai villages near town, Thai villages in intermediate location, and remote H'mong villages, the use of commercial feed decreased with increasing remoteness, and the use of garden and forest vegetables increased. In Thai villages, between 40 and 90%

of pigs were fed on purchased feedstuff with seasonal variations, while in remote H'mong villages it was only 4% (Huyen, 2004; Lemke et al., forthcoming).

In general, feeding depends on the crop season and the family's condition (Rodríguez et al., 1996). Monetary investment into feeding by smallholders is low (Tung, 1999; Ly, 2000).

6.1.2 Pig housing

Pig housing at smallholder level is simple (Rodríguez et al., 1996). According to Astroem (2000), prevailing systems in rural areas are free range systems or simple pens, both with a minimum of inputs.

Pig housing at smallholders' shows a great variation: H'mong and Thai farmers keep pigs as scavengers, occasionally confining them in paddocks; in wooden or bamboo-made pens, often stilted; in pens with concrete floor, wooden/bamboo-made fence and canvas/tile/asbestos roof; or brick-built stables (Lemke et al., 2000; Huyen, 2004). In the Central Highlands, most common are stables with a packed clay-floor, less frequently with a partially concreted floor and a partially packed-clay floor. Some pens are surrounded by a fence (often a 'live' fence of cassava or bamboo) to restrict the area in which piglets can scavenge (Rodríguez et al., 1996). Pig housing in Tuyen Quang province is on a closed concreted floor. Compartments are constructed either from bamboo or concrete; the roof is made from leaves, sometimes from tiles (Bosma et al., 2003). Smallholders in Ha Tay province (Red River Delta) were observed by the authors of this study to construct massive brick stables with concrete floor, tile roof, and compartmented by brick walls.

6.1.3 Diseases

Animal diseases are a risk to livestock development, with a relatively high mortality rate causing considerable losses of the GDP (NIAH, 2003). Low vaccination coverage has been identified as a major problem (Dung, 2002). Vaccination coverage for Vietnam in general in the 1990s was given with 40 to 50% (Thuy, 1999), and for North Vietnam with 25% (Lich and Tuyen, 2001). Among prevalent diseases, Foot-and-Mouth disease FMD and Classical Swine Fever are endemic (source: <http://www.oie.int>). Resistance of local pig breeds against diseases and endoparasites is often mentioned by Vietnamese sources (e.g. the I pig is said to be resistant against FMD), but not scientifically proven. High mortalities do not support such perceived disease resistance, but probably result from unimproved, input-extensive management (Lemke et al., 2000).

6.2 Productive and reproductive performance of different genotypes in different production systems

In Vietnam, pig production is based on two groups of breeds, the native and the exotic breeds. In Vietnam, native breeds are usually smaller than imported breeds. On the other hand, favourable characteristics including adaptation to climate and low-input production systems, robustness and lower susceptibility against diseases have been described (while not always been scientifically proven). Native pigs are able to thrive on poor quality feeds, and are productive under conditions where imported breeds would not (or would even not survive). Compared with exotics, local breeds can cope with lower amounts and qualities of inputs (e.g. feed, veterinary inputs) and less intensive care. It is for those favourable characteristics that farmers appreciate local breeds (Thong et al., 1996). Exotic breeds require more intensive feeding and management in order to yield performances according to their higher

genetic potential (Quac et al., 1996). In their countries of origin they are highly productive, but are difficult to raise under unfavourable conditions in Vietnam. It is estimated that exotic pigs in Vietnam realise only 60 to 70% of their performance potential, leading to low economic efficiency (Thien et al., 1996). In addition to reduced performance, mortalities of exotic pigs under tropical conditions are higher than in their native countries.

However, it may be that local pigs are only kept where there are no alternatives: if available, farmers keep exotic pigs because of their higher performances and reputation and in order to benefit from subsidies attached to those exotics.

Some local breeds have a reasonable reproductive performance and produce good quality meat. Disadvantages include a small body size and a low production output per time unit (Ly, 1993). Table 4 and Table 5 give an overview of reproductive and growth performance for different pig genotypes. As different genotypes were kept in different production systems, the performances should not be directly compared. In addition, for the growth performance data, age classes were not distinguished.

The improved Mong Cai has a higher production output but requires a higher input. The local Meo yields a lower output but needs less input (Lemke et al., 2002). Crossbreeds of (Large White x Mong Cai) genotype in Central Vietnam had significantly higher daily gains, when fed on protein supplements (Loc et al., 1996).

Mong Cai pigs are prolific, having large litters, and are robust. They seem to be less susceptible towards diseases. Disadvantages include a slow growth (liveweight at 10 months 60 to 68 kg), high feed conversion ratio (4.5 to 5.0 kg concentrate/kg LW gain) and low lean-meat rate of 32 to 34% (Thien et al., 1996). To benefit from the favourable reproduction and adaptation characteristics of Mong Cai, while improving the undesirable fattening and carcass traits, Mong Cai sows are commonly mated with exotic boars like Large White, Danish Landrace, Cornwall, Hampshire or Duroc (Astroem, 2000).

Meo pigs have a reputation of superior adaptation and robustness and can, like I and Co pigs, cope with a fibre-rich diet. Their meat quality is considered excellent. Anh and Dung (1994) give a lean meat ratio of 50 to 60%, higher than in other local breeds (the ages of pigs with this performance is missing). Meo sows farrow 5 to 15 piglets/litter, in 1.0 to 1.4 litters/year. Long farrowing intervals are due to high weaning ages (> 2 months), and to the fact that often male piglets sire the next litter after becoming sexually mature. The pre-weaning mortality is 20% (Anh and Dung, 1994; Thuy, 1999). According to To and Duc (1967), Meo pigs in Nghe An province (Central Vietnam) have growth rates of 4 to 8 kg/month (age 2 to 4 months) and of 12 to 15 kg/month (age 6 to 8 months); and Meo fatteners reach 250 kg liveweight at 12 to 18 months age; corresponding to growth rates of 133 to 266 g/day (2 to 4 months), 400 to 500 g/day (6 to 8 months), and 694 to 463 g/day for the total lifetime. It is assumed that those results are overestimated, especially in comparison with other data in Table 5.

The favourable adaptation traits of the I pig have been mentioned above. I pigs reach sexual maturity early with 3 to 4 months age, have a high reproductive performance, good mothering abilities and a remarkable longevity (Tang and Cuong, 1994; Ly, 1999). In contrast, Lemke et al. (2000) found a moderate litter size and especially high piglet mortality. I pigs are well-known for their calm temper and especially flavoursome meat. However, they get obese early and have an unappealing external appearance (Tang and Cuong, 1994). Their

growth rate is with 200 to 250g/day low. After 8 to 9 months of age, I pigs reach a liveweight of less than 50 kg. The lean meat proportion equals 35 to 39% (Doanh et al., 1985).

The reproductive performance of purebred Meo, I and Tap Na is comparable (see Table 4), but lower than that of Mong Cai sows. The litter size of Mong Cai sows is, even under extensive conditions, higher than that of (Yorkshire x Mong Cai) crossbreds at station, (Landrace x Mong Cai) crossbreds, and of pure Large White, Landrace and DBI-81. I crossbreds have a higher reproductive performance than pure I but a lower performance than Mong Cai sows. Co pigs have the lowest reproductive performance of all the local breeds.

Table 4: Reproductive performance of different pig genotypes in Vietnam

Genotype	Production system	Piglets born alive/litter	Piglets weaned/litter	Source
Meo	Extensive	7.3 ± 1.5	-	Lemke et al., 2002
I	Extensive	7.6 ± 2.1	5.6 ± 2.7	Lemke et al., 2000
Co	Extensive	5.0	-	Hot, 1982
Tap Na	Extensive	7.9	-	Duc et al., 2004
MC	Extensive	12.4	11.5	Lemke et al., 2000
MC	Semi-intensive	11.2 ± 2.7	-	Lemke et al., 2002
LW	-	10.6	-	Hot, 1982
LR	-	9.3 ± 1.7	7.2 ± 1.6 ¹	Thien et al., 1995
DBI-81	-	8.9 ± 1.6	7.3 ± 1.3 ¹	Thien et al., 1995
YR x MC	Experimental farm	9.4 ± 0.6	8.6 ± 0.6	Quac et al., 1996
YR x I	-	8.3	7.5 ¹	NIAH, 2004
LR x I	-	8.2	7.2 ¹	NIAH, 2004
LR x MC	-	10.4 ± 2.4	7.9 ± 1.2 ¹	Thien et al., 1995
Pi x I	-	13.0	11.0	NIAH, 2004

¹ n piglets after 60 days; abbr.: MC = Mong Cai, LW= Large White, YR = Yorkshire, LR = Landrace, Pi = Piétrain

Compared to the growth performance of exotic pigs kept at experimental farms, the growth performance of local breeds and its crossbreds with Large White boars under smallholder conditions is poor. Among the local pigs, the Tap Na yielded the highest growth rate, Mong Cai yielded under extensive production conditions a lower growth rate, and the lowest growth rates were found for Meo and (Large White x Meo) genotypes (Table 5).

Table 5: Live weight gain of different pig genotypes in Vietnam

Genotype	Liveweight gain (g/day)	Source
Meo	186 ± 106	Lemke et al., 2000
Meo (Ban)	65	Lemke et al., forthcoming
I	167	Lemke et al., 2000
I	200 – 250	Doanh et al., 1985
Lang Hong	165 ± 29	Lemke et al., 2000
Tap Na	302	Duc et al., 2004
MC	120	Lemke et al., forthcoming
MC	166	Valle Zárate et al., 2003
DBI-81	479	Thien et al., 1995
LW	520	Duc et al., 1997
LR	587	Thien et al., 1995
LW x Meo (Ban)	83	Lemke et al., forthcoming
LW x Meo	115	Valle Zárate et al., 2003
LW x MC	161	Lemke et al., forthcoming
LW x MC	165	Valle Zárate et al., 2003
LW x MC	291	Loc et al., 1996

Abbr.: MC = Mong Cai, LW = Large White, LR = Landrace

Summarising the results, local breeds seem to have some unique adaptation characteristics. They have lower performances, which they yield, however, under low-input conditions. In contrast, exotic pigs yield higher performances, but require higher inputs: the higher growth rates in Table 5 were mainly recorded in experimental stations or in breeding centres. However, Mong Cai were shown to have higher reproductive performances than exotic pigs or their crossbreds under improved conditions, and local pig breeds yielded growth rates comparable to that of (exotic x local) crossbreds.

The results in this chapter hint at the production potential of some local pig breeds. However, there have been no systematic investigations on keeping improved breeds under extensive conditions, or keeping local pig breeds under improved conditions. Investigations on the performance of crossbreds of different genetic make-up under different production conditions are also missing. Further there is little information on adaptation traits of local pig breeds. Currently, a project by the University of Hohenheim, Institute of Animal Production in the Tropics and Subtropics, in Vietnam is trying to close these gaps by conducting a systematic investigation on different purebred and crossbred genotypes, including exotic breeds (Large White), Vietnamese improved breeds (Mong Cai) and local breeds (Meo/Ban) under different production conditions in a cross-classified design. Further studies deal with the impact that (governmental) subsidies have on farmers' keeping local or exotic pig breeds in Vietnam, and explore market niches for pork produced from local breeds.

Over the last decades, exotic pigs have steadily spread and replaced local pigs in the Vietnamese pig population (see also Figure 5). As part of ongoing socio-economic developments, these exotic pigs have become increasingly available and accessible for farmers and have enabled them to produce pork with increasing efficiency. However, the question remains whether pig-keeping resource-poor smallholders in remote and mountainous regions can be included, or if they can set up niche production with local pig breeds.

7 IMPACT OF IMPORTS ON BIODIVERSITY

The third edition of the World Watch List for Domestic Animal Diversity published by the FAO and UNEP reports that every week the world loses two breeds of domestic animals, while 1,350 breeds face extinction in the near future. The greatest threat to domestic animal diversity is the export of animals from developed to developing countries, leading to cross-breeding and even replacement of local breeds. In developing countries, breeds from the industrialized world are considered more productive. The problem, however, is that those animals realize performances according to their genetic potential only under management conditions and at an input level that most local farmers cannot supply, thus putting them under a considerable economic risk.

For a long time, the animal production of Vietnam was based on local genotypes. Due to their slow growth, low feeding efficiency and early deposit of fat, local genotypes have been progressively “improved” through crossbreeding or been replaced with imported high-yielding breeds (“lean meat programs”). As shown above, Vietnam has a long history of importing exotic pig breeds; under French and American rule and later on as the Socialist Republic of Vietnam. At certain earlier times, the government had supported higher-yielding local breeds, especially the Mong Cai (“Mong Cai-isation”). Importing exotic breeds and promoting a single higher-yielding local breed have led to a severe decrease in the number of indigenous breeds. Meanwhile, exotic pigs and their crossbreds dominate the Vietnamese pig production, and some local breeds have already disappeared or are severely endangered by extinction (NIAH, 1997). As an example, in North Vietnam the proportion of local genotypes in the total sow population decreased from 72% in 1994 (Thien et al., 1996) to 45% in 1997 (NIAH, 1997). In 2002, the Vietnamese pig population was a mere 26% of local pigs. Among 14 indigenous Vietnamese pig breeds, five breeds were in vulnerable state (36%), two in critical state (14%), and three were facing extinction (21%) (Country Report of Vietnam, 2003).

To prevent the extinction of local breeds, Vietnam founded the National Program on Conservation of the Vietnamese Animal Genetic Resources. Under the direction of NIAH, special sub-programs were founded for the protection and conservation of certain domestic animal breeds. In contrast to the majority of conservation programs in other countries, most of the conservation programs implemented by NIAH are conducted on farms with farmer participation (Lemke et al., 2000). There is a growing recognition that preserving local breeds is not only important to ensure the livelihoods of resource-poor farmers depending on those animal breeds; but their conservation is regarded as a national insurance policy, as locally adapted animal genetic resources could become future assets in livestock breeding programs.

According to the FAO Global Databank for Farm Animal Genetic Resources, most Vietnamese local pig breeds are not at risk, and population trends are stable (Mong Cai) or decreasing (e.g. Co, Lang Hong, I, Meo). Only the Bo Xu is considered extinct. However, according to later Vietnamese sources, those data do not reflect real conditions:

I pigs were in the 1970s and 1980s widely kept in the North Vietnamese delta provinces (Ly, 1999) and used to create improved crossbred genotypes (see above). As Mong Cai pigs have progressively replaced the I pig as sow line (Ly, 1999), the I population was at the edge of extinction at the end of the 1970s (Thuy, 1996). It is nowadays in a critical condition, with a decreasing population trend (Country Report of Vietnam, 2003).

The Mong Cai was for a long time the dominating breed in North and Central Vietnam, and its population increased quickly between the 1960s and 1980s. Initially, the government supported its spread and use nationwide. Since 1975, state farms exported Mong Cai to other provinces, to replace lower yielding local pig breeds (Duyet and Duong, 1996). In the course of its ubiquitous distribution, the Mong Cai has mixed with Lang Hong pigs and other local pig breeds (Doanh et al., 1985; Ly, 1999). Although Mong Cai were raised at state farms and widely promoted, the population declined in the early 1990s. After an increase in population size up to 1995, the population is now stable, but the population trend is decreasing, and the degree of crossbreeding in the population increasing (Country Report of Vietnam, 2003). The Mong Cai remains one of the major local sow lines in North Vietnam (Ly, 1999).

In North Western mountainous provinces, the Meo (and related breeds/types) are commonly kept. However, exogenous and indigenous influences may lead to a replacement of local Meo/Ban pigs (Lemke et al., 2002). Among others, the construction of a huge hydropower plant in Son La province and related effects concerning transportation, infrastructure, connectedness to markets, and income of inhabitants, will probably influence the keeping of local Meo/Ban pigs in and around Son La. Meo and Muong Khuong are currently not at risk, while Ban and H'mong are in a vulnerable state. For all four breeds, populations are declining.

The Lang Hong is currently in a critical state, with a decreasing population trend. Ba Xuyen and Thuoc Nhieue are in a vulnerable state, also with declining population. The Phu Khanh faces extinction; and the pure population is decreasing due to mixing with other breeds.

In Central Vietnam, the Soc is not at risk, while the Co is already facing extinction. For both, populations are declining. In the last survey, no pure Co boars were found anymore. The Son Vi faces extinction, the Mini pig of Quang Tri is in a vulnerable state with declining population (Country Report of Vietnam, 2003).

Genetic diversity supports livestock's ability to adapt to many unfavourable environmental factors like diseases and parasites, variations in the availability and quality of feed and water, and extreme climate conditions. Animals in developed countries increasingly belong to a small number of high-performance breeds and hybrids, which have been developed over the last two centuries, strongly influenced by controlled scientifically funded breeding programs. Those animals have been selected for high yields, not for adaptation, and require standardised conditions and high inputs for exploitation of their potential.

Vietnamese local breeds are specific for particular regions, representing a large natural gene pool. Compared to exotic breeds, they show a high genetic diversity, although the Mong Cai breeds do so to a lesser extent. Vietnamese local breeds differ genetically according to their geographic location (Thuy, 2004). However, as the example of Meo/Ban highlights (see above), the definition of local pig breeds in Vietnam is not fully standardised. Indigenous populations are a source of adaptability for specific environmental challenges such as disease and extreme climatic conditions and a reservoir of worldwide genetic diversity for possible future changes in production systems (Olivier et al., 2002). Thuy (2004) showed that Vietnamese indigenous breeds were genetically distant to European pig breeds, had a higher number of alleles per gene locus, wider ranges of allelic sizes, and were genetically more heterogeneous than European breeds. The large genetic distance between the Vietnamese and European breeds could be exploited in crossbreeding, benefiting from heterosis and combination effects for performance traits. Vietnamese pigs harbour also a source of new alleles,

which might be significant for future genetic improvement and of unpredictable economic value. To which degree that prospective source will be maintained, depends on national willingness to pay for conservation programs. This depends on expectations of future benefits. Those expectations will not be based on fairy tales on the overall goodness of local breeds, but only on scientific proofs of special value of specific traits, controlled by specific alleles, and market-backed values of products.

8 CONCLUSIONS

Vietnam owns a considerable variety of local pig breeds. The introduction of pigs and breeds from neighbouring countries (Laos, Cambodia, China) started probably centuries ago, as part of human migration (e.g. Thai and H'mong migrating from China), occupation (China), and trade. The influx of breeds was an important component in the development of Vietnamese local breeds. However, information is lacking on those early phases. The earliest confirmed information on pig breed introduction goes back to the 1920s.

Gene flow in the recent past and present has probably been a net inflow of pigs. Exports (e.g. Vietnamese potbellied pigs to western countries as pets and for scientific use) were negligible. Before 1955 (end of French colonisation) and after 1986 (economic liberalisation), pig imports were directed by commercial interests as the main driving force of gene flow. From 1955 until 1986 the major driving force was the policies of the socialist government, and after 1990 additionally foreign developmental projects, both with the declared aim to benefit the poor farmers, but not always fulfilling their claim.

The inflow of pig breeds to Vietnam consisted of higher-yielding breeds from Europe and America, which were introduced due to their higher performances (in the countries of origin) to improve or replace the low yielding local breeds. Commercial imports consisted of exotic pigs. Current development and poverty alleviation projects at village level usually promote exotics, and only occasionally improved Vietnamese breeds (e.g. promotion of Mong Cai by *Vétérinaires sans frontières*, Phu Tho).

Information on pig gene flow to and within Vietnam is limited, due to the restricted information policy of both international breeding companies and Vietnamese official sources, but also due to the decentralised nature of pig breed import and distribution.

The introduction of exotic pigs was supported by the decentralised nature of the Vietnamese breeding system. Centralised coordination of breeding measures is not well developed, and centralised measures fulfilled their aims only partly. However, the impact of the state-run breeding stations has been considerable; and the advanced use of AI has strongly supported the introduction of exotic genetics to the smallholder producer level.

The influx of exotic breeds has positively influenced output and efficiency of pork production in Vietnam, while the local pig populations have been reduced. Today, pigs of various crossbreeding degrees are widely distributed. Most indigenous breeds show declining population trends, and the majority of local breeds are in a vulnerable or critical condition or even facing extinction. Conservation measures of Vietnamese institutions follow suitable approaches (in-situ conservation on-farm). However, due to shortcomings in set-up and implementation, they may not successfully preserve local pig breeds. National decisions and the willingness to pay for conservation programs depend on expectations for future benefits, which need to be based on scientific proofs of the value of specific traits, and market-backed valuations of products.

Research results indicate a considerable production potential of local pig breeds especially under low-input conditions, favourable adaptation traits, and genetic peculiarities, differentiating them from the European breeds. Local pig breeds are a significant component of the Vietnamese and worldwide biodiversity, are important for resource-poor farmers in Vietnam who depend on local breeds to ensure their livelihoods, and for future breeding measures

utilising e.g. favourable adaptation traits. On the other hand, exotic pigs have become increasingly available and accessible for farmers in Vietnam and have enabled them to produce pork with increasing efficiency. Whether pig-keeping resource-poor smallholders in remote and mountainous regions can be integrated in this process, or if they can set up niche production with local pig breeds, remains to be clarified by further investigations. Further investigations are required to define local pig breeds, further characterise their genetic specificities, and to comparatively evaluate their performances under standardised conditions.

9 REFERENCES

- ACIAR 2004. Research that works for developing countries and Australia. Project: Breeding and feeding pigs in Australia and Vietnam.
- Anh, N. Q. and H. S. Dung. 1994. Lon Meo-Nghe An. Meo pigs-Nghe An. p. 105. In: Ket qua nghien cuu bao ton quy gen vat nuoi 1990-1993 (Results of the research on conservation of domestic animal genetic resources 1990-1993). NIAH Ministry of Science, Technology and Environment; Ministry of Agriculture and Industry, Hanoi, Vietnam. (in Vietnamese).
- ASPS. 2002. Livestock policy briefs for Vietnam. MARD - DANIDA: Agriculture Sector Programme Support ASPSP; Agrifood Consulting International ACI, Hanoi, Vietnam.
- Astroem H. 2000. The Mongcai pig: digestibility studies of fibrous feeds, and a survey of smallholder production systems in two agro-ecological zones of Vietnam. Swedish University of Agricultural Sciences, Sweden.
- Bosma, R. H., R. L. Roothaert, P. Asis, J. Saguinhon, L. H. Binh, and V. H. Yen. 2003. Economic and social benefits of new forage technologies in Mindanao, Philippines and Tuyen Quang, Vietnam. Centro Internacional de Agricultural Tropical (CIAT), Los Baños, Philippines.
- Country Report of Vietnam for FAO's State of the World's Animal Genetic Resources. 2003.
- Doanh, P. H. 1985. Ket qua khao sat, giam dinh va dieu tra giong lon o mien Nam (Research results on pig breeds in the South). p. 7. In: NIAH (ed.). Studies on technique and science 1969-1979. Agricultural Publishing House. Hanoi, Vietnam (in Vietnamese).
- Doanh, P. H. 1994. Bao ton von gen quy cua giong lon Mong Cai (Conservation of the valuable gene resource of the Mong Cai breed). p. 30. In: NIAH (ed.). Ket qua nghien cuu bao ton nguon gene vat nuoi o Viet Nam (Results of livestock genetic conservation in Vietnam). Agriculture Publishing House, Hanoi (in Vietnamese).
- Doanh, P. H. et al. 1985. Mot so dac diem ve tinh nang san xuat cua giong lon noi (Production performance of local pig breeds). p. 10. In: Tuyen tap cong trinh nghien cuu chan nuoi 1969-1984 (Research in animal husbandry 1969-1984). NIAH. Hanoi, Vietnam. (in Vietnamese).
- Doanh, P. H. and D. H. Luan. 1985. Ket qua nghien cuu dac diem sinh hoc va tinh nang san xuat cua mot so giong lon ngoai (Research results on the production performance of some exotic pig breeds). p. 19. In: NIAH (ed.). Tuyen tap cong trinh nghien cuu chan nuoi 1969-1984 (Research in animal husbandry 1969-1984). Hanoi, Vietnam. (in Vietnamese).
- Doanh, P. H. and T. T. Thong. 1985. Ket qua nghien cuu lai tao giong lon moi DBI-81 va BSI-81 (Research results on the new crossbred pig breeds DBI-81 and BSI-81). p. 28. In: Tuyen tap cong trinh nghien cuu chan nuoi 1969-1984 (Research in animal husbandry 1969-1984). Hanoi, Vietnam. (in Vietnamese).
- Dong, N. V. and P. S. Tiep. 2002. Ket qua phat trien giong lon Mong Cai o Tuyen Quang. (Developing the Mong Cai pig in Tuyen Quang province). Khoa hoc ky thuat chan nuoi (Information on science and technologies in animal production) 5: 14-19 (in Vietnamese).

- Duc, N. V., B. P. Kinghorn, and H. U. Graser 1997. Studies on some Production and Carcass Traits of Mong Cai and Their Crosses in North Vietnam. p. 185. In: Proceedings of the Association for the Advancement of Animal Breeding and Genetics. Proceedings of the 12th Conference. RSL Complex and Western Plains Zoo Dubbo, NSW, Australia; April 6 to 10, 1997. Australia.
- Duc, N. V., G. H. Tuyen, and D. C. Tuan. 2004. Mot so dac diem co ban cua giông lon Tap Na (Basic characteristics of the local Tap Na pig breed in Thong Nong, Cao Bang). Download from http://www.vcn.vnn.vn/qg/quygen2004/qg_20_11_2004_2.htm at December 20, 2004. (in Vietnamese).
- Dung, T. V. 2002. The current status of veterinary service in Vietnam and development tendency aims to commercial animal husbandry in the first decade of 21st century. Workshop organized by NIAH and CIRAD, Hanoi, October 24-25, 2002. Hanoi, Vietnam.
- Duy, P. V., N. X. Hoan, and V. T. Binh. 2001. Ket qua buoc dau xay dung mo hinh nuoi lon nai ngoai giông Yorkshire trong dieu kien chan nuoi nong ho o Hop Tien-Nam Sach-Hai Duong (Creating a model to raise Yorkshire sows under smallholder conditions in Hop Tien, Nam Sach, Hai Duong province). In: Bao Cao khoa hoc chan nuoi thu y 1999-2000, phan chan nuoi gia suc (Scientific report on veterinary medicine and animal husbandry 1999-2000, animal husbandry part). pp. 67-82. Hanoi, Vietnam. (in Vietnamese).
- Duyet, H. N. and N. K. Duong. 1996. Pig breeding in central Vietnam and its improvement. In: Exploring approaches to research in the animal sciences in Vietnam: A workshop held in the city of Hue, Vietnam 31 July – 3 August, 1995. Canberra, Australia.
- FAO. 1999. Livestock in food security in Vietnam. RAP Publication. FAO. Bangkok, Thailand.
- FAO. 2004. DAD-IS. Download from <http://www.fao.org/dad-is> at November 29, 2004.
- General Statistical Office Vietnam. 2000. Statistical data of Vietnam. Agriculture, forestry and fishery, 1975 to 2000. Statistical Publishing House. Hanoi, Vietnam.
- Hai, L. T. 1994. Lon Thuoc Nhieu, mot nguon gene quy o dong bang song cuu long (Thuoc Nhieu pig, a valuable gene resource in the Mekong Delta). p. 42. In: Ket qua nghien cuu bao ton nguon gene vat nuoi o Viet nam (Results of livestock genetic conservation in Vietnam). Agriculture Publishing House, Hanoi, Vietnam. (in Vietnamese).
- Hai, L. T. 1996. Social features and the development of swine production in Vietnam. ACIAR Proc. 68: 186 – 189.
- Hai, L. T. and N. H. Nguyen. 1997. Outlines of pig production in Vietnam. Pig News and Information. 18: 91 – 94.
- Hoa, P. T. T. forthcoming. Phenotypic and Biometric Characterisation of Autochthonous Vietnamese Ban Pigs. MSc thesis. University of Hohenheim, Germany.
- Hot, V. T. 1982. Mot so dac diem ngoai hinh va sinh truong cua cac giông lon o Tay nguyen (Features of outer appearance and performance of pig breeds in the Central Highlands). Khoa hoc va ky thuat nong nghiep (Agricultural technique and science magazine) 13: 124 – 126. (in Vietnamese).
- Huy, V. S., L. V. Ly, and H. K. Giao. 1996. Mot so ket qua nghien cuu buoc dau ve sinh truong sinh san cua dan lon ngoai nuoi tai xi nghiep lon giông Dan Quyên Thanh Hoa (Performance of exotic pig breeds raised in a breeding enterprise in Thanh Hoa prov-

- ince). p. 24. In: Results of technical and scientific studies on animal husbandry 1994-1995. Agricultural Publishing House, Hanoi, Vietnam. (in Vietnamese).
- Huyen, L. T. T. 2004. Analysis of animal production systems in H'mong villages of Northern Vietnam. MSc thesis. University of Hohenheim, Germany.
- IFAD. From http://www.ifad.org/evaluation/public_html/eksyst/doc/profile/pi/vn.htm, April 1, 2005.
- Khanh, N. and D. D. Hien. 1963. Buoc dau khao sat ve giong lon I (First research on the I). Khoa Hoc va Ky Thuat Nong Nghiep (Science and Technique in Agriculture) 11:675-683. (in Vietnamese).
- Konrad-Adenauer-Stiftung. Vietnam Office. From <http://www.kas.de/proj/home/home/72/2/>, download at April 1, 2005.
- Lemke, U., L. T. Thuy, A. Valle Zárate, and B. Kaufmann. 2000. Characterisation of a model for conservation of autochthonous pig breeds on smallholder farms in North Vietnam. Project report for GTZ/ Sectoral Project: Tropical Ecology Support Program TOEB. Stuttgart, Germany.
- Lemke, U., L. T. Thuy, A. Valle Zárate, and B. Kaufmann. 2002. Characterisation of smallholder pig production systems in mountainous areas of North Vietnam. Deutscher Tropentag 2002. October 9 to 11, 2002, Kassel-Witzenhausen, Germany.
- Lemke, U., L. T. Thuy, B. Kaufmann and A. Valle Zárate. Forthcoming. Evaluation of smallholder pig production systems in North Vietnam considering input, management, output and comparing economic and biological efficiency.
- Lich, L. B. 1996. Livestock production of Vietnam in the passing year and development orientations toward 2000. MARD & VUSTA – National Seminar on Animal Science and Development to the year 2000. 26 – 28 November, 1996. Animal Husbandry association of Vietnam, Hanoi, Vietnam.
- Lich, L. B. and D. K. Tuyen. 2001. Livestock production development in the Northern provinces of Vietnam. Khoa hoc ky thuat chan nuoi- Information of science and technologies on animal production. Hanoi, Vietnam. (in Vietnamese).
- Loc, N. T., B. Ogle, and T. R. Preston. 1996. Pig production in Central Vietnam: results of a participatory rural appraisal survey and on-farm feeding trials with protein supplementation of traditional diets. Integrated farming in Human development. Proceedings of a workshop. March 25 – 29, 1996. Tune Landboskole, Denmark.
- Luong, T. V. and H. Gian. 1999. Kha nang sinh san cua lon Nai F1 (Yorkshire x Mong Cai) nuoi o ho gia dinh tai huyen yen dinh, Thanh Hoa (High reproduction of Yorkshire x Mong Cai sow raising in Yen Dinh, Thanh Hoa province). Tap chi chan nuoi (Animal husbandry magazine) 4 (25) 14 – 17 (in Vietnamese).
- Ly, L. V. 1993. Note on the local animal genetic resources and their conservation in Vietnam. Animal genetic resources information. UNEP, Rome, Italy.
- Ly, L. V. 1996. A review of animal science research in Vietnam. In: Exploring approaches to research in the animal sciences in Vietnam: A workshop held in Hue, Vietnam 31 July – 3 August, 1995, Canberra, Australia.
- Ly, L. V. 1999. Chuyen khao: Bao ton nguon gen vat nuoi o Viet nam (Animal genetic conservation in Vietnam). Agriculture Publishing House, Hanoi, Vietnam. (in Vietnamese).

- Ly, L. V. 2000. The development of a sustainable animal production system based on the advantage of tropical agriculture. Workshop-seminar "Making better use of local feed resources" January, 2000. SAREC-UAF, Hanoi, Vietnam.
- Ly, L. V. and T. T. B. Duyet. 2000. Mong Cai pig breed – a good genetic resource in Vietnam. Hanoi, Vietnam. Not published.
- Minh, L. H. 2000. Ket qua 6 nam (1992-1998) thuc hien Mong Cai hoa dan lon nai nen o Tuyen Quang (Six years Mong Cai-ization in Tuyen Quang province). Tap chi chan nuoi (Animal husbandry magazine) 2:16-18. (in Vietnamese).
- Molenat, M. and T. T. Thong. 1991. La production porcine au Viet Nam et son améiioration. WAR 68:26-36. (in French).
- NIAH. 1985. Ket qua nghien cuu chan nuoi lon (Research on pig husbandry). p. 7. In: Research on technique and science from 1969-1979. Agricultural Publishing House, Hanoi, Vietnam. (in Vietnamese).
- NIAH. 1997. The national policy on conservation and use of indigenous animal genetic resources in Vietnam. GCP/RAS/144/JPN project. Hanoi, Vietnam.
- NIAH. 2003. Livestock research and development towards 2010. A strategic plan for the National Institute of Animal Husbandry (NIAH), Vietnam. Information on science and technologies in animal production. National Institute of Animal Husbandry. Hanoi, Vietnam.
- NIAH. 2004. Ket qua buoc dau nghien cuu cac cong thuc lai giao lon nai i va lon duc ngoai (Results of crossbreeding between I sows and exotic boars in Thanh Hoa province). Download from http://www.vcn./qg/quygen2004/qg_20_11_2004_2.htm, December 20, 2004. (in Vietnamese).
- Nhien, T. 2004. UK holds pig breeding conference in Vietnam. Vietnam Economy. http://www.vneconomy.com.vn/eng/article_to_print.php?id=041208104058, April 1, 2005.
- Olivier, J. J., S. Moyo, H. H. Montaldo, W. Thorpe, A. Valle Zárate, and K. R. Trivedi. 2002. Integrating genetic improvement into livestock development in medium-to low-input production systems. 7th World Congress on Genetics Applied to livestock production. August 19-23, 2002. Montpellier, France.
- Peters, D. 1998. Improving small-scale pig production in northern Vietnam. WAR 91: 2– 12.
- Pig International. 1998. Foreign investors speed Vietnam's transition. Volume 28(1): 25 – 27.
- Quac, N. K., T. V. Phung, and G. Hussain Jaffar. 1996. Study on the physiological characteristics and reproduction of crossbred-sows F1 (Yorkshire x Mong Cai). Agricultura Tropica et Subtropica. Universitas Agriculturae Praga 29: 59 – 64.
- Rodríguez, L. J., T. R. Preston, and F. Dolberg. 1996. Participatory Rural Development: "Experiences in Binh Dien and Xuan Loc villages in Central Vietnam". Livestock Research for Rural Development 8: 1 – 40.
- Singh, D. N., C. P. McPhee, and J. S. Kopinski. 1996. Helping to improve pig production in Vietnam. ACIAR Proc. 68: 176 - 181. Canberra, Australia.
- Tang, D. X. and N. N. Cuong. 1994. Ket qua buoc dau giu quy gen lon I Thanh Hoa (Results of genetic conservation of I pigs in Thanh Hoa). In: NIAH (ed.) Ket qua nghien cuu bao ton nguon gene vat nuoi o Viet nam (Results of the livestock genetic conservation in Vietnam). Agriculture Publishing House, Hanoi, Vietnam. (in Vietnamese).

- Thien, N. 2002. Ket qua nghien cua va phat trien lon lai co nang suat va chat luong cao o Viet nam (Research results on developing crossbred pigs with high quality and high yield in Vietnam). p. 82. In: NIAH (ed). Vien Chan nuoi 50 nam xay dung va phat trien (NIAH - 50 years of development). Agriculture Publishing House, Hanoi, Vietnam. (in Vietnamese).
- Thien, N., P. H. Doanh, and P. T. Van. 1992. Kha nang sinh san cua cac giong lon Landrace, Dai Bach, DBI-81 va cac cap lon lai huong nac (Reproductive performance of Landrace, Large White, DBI-81 and other lean meat hybrid pigs). p. 17. In: Results of technical and scientific studies on animal husbandry from 1985-1990. Agricultural Publishing House, Hanoi, Vietnam (in Vietnamese).
- Thien, N., P. T. Van, N. K. Quac, P. H. Doanh, and P. N. Le. 1995. Ket qua nghien cuu cac cong thuc lai giua lon ngoai va lon Vietnam (Studies on crossbreeding between exotic and Vietnamese pig breeds). Selection of scientific works on animal production 1969-1995. Hanoi, Vietnam. (in Vietnamese).
- Thien, N., P. T. Van, P. N. Le, P. H. Doanh, N. Nghi, N. K. Quac, and V. T. Hot. 1996. Improvement of productivity and meat quality of pigs in the Red River Delta region by crossbreeding. ACIAR, Canberra, Australia.
- Thong, T. T. 1996. Animal husbandry advances which contributed to major livestock development in Vietnam. In: Exploring approaches to research in the animal sciences in Vietnam: A workshop held in Hue, Vietnam 31 July – 3 August, 1995, Canberra, Australia.
- Thong, T. T., L. T. Hai, and V. A. Quac. 1996. Research wok on pig production in the Mekong Delta. ACIAR Proc. 68: 56. Australia.
- Thu, A. 2004. Lon Muong Khuong se xuong nui. Lao Dong newspaper vol. 312 (in Vietnamese).
- Thuong, N. V. 1985. Vien chan nuoi, 15 nam nghien cuu khoa hoc va san xuat 1969-1984 (NIAH – 15 years of research and production 1969-1984). NIAH, Hanoi, Vietnam (in Vietnamese).
- Thuy, L. T. 1999. Lon Meo Nghe An (Meo pigs in Nghe An). NIAH, Hanoi, Vietnam. Not published (in Vietnamese).
- Thuy, N. T. 1999: Desk-study on animal health field services in Vietnam (SVSV ALA/96/20). Ministry of Agriculture and Rural Development, European Commission, Vietnam.
- Thuy, N. T. D. 2004. Genetic diversity and distances of Vietnamese and European pig breeds analysed with microsatellite loci. Dissertation. Shaker Verlag. Aachen, Germany.
- Tjällden, U. 1999. Indigenous breeds of domestic animals in northern Vietnam. Opinions of, and attitudes towards, local breeds among farmers. Minor Field Studies International Office, Swedish University of Agricultural Sciences, Uppsala, Sweden.
- To, L. V. and L. D. Duc. 1967. Giong lon Meo nuoi o Dong Bang- Nghe An (Raising Meo pigs in Dong Bang, Nghe An province). Tap chi khoa hoc ky thuat nong nghiep nam 1967 (Journal of Science and Technology in agriculture 1967) 17: 154 – 158 (in Vietnamese).
- TOPIGS. Download from <http://www.topigs.ca/pbcd.htm> at April 1, 2005.
- Truc, D. X., N. Thien, N. H. Cuong, T. V. Linh, P. T. Van, P. S. Tiep, N. H. Tao, and P. S. Lang. 2003. So tay ky thuat chan nuoi lon trang trai (Handbook of the technique in

- pig husbandry on farm). Agricultural Publishing House, Hanoi, Vietnam (in Vietnamese).
- Tung, D. X. 1999. Roles of livestock on smallholder farming systems in northern provinces of Vietnam. Agricultural University of Norway; Centre for International Environment and Development Studies, Norway.
- Valle Zárate, A., B. Kaufmann, U. Lemke, L. T. Thuy, L. V. Ly, and N. D. Vang. 2003. Efficiency of smallholder animal husbandry depending on intensity of management and genetic potential of livestock in mountainous regions of Northern Vietnam. Interim report to DFG, Germany. Universität Hohenheim, Stuttgart, Germany.
- Vang, N. D. 2002. Livestock Development of Vietnam towards 2010: prospect and challenges. p. 71. In: NIAH (ed.) *Vien Chan nuoi 50 nam xay dung va phat trine* (National Institute of Animal Husbandry - 50 years of development). Agricultural Publishing House, Hanoi, Vietnam (in Vietnamese).
- Xuan, V. T., L. Th. Hai, and Ch. B. Loc. 1995. Research priorities for improving animal production by agro-ecological zone in Vietnam. p. 197. In: IRRI (ed.) *Global Agenda for Livestock Research. Proceedings of the consultation for the South-East Asia region, 10 - 13 May 1995*, IRRI, Phillipines.

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