Genomic Breeding Technology in Livestock

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Regulation for genomic breeding - **Animal Industry Act Article 17**

The competent authority may dispatch inspector to examine or test **the breeding flock,** breeding stock, facilities, pedigree registry and related records of breeders, and the breeders shall not evade, interfere with or object to such examination or testing.

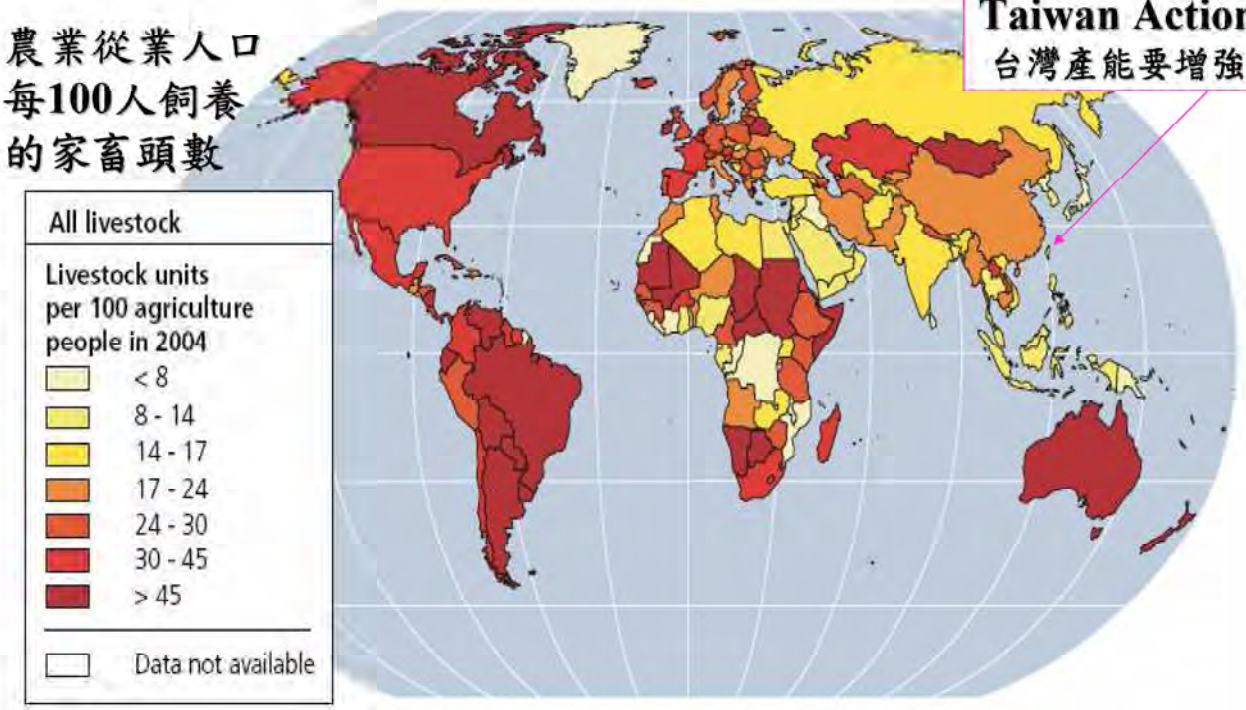
Breeding flock or breeding stock found to have contracted notified disease or have **hereditary disease** during the aforesaid examination or testing shall be **banned** from breeding. The aforesaid inspectors shall present their identification when carrying out their duty.

Livestock density in relation to human population

全球各國家畜飼養密度

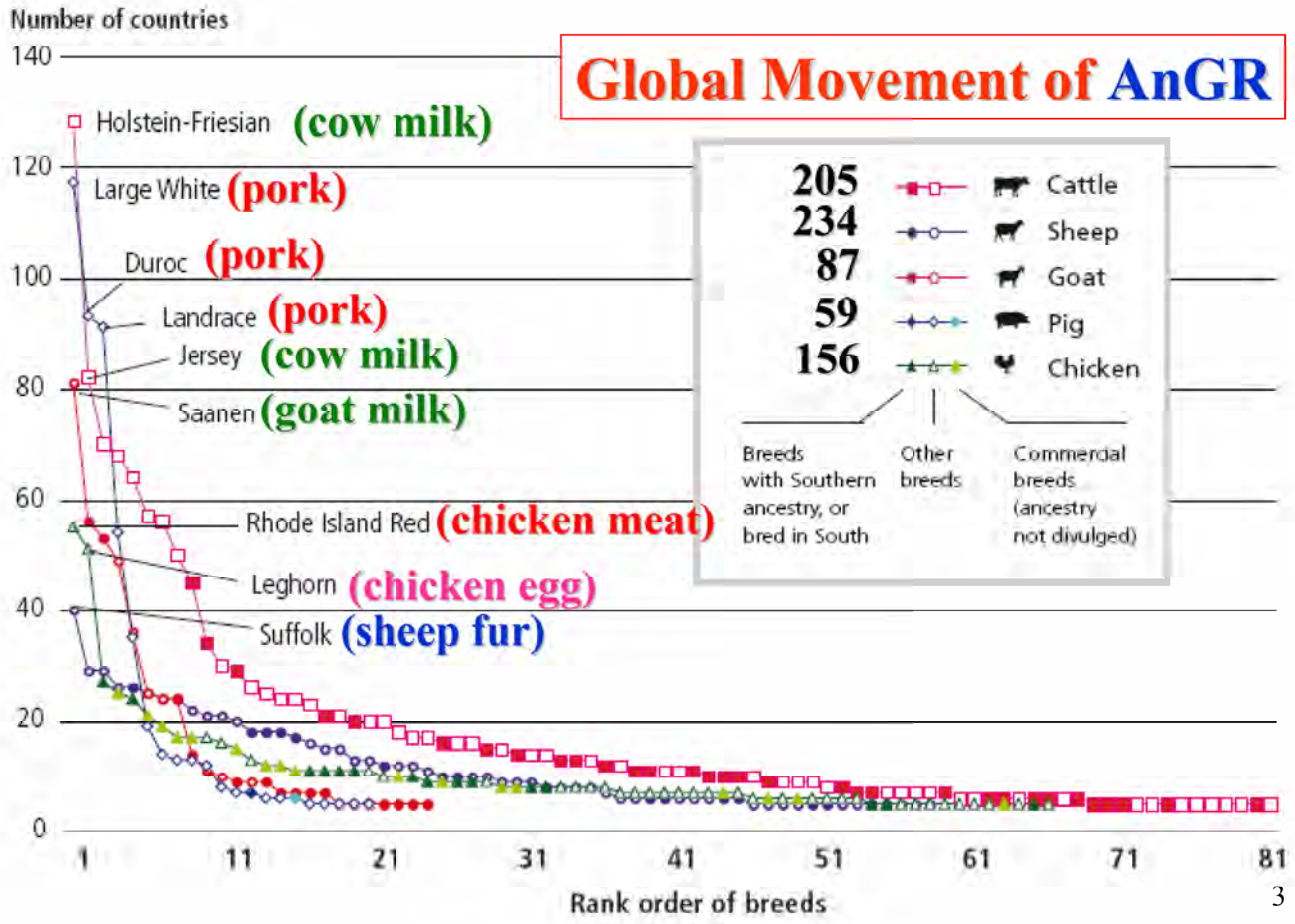
Taiwan Action
台灣產能要增強

農業從業人口
每100人飼養
的家畜頭數



Source: FAOSTAT – figures for 2004.

Distribution of transboundary breeds (source:FAO, 2007)



BioUtilization

Conservation

Species

Biodiversity

Selection

Demand

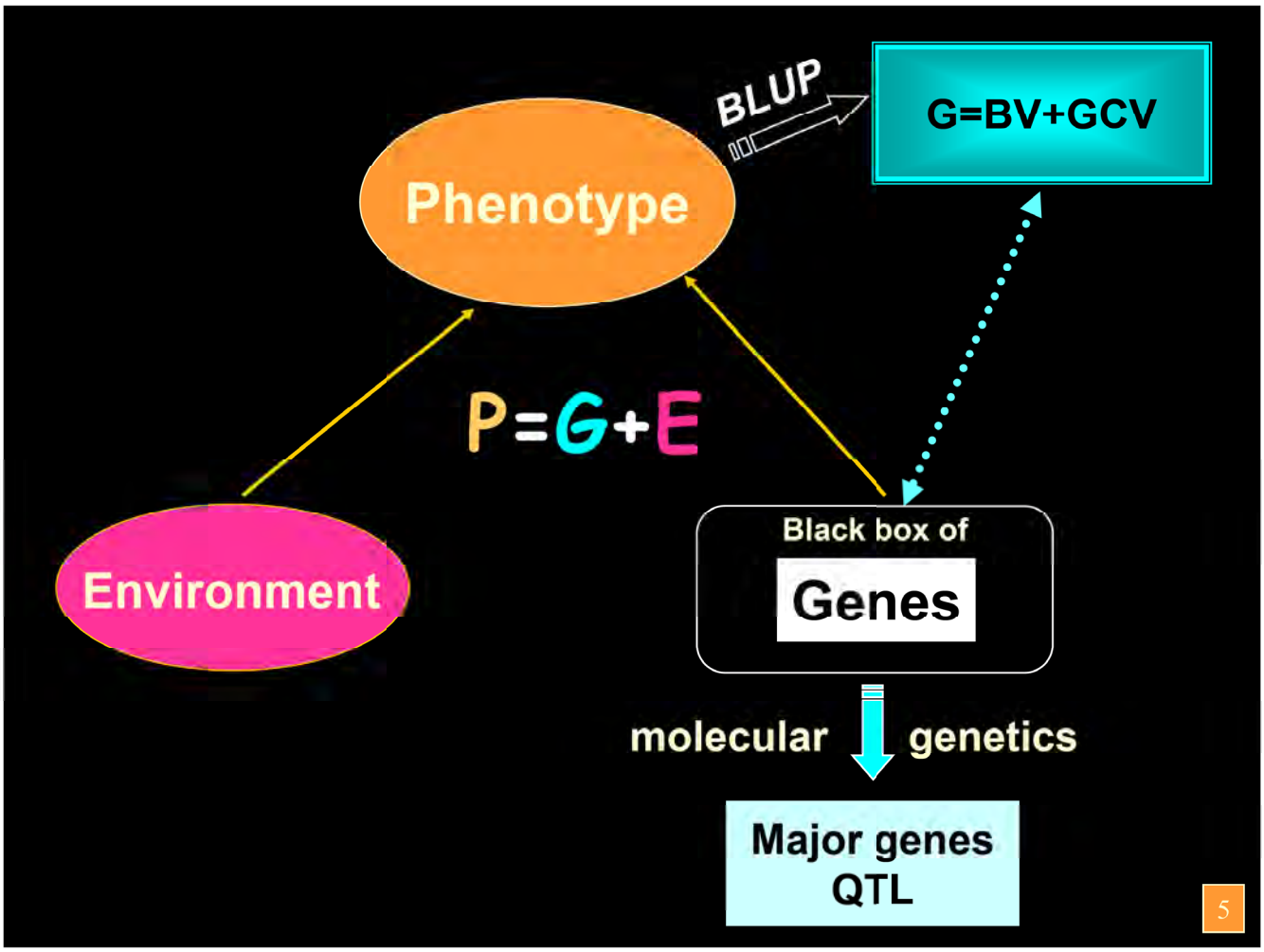
Value add

Export

Tracking

Genomic breeding

- **Species** verification
- **New breed/line**
- **Genetic** improvement


BLUP
G=BV+GCV
Phenotype
P=G+E
Environment
Black box of
Genes
molecular
genetics
Major genes
QTL
5


後腿部位
胸腹部位
羊排・羊扒
前腿部位
內 臟
Origin
assurance
-Market to Farm
-Farm to Fork
6

Food Producer First!

Genomic selection of heat-tolerance animals must be promoted under housing and feeding managements to overcome the environment as follows:

- **Climate is subtropical, with hot humid summers, mild winters and heavy rainfall.**
- **Typhoons, violent summer thunderstorms, and flooding, as well as prolonged winter droughts.**
- **Formulated livestock feeds using mostly imported ingredients**

Genetic Banking

Living form
Cell/tissue
DNA/RNA/mRNA/cDNA/protein

Regulation for genomic breeding - **Animal Industry Act** Article 17

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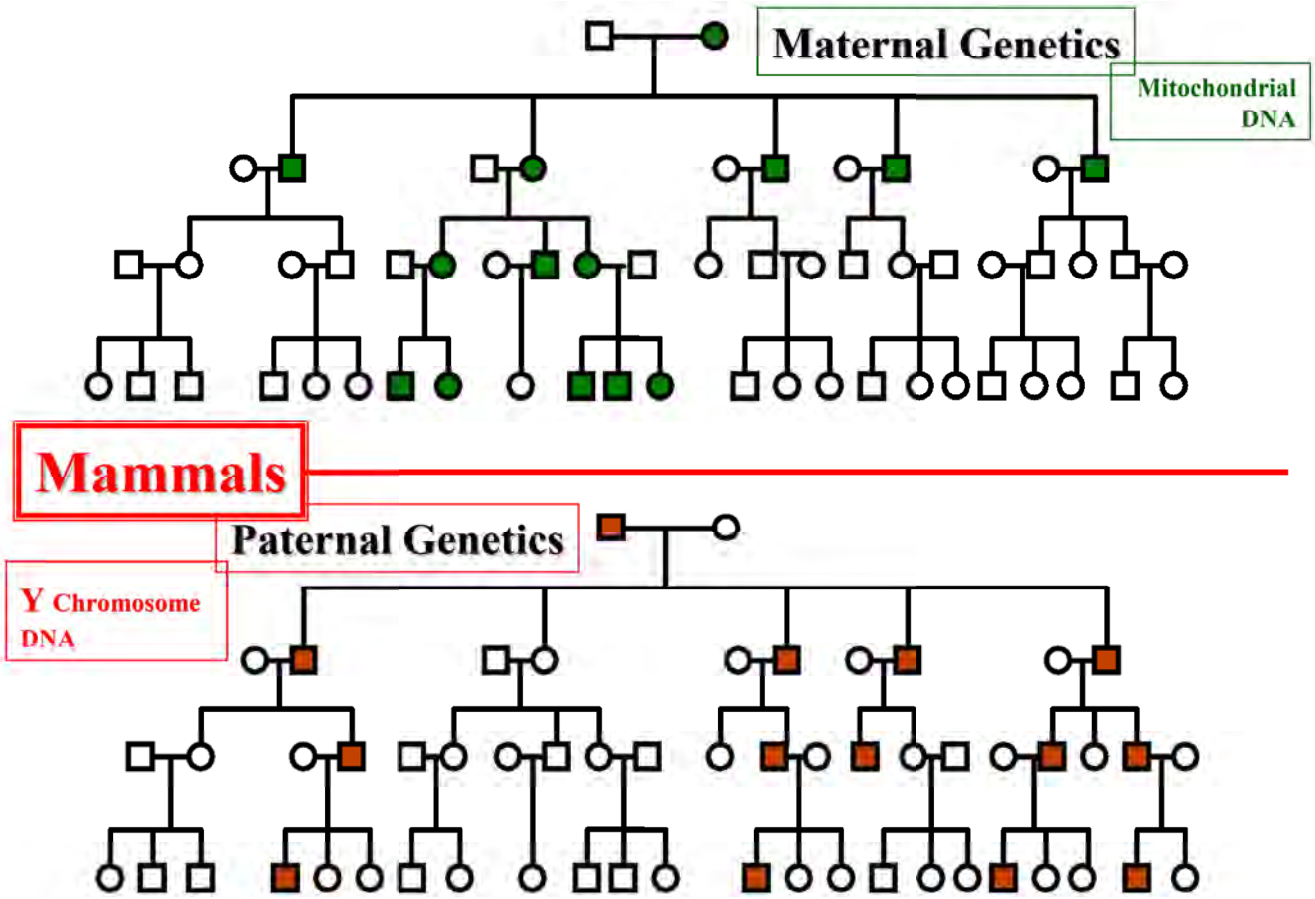
	Pig	Cow	Goat	Chicken	Duck	Goose	Deer	Rabbit
Gene	Hal-1843 ESR HFABP-H HFABP-ad IGF2-In3 IGF2-In7 D5FAD D-Loop SW18 SW1943 SW2588 PRLR	BLAD DUMP CITR CVM XY GH mtDNA	G6S IGF2 mtDNA	HSP70 PRLR PRL ESR mtDNA ZW	PRL ESR ZW mtDNA	PRL ESR ZW mtDNA	IGF2 XY D5FAD mtDNA	GPI PGD XY IGF2 mtDNA



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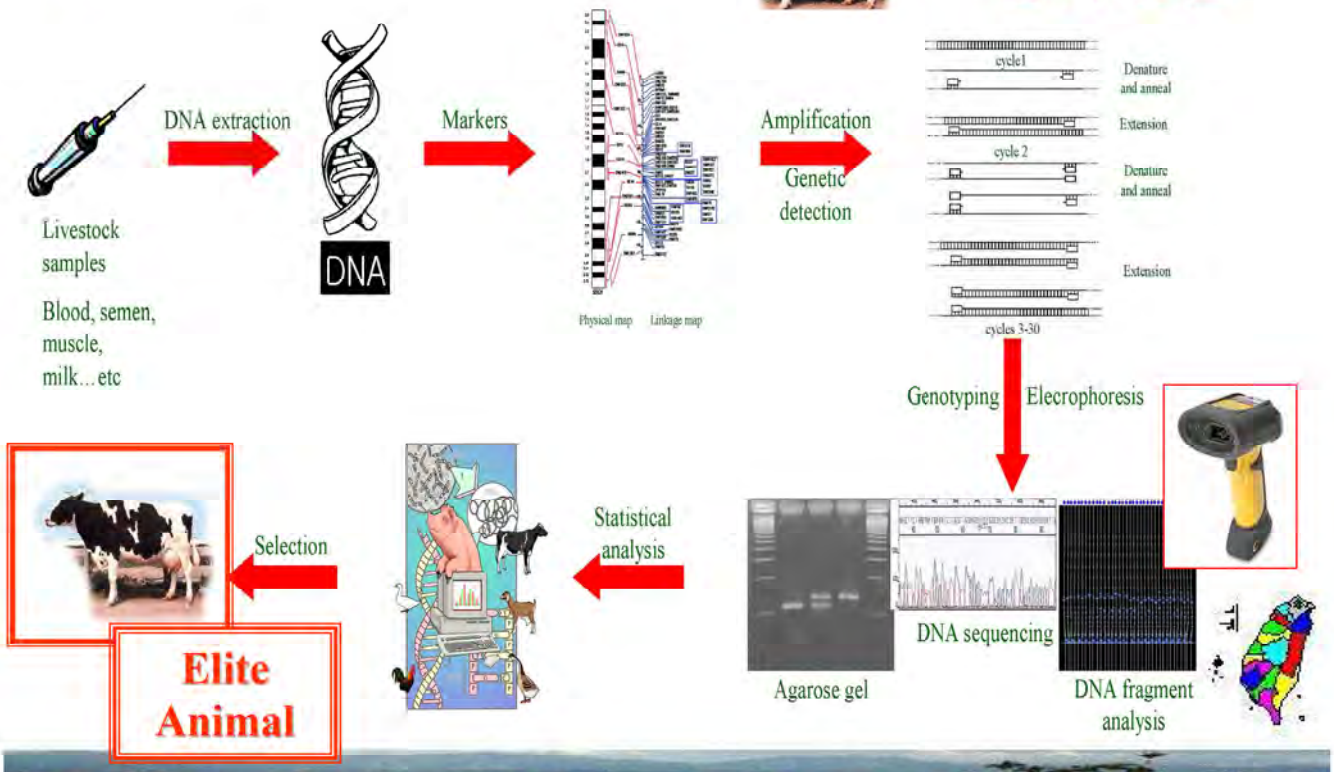
Genomic Breeding
基因選種



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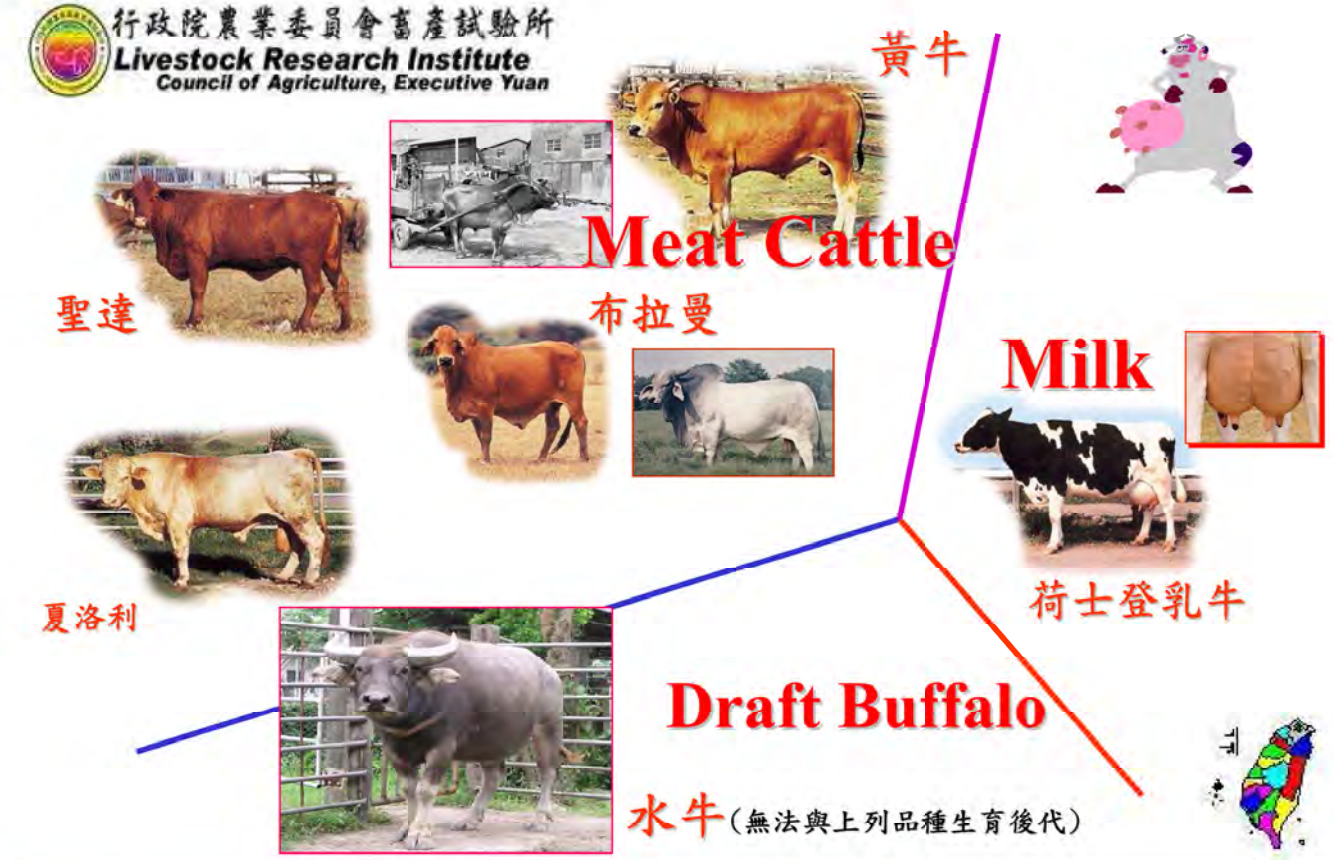
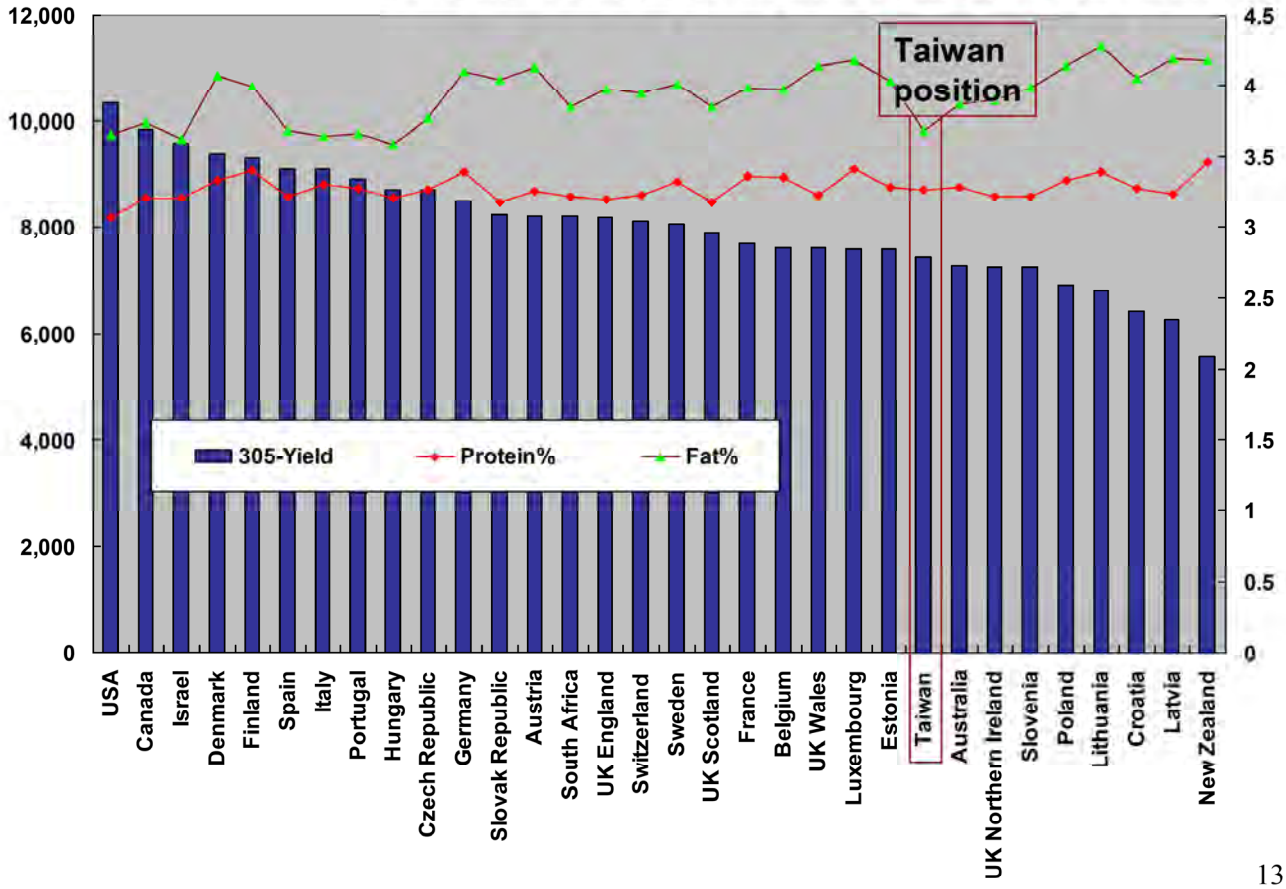


Taiwan Position in Milk Yield, Fat % and Protein % in 2008



DNA Test on Frozen Bull Semen

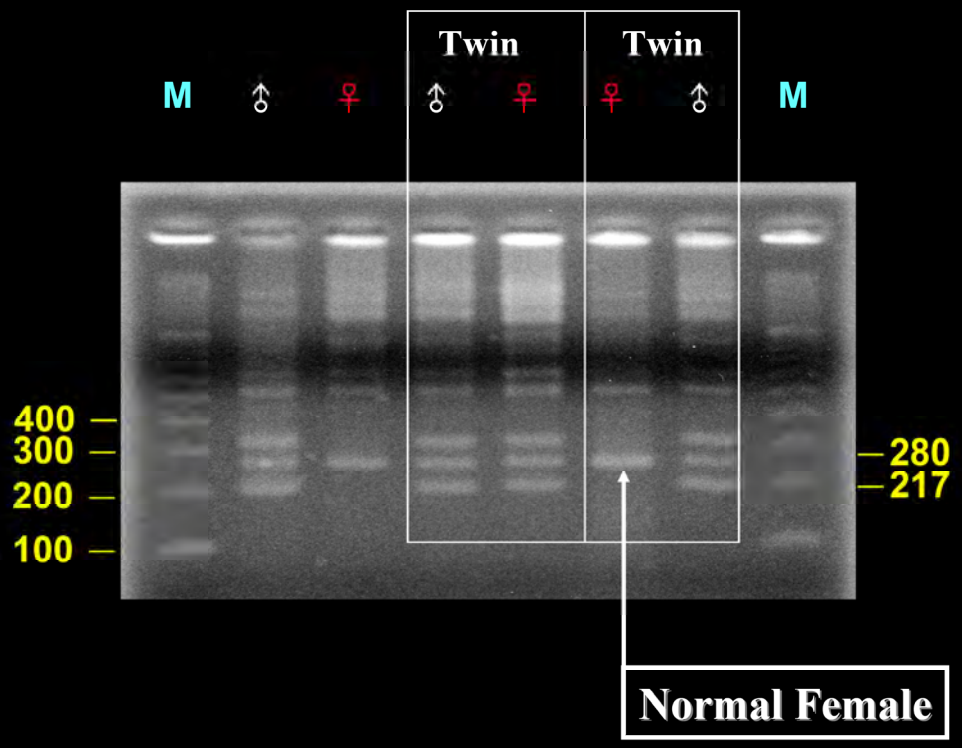
Genetic Defects in Cow Reproduction

- Complex vertebral malformation (CVM)
- Uridine monophosphate synthase (DUMPS)
- Bovine leukocyte adhesion deficiency (BLAD)
- Citrullinemia (Citr)

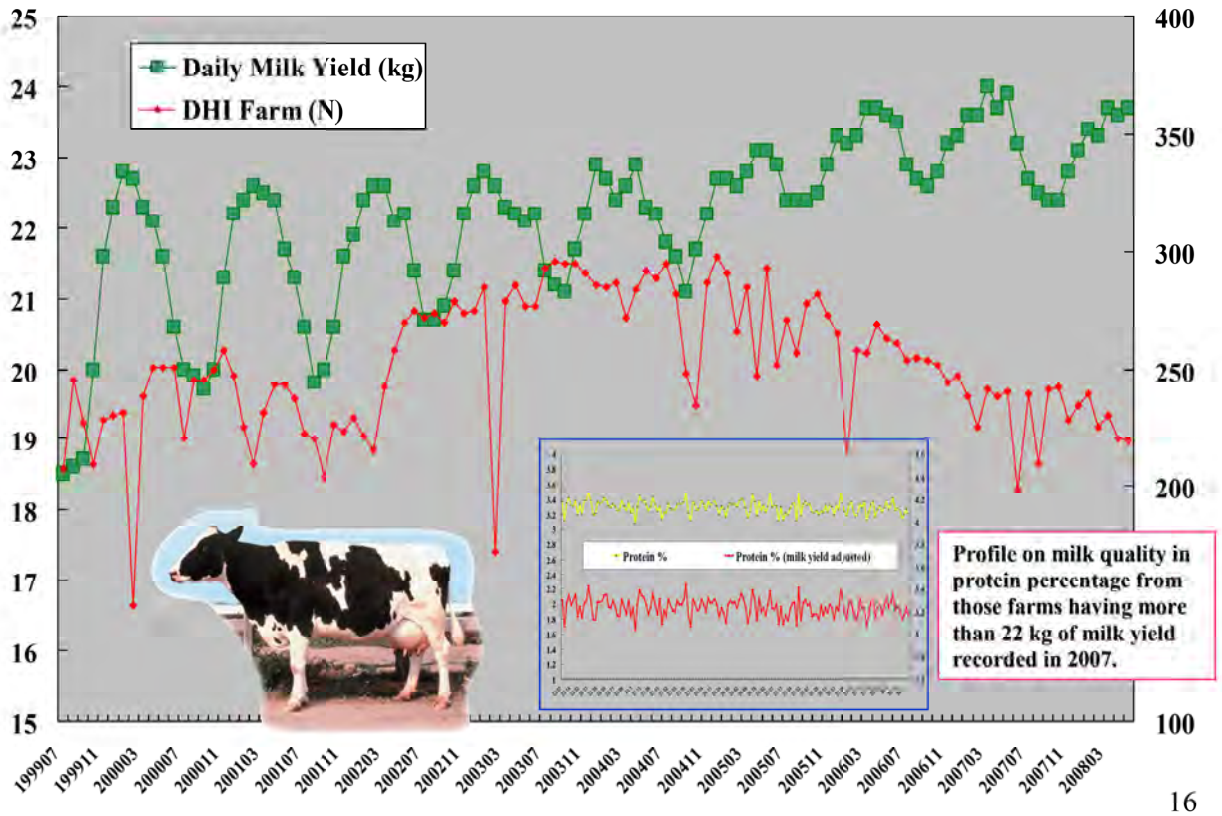
Semen sources

- USA
- Canada
- Japan
- Holland

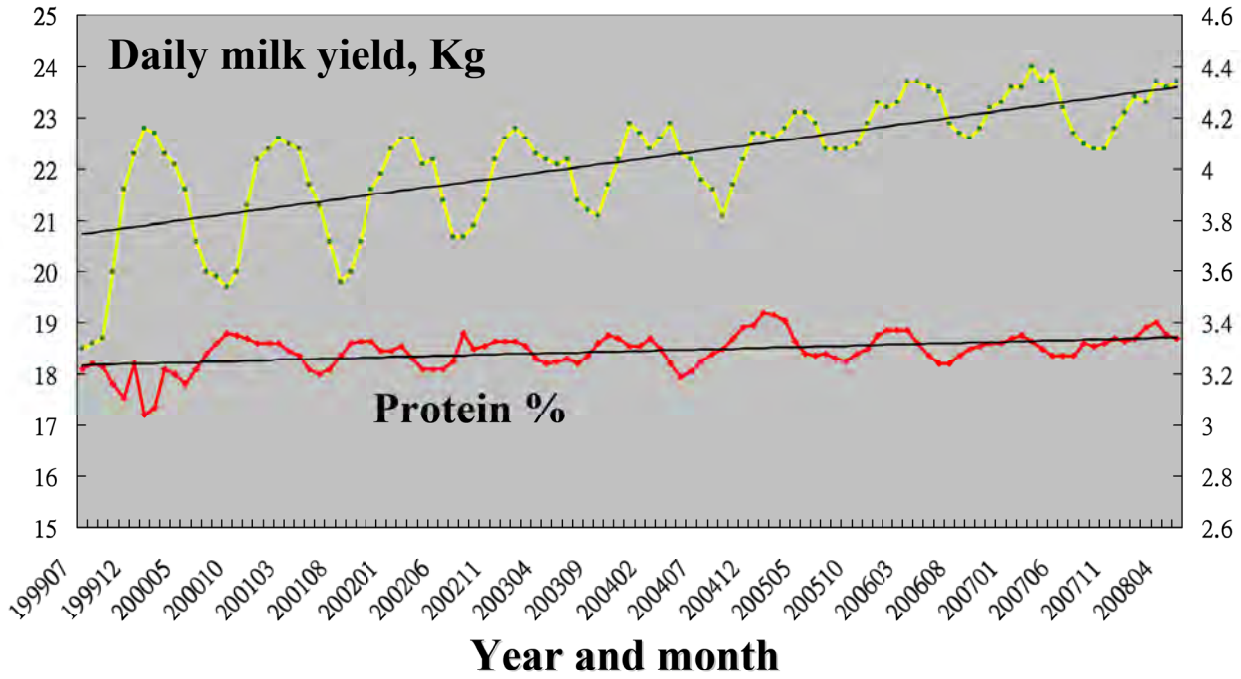
Freemartin Test for Cattle & Buffalo



Profiles of daily milk yield per cow in average and number of DHI farms (1999 ~ 2010)



Daily milk yield (kg) per cow and protein % (1999 to 2010)



Mastitis Diagnosis

Milkchip

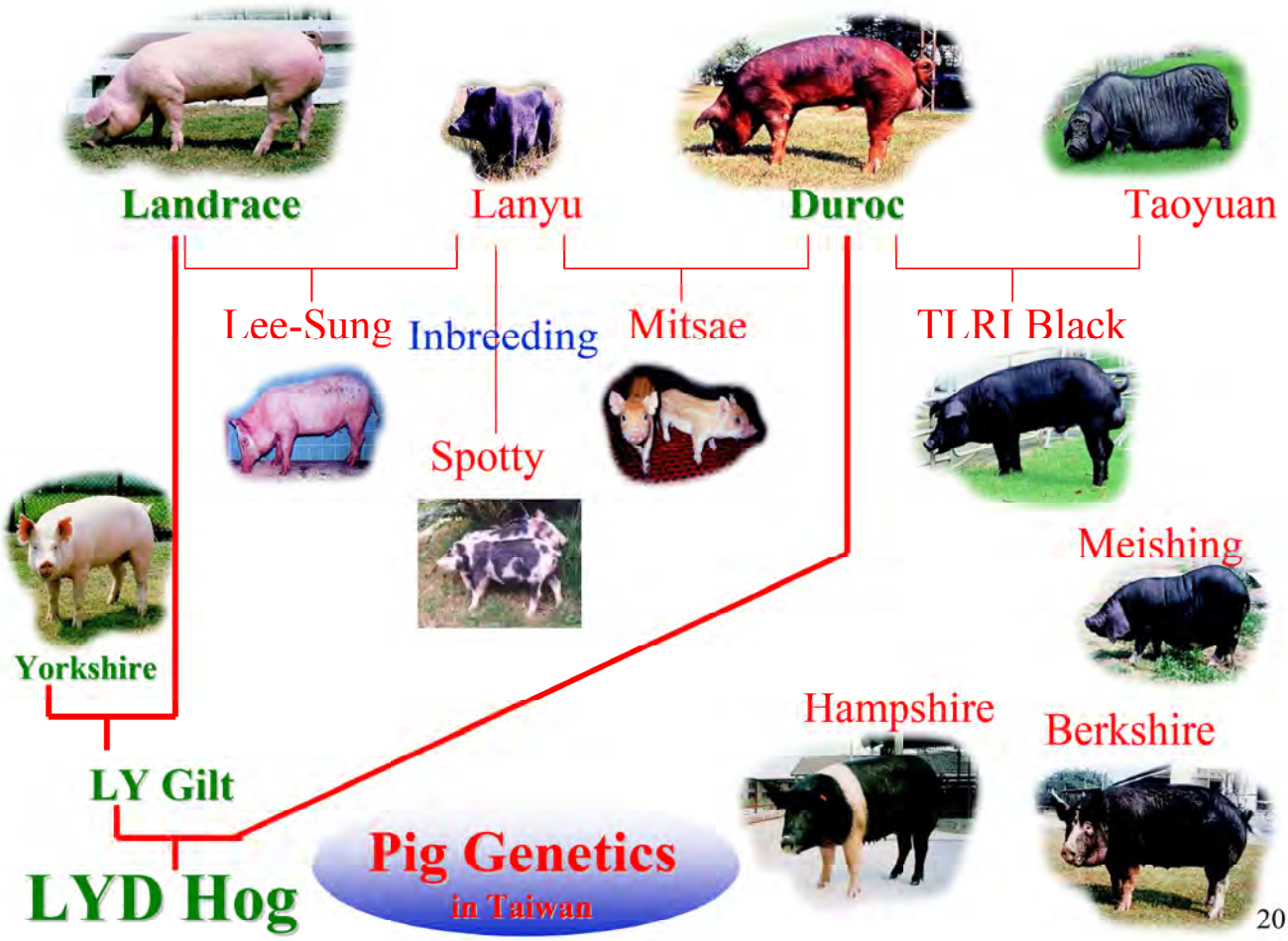
CMT

Bacteriology Culture

DR. Chip

Bacteriology Culture vs. DR. Milk Chip

Bacteria species	Bacteriology culture	Milkchip
Streptococcus spp.	At least 2 days	Detect 7 mastitis-causing bacteria simultaneously in 6 hours
Strep. uberis	5 days	
Strep. bovis		
Strep. agalactiae		
Strep. dysgalactiae		
Staphyl. aureus	5 days	
E. coli	4 ~ 7 days	
Mycoplasma bovis	7~ 10 days	



Meat Products of TLRI Black-1 (E)

畜試黑豬一號為2000年育成的黑毛豬新品種，肉質佳，已技轉給**台畜食品公司**進行全豬利用，生產特色性產品。

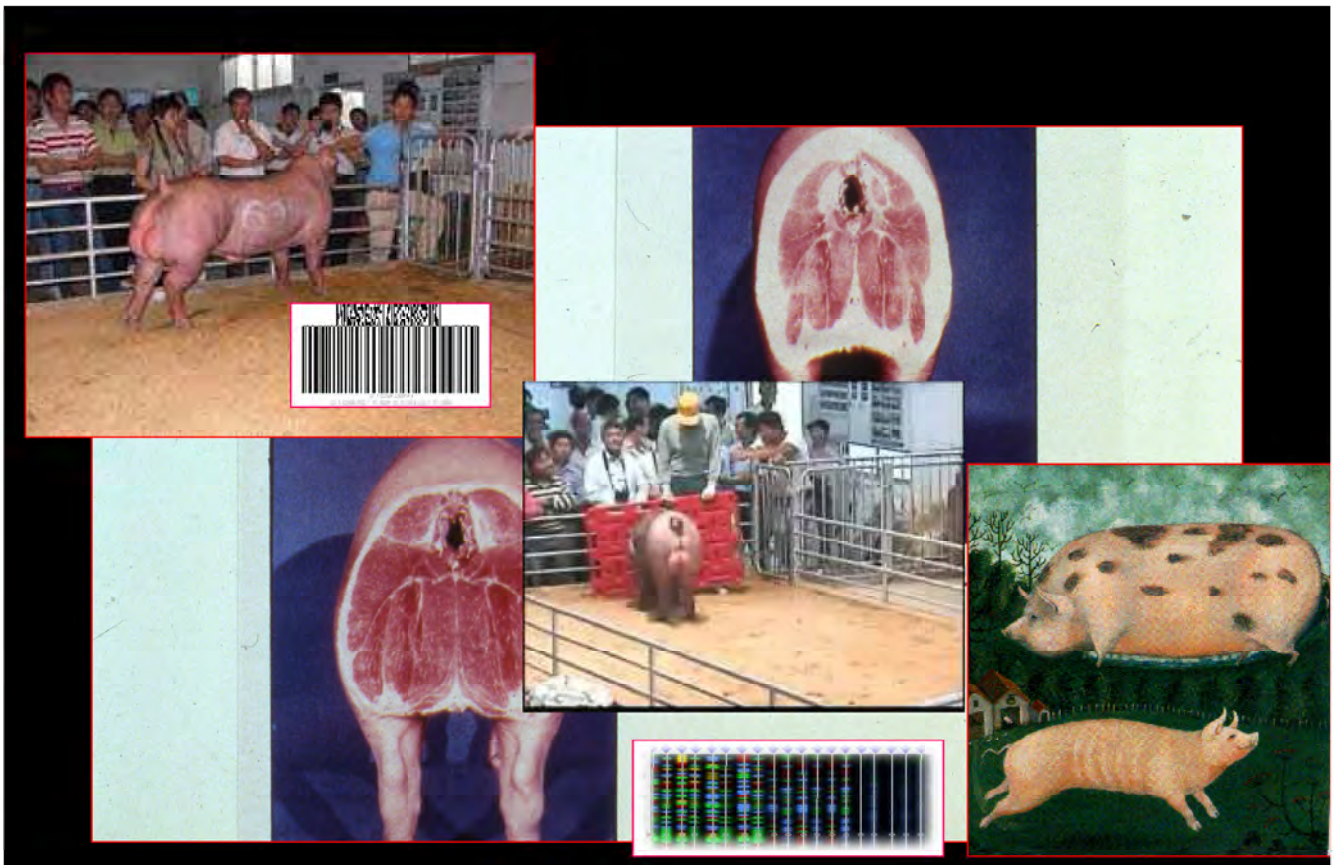
珍鑽黑豬 LRI Black Pig

商標

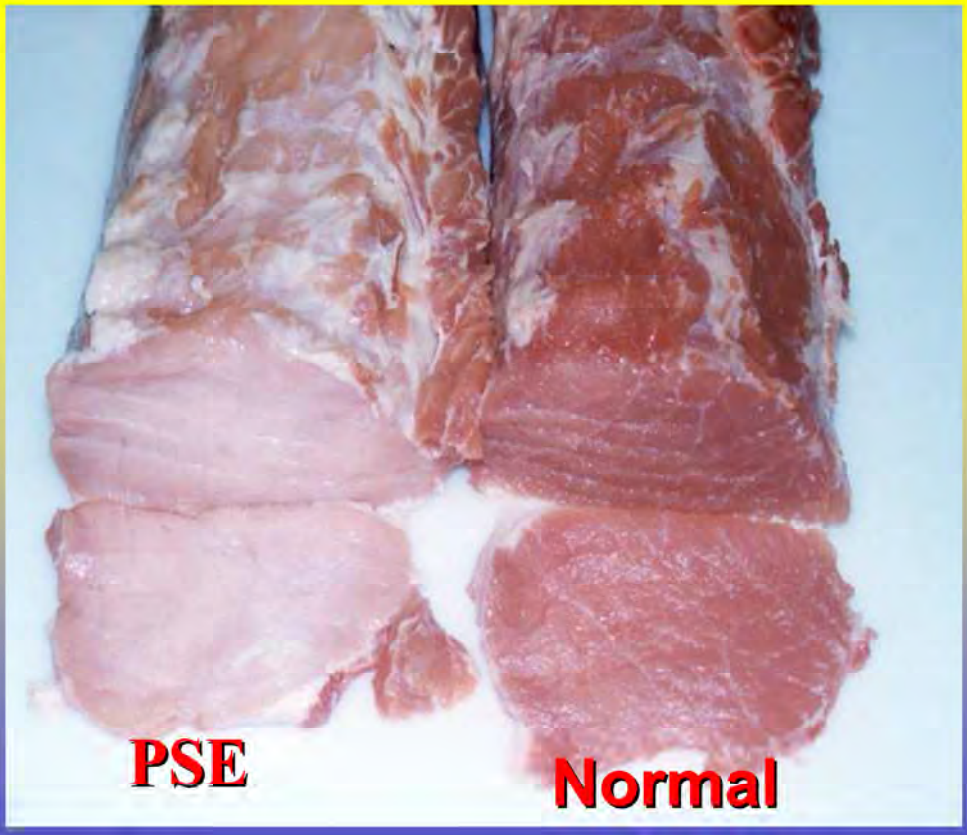
Technology Chain for Breeding Pig Industry

Birth recording	Trait performance test	Pedigree registration	Auction
Mating date of female (NS/AI) Farrow date of sows (F/AF) Birth pedigree: Sire Dam Sire of Sire Dam of Sire Sire of Dam Dam of Dam	Pigs born (male/famale) Teat number (left/right) Birth weight 3-week weight 5-month weight Day of age at 110(100) kg weight (male/female) 110(100) kg Back fat thickness (male/female) 40~110 (100) kg body weight (male/female) — daily gain **feed efficiency (FE)** Body conformation evaluation Conformation trait (length, width, height, depth) Semen quality (sperm number, normality)	Basic Pedigree Growth Performance (GP) Reproductive Performance (RP) Superb GP Superb RP Plum Blossom Award **Genotype —** **Hal-1843(CRC)** **ESR** **HFABP** **IGF2in7** **IGF2in3** **PRLR**	Test Station (7.5 months old)— Duroc Landrace Yorkshire FFASI (8~10 months old) — **Duroc** **Landrace** **Yorkshire** **Berkshire**

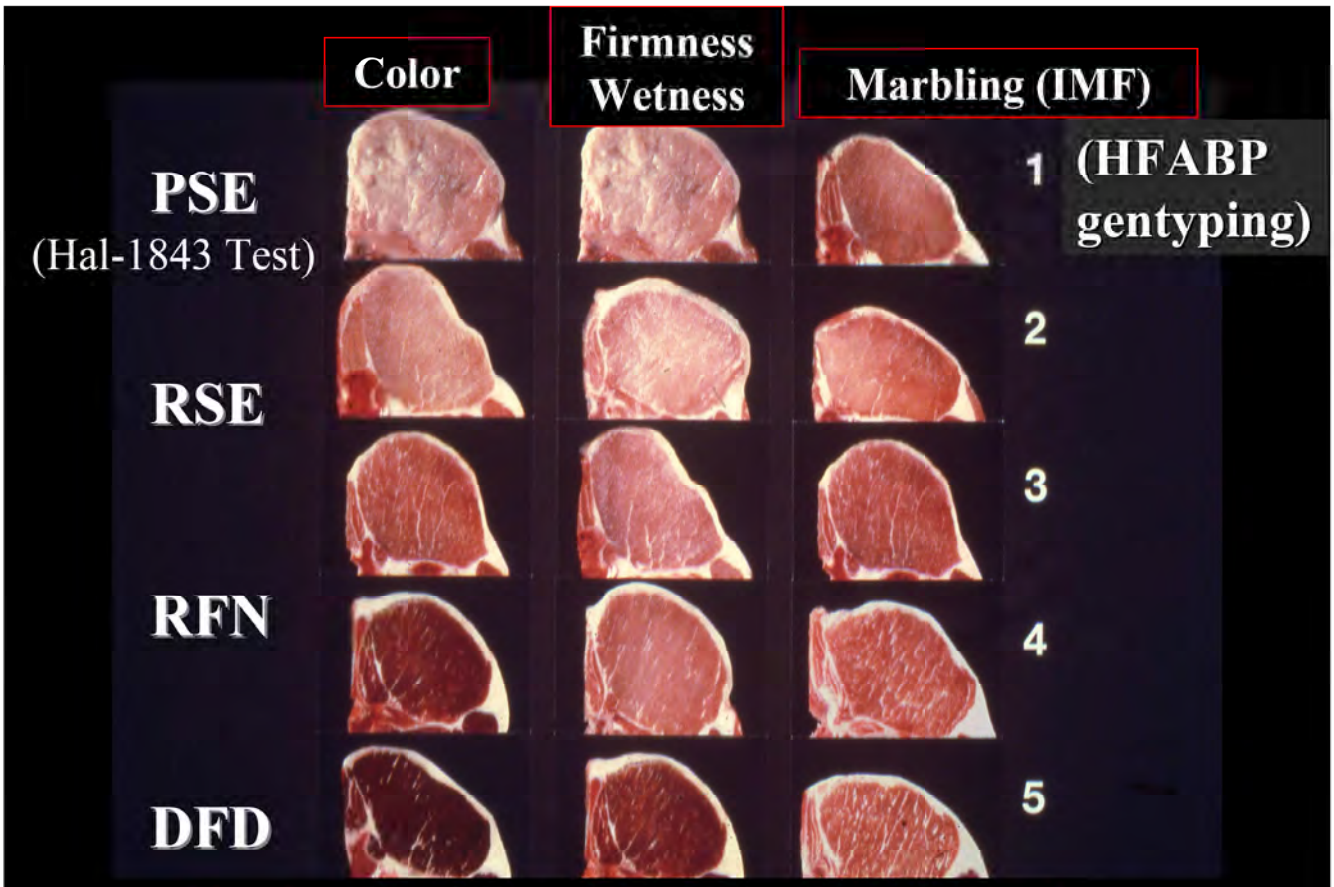
Pedigree Registration: NAIF
Performance Test Station: Hsinhua (Farm with registered sows in one breed should be at least 30 sows.)
Genotyping: TLRI, NPTU (Prof. HL Chang), NAIF
Conformation Evaluation: YY Sung, LC Hsia, RC Weng, YY Lai, PH Wang
Selection Index: TLRI (MC Wu and YC Huang)



Lean pork is gene expression.



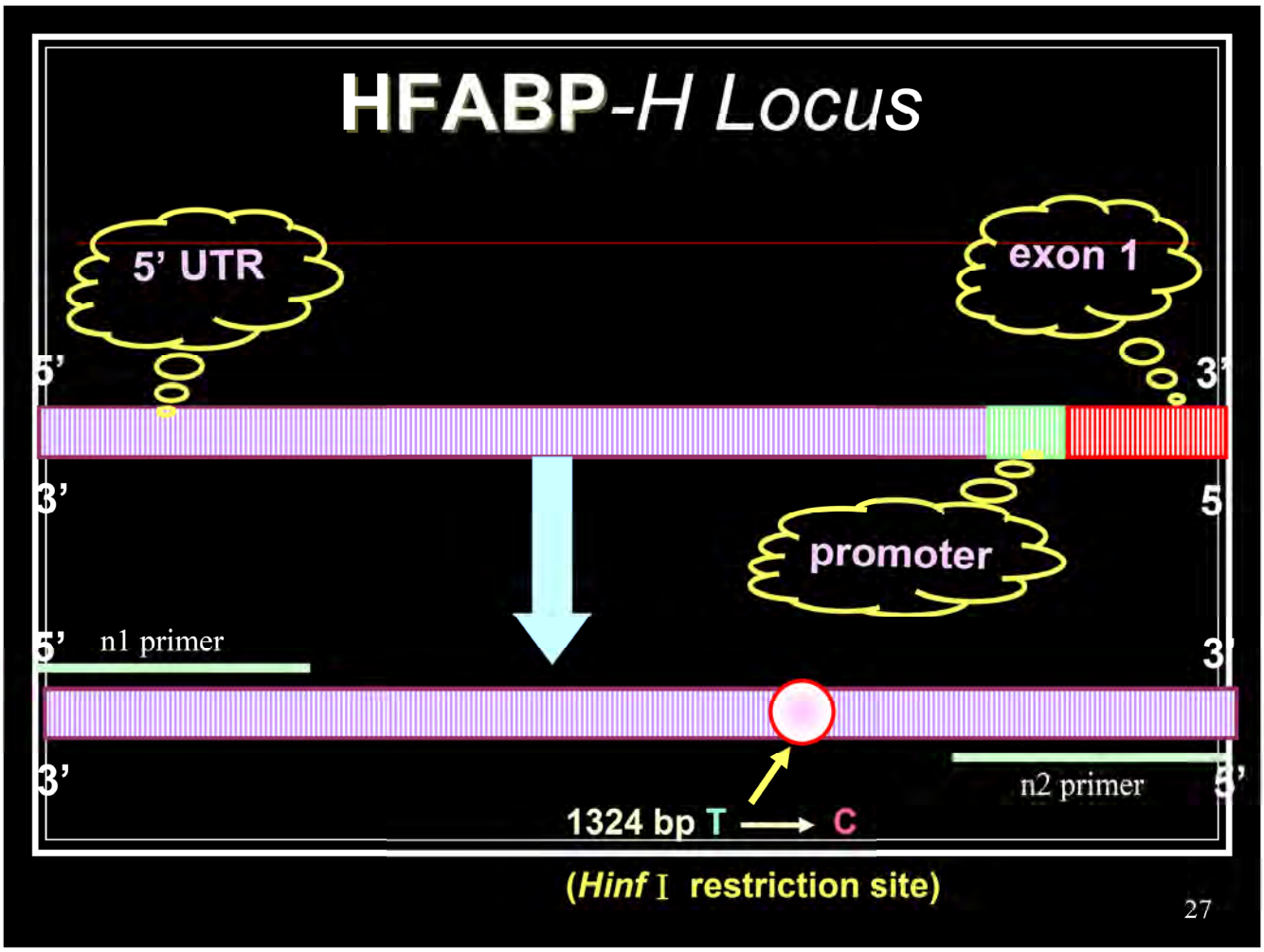
Pork quality is gene expression.

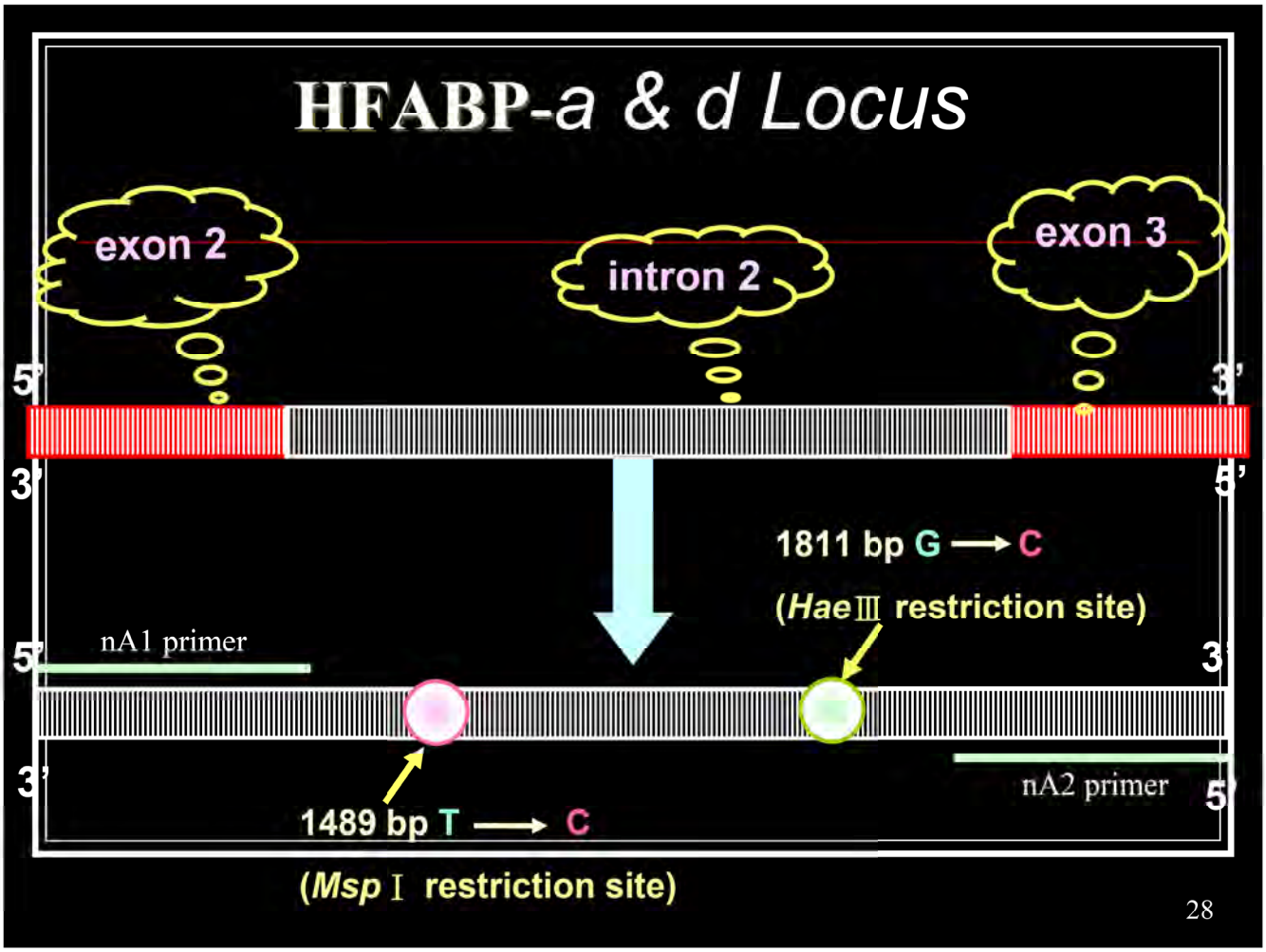


Pork quality is gene expression.

Marker Genotype Screened by Pig Industry in Taiwan

Favorable genotype		Start year
Hal-1843	AA	1996
ESR	MM + MN	2001
HFABP	HH6 + HL5	2002
IGF27	FF	2005
IGF23	QQ	2005
PRLR	PP+LP	2008


HFABP-H Locus
5' UTR
exon 1
5'
3'
3'
5'
promoter
5'
n1 primer
3'
3'
n2 primer
5'
1324 bp T → C
(Hinf I restriction site)
27


HFABP-a & d Locus
exon 2
intron 2
exon 3
5'
3'
3'
5'
1811 bp G → C
(Hae III restriction site)
5'
nA1 primer
3'
3'
nA2 primer
5'
1489 bp T → C
(Msp I restriction site)
28

Classification of HFABP gene combination

HHaadd

HH6

HHaaDd

HHAadd

Hhaadd

HHaaDD

HHAaDd

HHAAdd

HhaaDd

hhaaDd

HhAadd

HQ: HH
(High IMF)

HL5

HL4

HL3

HHAaDD

HhaaDD

HHAADd

HhAaDd

hhaaDd

HhAAdd

hhAadd

HQ: HL

Classification of HFABP gene combination

HhAADD

LL1

hhAaDD

hhAADd

HHAADD

HhAaDD

hhaaDD

HhAADd

hhAaDd

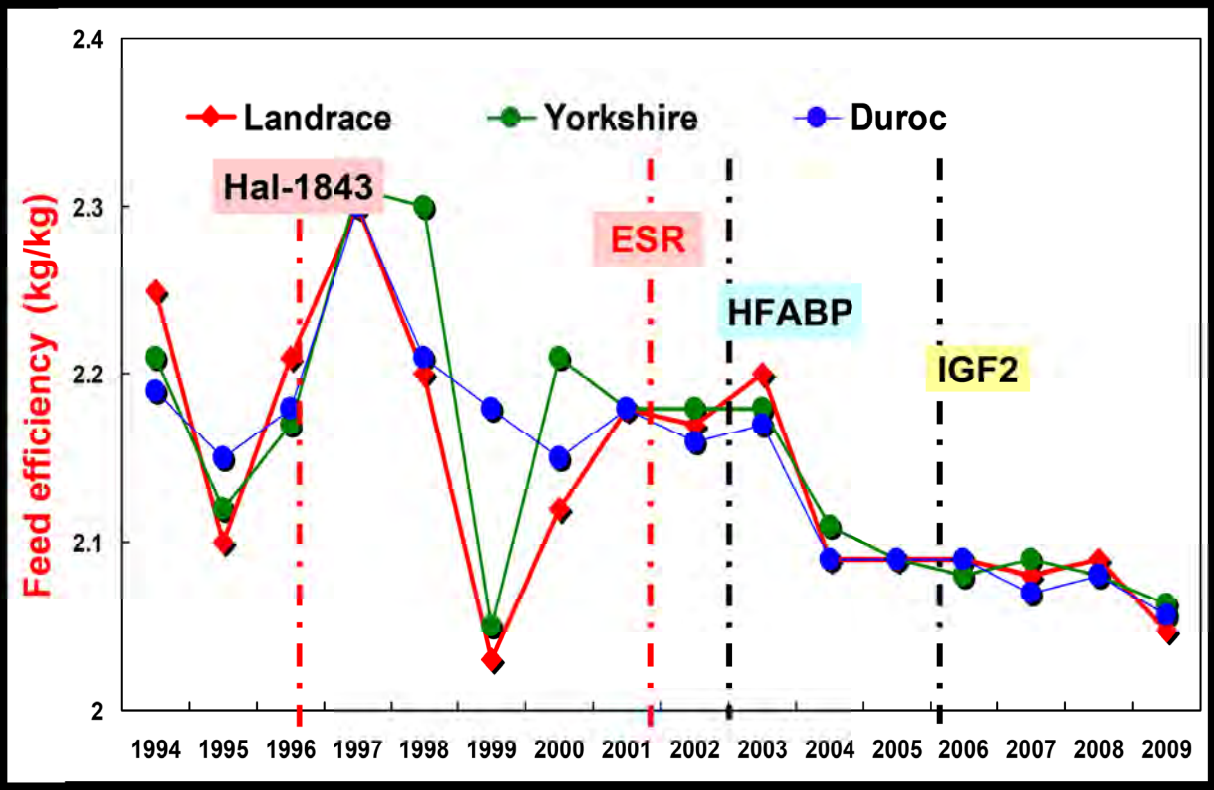
HHAAdd

LL2

LL0

hhAADD
(no favorable allele)

HQ: LL (Low IMF)



Phenotypic trends of feed efficiency for off-test boars from test station in Taiwan (1994~2009)

AID-COA
TLRI
NAIF
FFASI
NPTU
ATIT

Genomic Breeding Pig in Taiwan

www.angrin.tlri.gov.tw

Goal:

Feed efficiency (Feed/Gain) of growing boars from 40 to 110 kg of body weight

FE=3.17 in 1975 and upgraded to FE=2.08 in 2005, projected to FE=1.80 in 2015

Major breed: Duroc

Hsinhua Station
D gilt, The Best

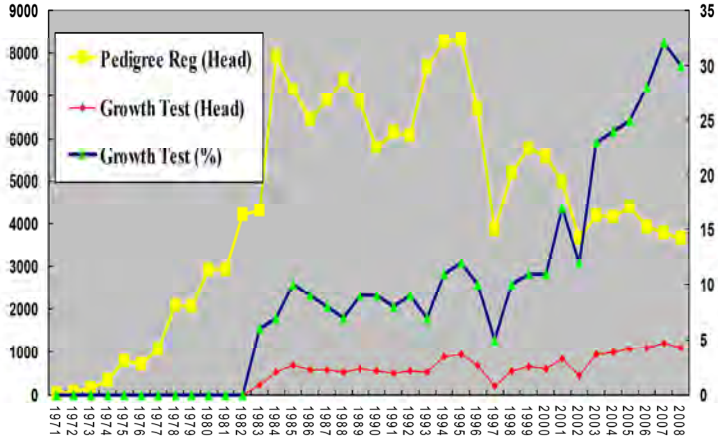
Fortune D0634-11
(FE=1.95) 2005/3/13

Hsinhua Station
D boar, The Best

Huei Huang D0329-05
(FE=1.90) 2003/8/26

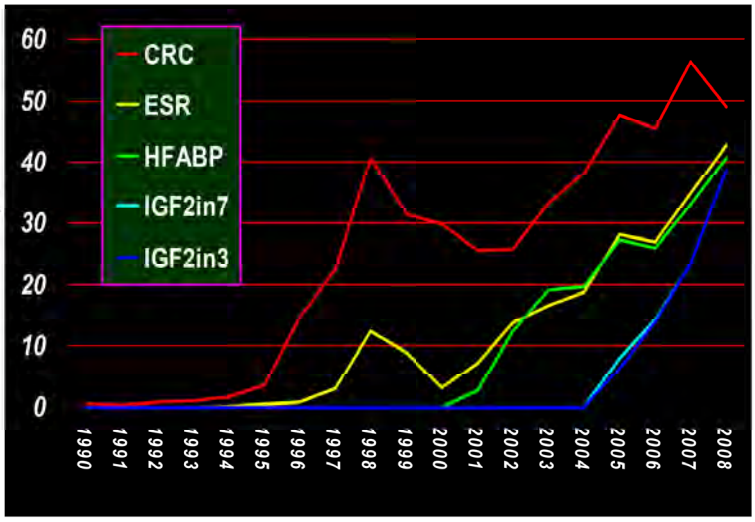
Zhunan Station
D boar, The Best

Shun An D0785-01
(FE=1.51) 2004/6/29



- **Pedigree registration and with growth performance test of pigs born at 1990 to 2010**
- **Genotype of CRC, ESR, HFABP, IGF2in7 and IGF2in3 in percentage of registered pigs**

ESR-IGF2-Hal-HFABP-PRLR on chromosome 1-2-6-6-16 of pig genome



Growth Performance of Boars at Hsinhua Station (2009/3/3)

Birth year	Breed	head	sire	farm	Day at 110 kg		ADG(Kg)		FE(F/G)		Backfat th. (cm)	
					Min	Avg	Max	Avg	Best	Avg	Thinnest	Avg
2008	D	194	67	19	134	150	1.271	1.084	1.93	2.057	1.10	1.242
2007	D	278	80	16	128	146	1.329	1.094	1.95	2.041	1.07	1.232
2008	L	75	34	14	131	146	1.371	1.091	1.98	2.057	1.09	1.235
2007	L	144	51	16	120	142	1.357	1.124	1.86	2.046	1.05	1.234
2008	Y	27	15	7	133	146	1.273	1.112	1.96	2.059	1.10	1.246
2007	Y	37	18	8	127	142	1.299	1.117	1.96	2.058	1.10	1.242

Growth Performance of Gilts at Hsinhua Station (2009/3/3)

Birth year	Breed	head	sire	farm	Day at 110 kg		ADG(Kg)		FE(F/G)		Backfat th. (cm)	
					Min	Avg	Max	Avg	Best	Avg	Thinnest	Avg
2008	D	16	11	5	136	153	1.129	0.934	2.07	2.171	1.10	1.208
2007	D	30	19	6	138	148	1.086	0.952	1.97	2.127	1.03	1.218
2008	L	31	18	8	128	147	1.200	0.979	2.02	2.153	1.09	1.213
2007	L	64	33	11	125	146	1.257	0.972	1.98	2.123	1.00	1.191
2008	Y	8	7	3	138	148	1.230	0.978	2.06	2.156	1.01	1.159
2007	Y	7	6	4	140	144	1.063	0.958	2.10	2.190	1.03	1.156

Art. 20 of Animal Industry Act Performance test on breeds for farm production should be carried out by research institutes under regulations of COA.

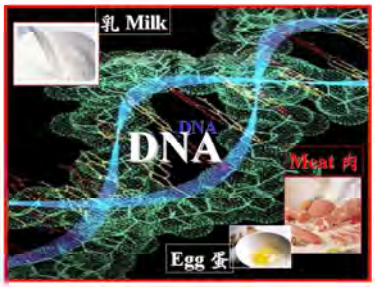
Price difference between AA (normal CC) and BB (stress TT) Hal-1843 genotype in Duroc boars

Birth year	Hal-1843	Hsinhua Station			Zhunan Station			Breed Association			In total	
		Head	Avg Price (NT$)	Highest Price (NT$)	Head	Avg Price (NT$)	Highest Price (NT$)	Head	Avg Price (NT$)	Highest Price (NT$)	Head	Avg Price (NT$)
2008	AA	119	47798	129000				87	34551	120000	206	42203
2008	AB	18	39555	119000				15	27866	71000	33	34241
2007	AA	218	36740	148000	253	38891	250000	178	32685	173000	649	36466
2007	AB	27	33592	88000	34	34544	93000	28	31428	70000	89	33274
2006	AA	222	37157	160000	275	33101	215500	141	33226	201000	638	34539
2006	AB	34	26911	81000	28	24446	55000	35	30457	202000	97	27478

Art. 17 of Animal Industry Act Genetic defects of breeding animals and germplasm should be removed from the population of breeding stocks after the confirmation under regulations of COA.

DNA barcoding for pigs

Hal-1843 gene for stress (AB), ESR gene for prolificacy (MN) and 16,613bp mtDNA for maternal origin, especially on D-loop region (1,175bp) of 29 SNPs and UTRn (tacacgtgcg 10bp)$_{17\sim27}$ in various breeds of pigs.



AB+MN+18SNP+UTR+11SNP

mtDNA D-Loop

A0021-02 Lanyu	AAMNcaattgctcgtttctcag24tgctcgaaacc
T0596-01 Taoyuan	AAMMcaattgcttgttttccag24tgctcgaaact
L0074-10 Landrace	AAMNttgccattcaccctccaa27tgcttaaaatt
Y0150-03 Yorkshire	AAMNcaattgcctgttttccag25tccccgaaacc
D0167-05 Duroc	AANNttgccattcaccctccaa26tgcttaaaatc

Breeding Farm Evaluation (by Breed)

Nuclear Farm
Good Farm

Top Quality Award
(Nuclear level in evaluation for three breeds with more six years)
Outstanding Award
(Nuclear level in evaluation in the same breed more than 10 years)

Standards:

Art. 21 of Animal Industry Act Farm and station evaluation should be carried out annually by COA.

A. Farm registration.
B. Pedigree registration for boars in 100% and for sows in 50% or more.
C. Herd books for growth, reproduction, disease control and genetic improvement plan with qualified personnel.
D. At least of 20 pigs were in test and 10 off-tested pigs for Duroc and Landrace in the last year. Half of number in test and off-tested were required for Yorkshire.

Score 100 points (Performance Test, 40; Pedigree Registr, 36; Auction, 4; Breeding Record, 20)
Score plus, 4(ADG>1.40 or FE<1.80 in one case for 2 points) — Scoring sheet will be adjusted in 2009

Boar Semen Station Evaluation

Nuclear Station
Good Station

Best Promotion Award
(Nuclear Station in the listings after evaluation at least six years)

Score

Boar management (20 points)
Semen quality (55 points)
Health program (10 points)
Cost and benefit (15 points)

Item required: Nuclear Station must have all points after 2009.
Boar with PR and PT: All boars must have (4 points)
Housing with temperature control: Yes (2 points)
Records for semen examination: Yes and in detail (3 points)
Biological examination (Virus and microbes): at least 3 times (3 points)

Dated to March of 2009: Performance Test Station in 34th year, Auction in 33rd year, Breeding Farm Evaluation in 11th year, and Boar Semen Station Evaluation in 7th year as the base for a better development in breeding pig industry.

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Meat Goat


Boer


Taiwan Goat


Nubian


Black Boer


Jian Goat

Milk Goat


撒能


可爾拜因

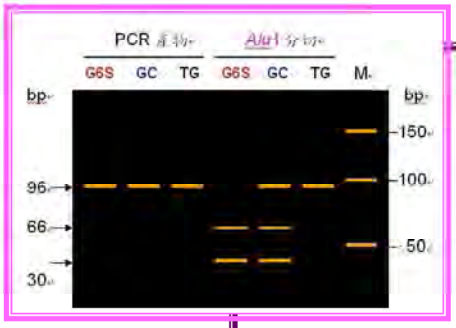
Fur Sheep


巴貝多綿羊


考利黛綿羊

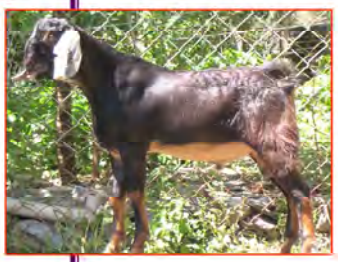

吐根堡

Goat mucopolysaccharidosis (G6S) allelic selection



13 Dam × 3 Sire

GC × GC



Normal	TG	6	4
Less meat	GC	2	5
Stillbirth	G6S	2	1

Goat Milk Products

Conditions that are good for MAS
(Genomic Selection or Genomic Breeding)

- not measurable on living animals (meat quality)
- low heritability – fecundity
- sex limited – milk production, fecundity
- not measurable at early life – milk yield, longevity (juvenile selection)
- difficult measured – disease resistance, pigmented fibers