Swine Genetic Improvement Program in China

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Introduction

Pork is the major meat for Chinese people. It made up 64.9% of the total meat consumed in 2004. The demand for meat in China is still growing and pork consumption is continuously increasing (47.02 million tons in 2004). Corresponding with the increase in pork production the breeding stock business has shown phenomenal growth over the past 10 years. There has been a massive change in breeds used at the commercial level. New and modern swine farms have been started in many locations across the country. The technical segment has been stimulated and developed by the demand for high quality meat. Foreign genetics are being used to upgrade the quality and efficiency of the traditional breeds. A concern to some of pig breeding farms in China is a lack of attention of performance testing and the selection program based on the testing results. The National Swine Breeding Improvement Program was developed to facilitate the performance testing program and to insure the long term success and sustainable development of seedstock business in China. This program requires the cooperation between scientists (university), administrators (government) and producers (breeding farm).

History of pig breeding in China

The history of the pig industry in China may be traced back to the early and middle period of the Neolithic Age. Skeletons of a domestic pig about 9000 years old was found in the relics of Zengpiyan, Guilin and Guangxi. Among the unearthed animal skeletons of about 7000-8000 years ago in the relics found in Hemudu, Yuyao and Luojiajiao, Tongxiang of Zhejiang Provinces, skeletons of domestic pigs constituted a large proportion. Along with the pig skeletons pottery pigs were unearthed. This proves that pig raising had developed quite a long time ago. During the Han Dynasty the small-ear pig from Southern China was introduced to the Roman Empire. Up to the seventeenth and eighteenth centuries, the Chinese pig (Guangdong pig variety) was introduced into the western countries[1].

Swine improvement programs in China underwent considerable change from the beginning of the last century. The development may be summarized below[2,3,4].

- At the turn of the last century, western breeds were brought to the Foreign Concessions, in Shanghai by the British, in Qingdao by the Germans, later by the Russians to Heilongjiang and still later by the Japanese to the Northeast.
- Early 50's, no coordinated breeding strategy existed due to the lack of funding and limited availability of pure lines. However, successful products were used to form the beginning of new lines.
- Since the 50's state owned breeding farms imported pigs to cross with local breeds as a means to increase productivity from which commercial products and synthetic lines were

made. The majority of the crossing were one-way crossing, the local breed as basic stock topped by the Soviet Large White(1950-1960) and Landrace (1970-1980).

- Between 1979 and 1984 10 indigenous breeds were evaluated for 1) reproductive traits, 2) growth and development, 3) physiological and biochemical criteria, 4) breeding and genetics including the estimation of genetic parameters, 5)meat quality, 6) antistress properties and 7) behavior[3]. Most of the studies compared the indigenous breeds with Landrace. It provided a quantified, comparative assessment of breed genotypes. Possibly the first of its kind in porcine literature.
- From 1981 to 1986, compilation of a Chinese Swine Register at the federal and provincial levels with 48 pig breeds in total officially approved.
- From 1950 to 1990's, about 30 new breeds (like Hubei White, Zhejiang White, Beijing Black, etc.) have been recognized by the federal or provincial governments.
- From 1978 to 1980's, one feature of the "Sixth Five Year Plan" for animal husbandry was the lean swine project which lead to the development of cross breeding programs to produce commercial pigs that satisfied the demand for lean meat. Such as Duroc x Hubei White, Duroc x Zhejiang White, Duroc x Sanjiang White, Duroc x Landrace x Beijing Black, Landrace x Large White x Taihu, etc.
- Since 1990's, the two-way cross was transformed into three-way crosses for the technical commercial pig producers resulting in greater variations in visual type and performance.
- In 1990's, local pig breeds conservation program was initiated. The Ministry of Agriculture identified certain number of indigenous breeds for preservation. Additionally the provincial and county governments began preservation programs for local breeds.
- In 1993 three pig breed associations (for Landrace, Large White and Duroc) were established. They might be merged to form a single association – Chinese Pig Breed Association.
- In 2000 the National Swine Genetic Evaluation Protocol was issued by the General Station of Animal Husbandry and Veterinary Services of Ministry of Agriculture.
- In 2002 the results for the first national genetic evaluation using on-farm data was published by the General Station of Animal Husbandry and Veterinary Services of the Ministry of Agriculture.

Issues related to the National Swine Genetic Improvement Program (NSGIP)

NSGIP is an extensive on-farm based genetic improvement program which combines on-farm testing for reproduction and growth traits with the potential for an across-herd genetic evaluation at the regional and/or national level. It is an essential force in driving genetic improvement in most of the breeding farms. After the establishment of genetic links between herds it allows for the identification of the superior genetic lines within the big "Provincial Nucleus" or even "National Nucleus". This program was initiated by the China Canada Lean Swine Project, of which two members of the National Genetic Evaluation Expert Team (Dr. Xuewei Li and Dr. Yan Fu) served as consultants.

1. NSGIP objectives

- To meet the increasing demand for better breeding animals and reduce the importation of breeding pigs.
- Increase the rate of genetic improvement through better application of genetic selection of existing breeding stock.
- Assuring long term success and sustainable development of the breeding stock business in China.

2. National Advisory Committee for NSGIP

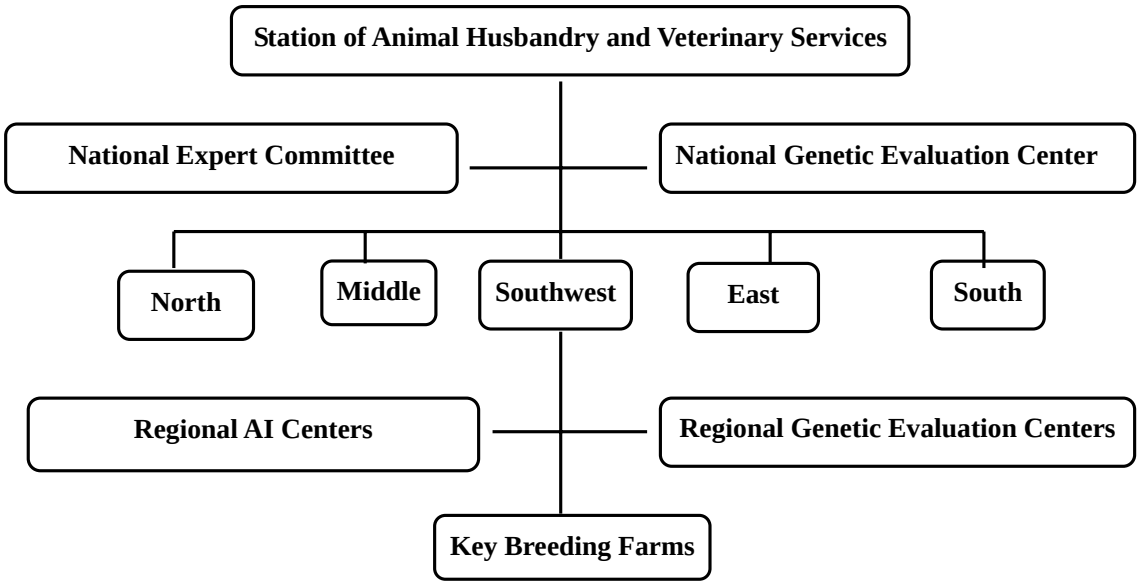
In 1997 The General Station of Animal Husbandry and Veterinary Services of the Ministry of Agriculture nominated a National Genetic Evaluation Expert Team (NGEET) of five geneticists:
Dr. Yaosheng Chen, Professor from South China Agricultural University in Guangzhou
Dr. Qing Zhang, Professor from China Agricultural University in Beijing
Dr. Aiguo Wang, Professor from China Agricultural University in Beijing
Dr. Xuewei Li, Professor from Sichuan Agricultural University in Yaan
Dr. Yan Fu, Professor from Zhejiang University in Hangzhou
Mr Hailiang Liu, Deputy Director of the Office for Animal and Poultry Breeds being representative of the Ministry of Agriculture served as coordinator of the Expert Team.

The NGEET was expanded in 2003 and formed a National Advisory Committee. Six people were added to the above-mentioned group:
Dr. Jiaqi Li, Professor from South China Agricultural University in Guangzhou
Dr. Lixian Wang, Professor from Chinese Academy of Agricultural Sciences
Dr. Yuchun Pan, Professor from Shanghai Jiaotong University in Shanghai
Dr. Minggang Lei, Associate Professor from Huazhong Agricultural University in Wuhan
Dr. Chong Wang, Associate Professor from South China Agricultural University in Guangzhou
Dr. Xiaohong Liu, Provincial Department of Agriculture, Guangdong

Duties of this committee are to provide recommendations of breeding program, supervision of data collection procedures, and oversight of genetic evaluation. The members of the National Advisory Committee get together several times a year to discuss issues related to the NSGIP.

3. Structure of National Swine Genetic Improvement Program

The NSGIP has developed an efficient structure and system to carry out the program. The regional centers, such as in South (Guangdong), Southwest (Sichuan), Middle (Henan) and North (Beijing) have been established.



4. National Standards

National standards are developed or used for the NSGIP:

- Criteria and certification for breeding farms
- Performance testing protocol
- Trait definition and measurements
- Database format
- Nutrition program
- Health program
- Management program
- Computer software (GBS)

5. Pig ID

Maintaining the exact identification of an animal throughout its lifetime and its identity to its parents is important. National Swine Genetic Improvement Program requires that all the participating breeding farms have a national unique animal ID system. The components of a unique animal ID include the breed of pig, birth date, farm of origin, litter number at the farm and the individual pig ID within its litter. The recommended ID system consists of 15 numbers and letters:

- 1-2: two letters for breed of pig, like DD for Duroc, LL for Landrace, YY for Large White and HH for Hampshire. 2-way crossing sow will use first letter for sire and second letter for dam, e.g. LY is cross of Landrace sire and Large White dam;

- 3-6: four letters for the name of breeding farm;
- 7: number or letter for subunit of a breeding farm (number from 1 to 9 will be first used, then the letter A to Z. For farms without subunits the number 1 will be used);
- 8-9: two numbers for birth year;
- 10-13: four numbers for litter's number in the farm;
- 14-15: two numbers for piglet's number within a parity.

For instance, pig with the ID "DDXXXX299000101" is the first Duroc pure breed pig from first parity in 1999, in the second subunit of the farm XXXX.

6. Definition of key traits

The national genetic evaluation for pig breeding farms relies on the standardization of performance testing on farm. 15 traits are recommended for on farm measurements. The NSGIP requires three basic traits, which all the participating farms have to measure: 1) age at 100 kg live weight, 2) backfat thickness at 100 kg live weight, 3) number pigs born per litter. Farms are encouraged to measure additional traits if labor is available to correctly measure these.

Optional measurements:
For growing performance: 4) age at 50 kg live weight, 5) feed conversation (It is also possible that average daily feed intake and feed conversion are calculated on a pen basis);

For reproduction performance: 6) number pigs born alive per litter, 7) litter weight at 21 days, 8) farrowing interval, 9) age at first farrowing;

For carcass and meat quality: 10) loin eye area, 11) proportion of ham, 12) muscle pH, 13) meat color, 14) drip loss, 15) marbling score.

Sow productivity is significantly affected by management and environment, its improvement is more difficult and requires greater organization than improvement of growth performance. Therefore sow productivity is not yet included in the genetic evaluation program and conformation scoring system will be developed later.

7. Number for performance testing

The value of testing for genetic improvement purposes is greatly enhanced by testing all of the individuals in the herd. Most pig breeding farms in China sell breeding stock at early ages (30-40kg). NSGIP requires a minimum number of pigs for performance testing:
- Before 50kg: 2 male and 3 female from every litter
- At 100kg: at least 1 male and 1 female from every litter

10. Database format

At the heart of the NSGIP is its database of pig performance records and genetic evaluation. Most breeding farms use a production data computer program for herd monitoring, in which all the performance testing data should be recorded. The participating farms were asked to

transfer their data information via internet to the regional center and then to the national center.

Software to calculate EBVs and for data management can be obtained from the NSGIP Committee. In case breeding farms use the other software programs, they are required to follow the NSGIP database format which can be found from table 1 to table 4.

Table 1. Individual information

Word string	Pig ID	breed	Sex	Birth date	ID of sire	ID of dam	Note
name	ID	BREED	SEX	BDATE	SIRE	DAM	NOTE
type	Word	Word	Word	Date	Word	Word	Note
length	15	2	1	8	15	15	—
Point position	—	—	—	—	—	—	—

Table 2. Growing performance

Word string	Pig ID	Days to 50kg		Days to 100kg					30-100kg Feed efficiency	Note
		Weigh date	Weight	Weigh date	Weight	Backfat	Loin eye area or thick-ness	Ultra-sonic machine		
Name	ID	DATE50	WT50	DATE100	WT100	FAT	LMA	EQ	FCR	NOTE
Type	Word	Date	Number	date	Number	Number	Number	Word	Number	Note
Length	15	8	5	8	6	5	5	1	4	—
Point position	—	—	2	—	2	2	2	—	2	—

Table 3. Carcass and meat quality

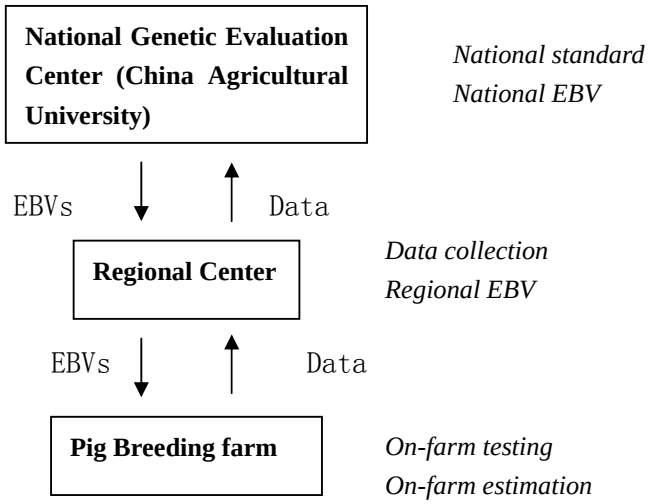
Word string	Pig ID	Date of slaughter	Live Wt	Carcass				Meat quality				Note
				Carcass weight	% of ham	Back-fat	Loin eye area	pH-value	Color	Drip loss	Marb-ling	
Name	ID	SDATE	SWT	CWT	HAM	CFAT	CLMA	PH	COLOR	DRIP	MARBL	NOTE
Type	Word	Date	No.	No.	No.	No.	No.	No.	No.	No.	No.	Note
Length	15	8	5	5	5	5	5	4	3	5	3	—
Point position	—	—	2	2	2	2	2	2	1	2	1	—

Table 4. Reproduction performance

Word string	Pig ID	Breed-ing date	Service ID*	Type of mating	Parity	Farrowing record						Foster		21days		Note
						date	Total no. born	No. live	No. still-born	Defor-mity	No. mum-miies	Out	In	No.	Litter weight	
Name	ID	MDATE	BOAR	Type	Parity	FDATE	TNB	NBA	SBN	ABN	MUM	OUT	IN	LN21	LWT21	NOTE
Data type	Word	Date	Word	Word	No.	Date	No.	No.	No.	No.	No.	No.	No.	No.	No.	Note
Length	15	8	16	1	2	8	2	2	2	2	2	2	2	2	5	—
Point position	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—

9. Information System

The data collected from participating farms is transferred via the internet to the regional centers and then to the server at the China Agricultural University. The EBVs from the National genetic Evaluation Center or from the regional center will be sent to the breeding farms.



At the moment the NSGIP does not have a full-time geneticist and programmer /analyst to run the national evaluation system. Instead of full-time staff the Ph.D.-students at China Agricultural University have worked temporally for the national program.

10. BLUP Model for Genetic Evaluation

For required basic traits, age at 100 kg and backfat at 100 kg, a multi-trait model will be used:
Y = hyss + l + g + a + e, or y = hyg + l + g + a + e
Where Y = an observation of a trait
hyss = fixed effects of herd-year-season-sex
l = random litter effect
g = phantom group effect
a = random individual additive genetic effect
e = residual error

- The correlations for backfat and age are based on Canadian parameters.
- If 70 day weights used, use phenotypic correlation at first.
- For on-farm evaluation remove phantom groups.
- Seasons calculated by quarter (3 months) if management groups not available.

For litter size:
Y = hys + l + a + p + e
Where Y = an observation of litter size
hys = fixed effects of herd-year-season
l = random litter effect
a = random individual additive genetic effect
p = permanent maternal environmental effect
e = residual error

Pre-adjust for: 1) parity, 2) age at farrowing within parity (covariate), 3) breed of sire, 4) type of mating (AI vs. natural service), 5) age at weaning of the previous litter (optional), 6) weaning to conception interval for the previous litter (optional).

Other models to be developed later:
- Define 2 key conformation traits (such as leg or muscle scoring) if deemed useful
- other traits as market demands

Regional EBVs are calculated in specific regional centers based on the requirements of the on farm selection and mating programs. EBVs are also calculated regularly for all participating farms at national center at China Agricultural University.

11. Connectedness and Al stations

Some challenges lie ahead on how genetic links (connectedness) will be established, how more breeding farms will be attracted to participate in the “Provincial Nucleus” or “National Nucleus” program. If there are few or no genetic exchange between a herd and remainder of the tested population, the EBVs of animals in that herd cannot be compared accurately to the EBVs estimated in other herds, even when they have a high repeatability, because of the lower degree of connectedness[5]. A minimum of 10% of matings in participating herds should

come from common sires (minimum level of connectedness=5%). AI is an essential step to establish the links between breeding farms. The NSGIP suggested that government owned AI centers both in southern and northern China should be established for dissemination of superior genetics to different farms. It is an essential technology for rapid and lasting genetic improvement. The AI centers help the NSGIP to create genetic ties and connectedness, which are essential for accurate across herd comparisons. The boars for the stud are selected from the national genetic evaluation program and/or imported. The use of semen from genetically superior boars is done in a manner that does not risk health and adds to the genetic improvement of the participating farms.

12. Within farm genetic improvement program

National Genetic Improvement Program, especially the regional center programs focus on the participating farms' genetic improvement rather than across farm programs. In many provinces NSGIP committee members have combined their national responsibilities with provincial key projects. Working with the university extension services this is providing good implementation of BLUP selection technology to the participating farms.

13. Seminars and training programs

The NSGIP annual programs consist of workshop and training sessions. 2-4 seminars or training programs are organized every year.

- Training of farm staff and advisors
  focus on understanding EBVs, why and how to use them
- Training on-farm ultrasonic measurement technicians
- Training technicians in data entry

14. Accuracy of backfat measurement

Ultrasonic measurement is a viable method to estimate backfat thickness and loin muscle area in the live pig. However accuracy of ultrasonic estimates are technician dependent. Some regional centers of the NSGIP have implemented training programs to standardize ultrasonic measurement. The Participants were however not evaluated and certified. To standardize the measurement and improve accuracy, the NSGIP will start certification programs for utilizing real-time ultrasound.

15. Genetic research

An important part of the NSGIP is research. Research projects are in molecular genetics, meat and carcass quality, genetic evaluation, selection methods, etc. Genomics research will also open up new directions for swine testing programs. Therefore, the NSGIP will also coordinate with university molecular genetic research programs for developing and integrating marker assisted selection in the national program.

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