
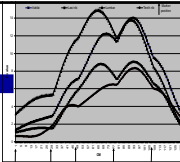


Present Applications of Molecular Genetics in the Pig Industry


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Introduction

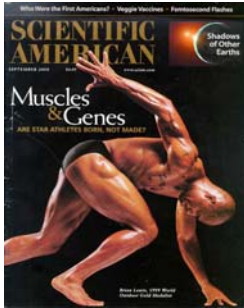


- ❖ The goal of genomics is to find important genes.
- ❖ Primary approaches have been employed:
 - 1) Identification of QTL through linkage mapping to anonymous markers.
 - 2) Identification of QTL through association studies involving candidate genes.
- ❖ These approaches can be combined.



Candidate Genes

- ❖ Candidate genes are those believed to control a specific physiological process.
- ❖ We can examine:
 - biological candidates
 - mutational candidates
 - (comparative) positional candidates






Meishan Sow from China



ESR - a good candidate gene?

- ❖ Estrogen plays a central role in many reproductive functions: embryo survival, fetal development, fertility, maintenance of fertility, and secondary sexual characteristics.
- ❖ It seems obvious that its receptor is therefore crucial.

Effect of ESR on Litter Size in Meishan Synthetics

ESR Genotype	N	First Parity	
		TNB	NBA
AA	75	11.2 ^a	10.0 ^a
AB	94	12.5 ^b	11.1 ^b
BB	38	13.5 ^b	12.3 ^b
Effect [†]			
Additive		1.15**	1.13**
Dominance		0.15	-0.05

N = total number of records, TNB = total number born, NBA = number born alive.
[†] Additive effect was estimated as the linear regression of litter size on ESR. **P<.01.
 Dominance effect was estimated from the Least Squares means.
 a,b Means in the same column with different superscripts significantly differ P<.01.

ESR GENE TEST

Increasing the high protein part of the leanest carcass using up to every piglet with the best of a commercial challenge for genetics.

ESR Gene Test is a DNA test that identifies the presence of a specific gene that is associated with increased lean meat production. This gene is found in the DNA of pigs that are bred for high lean meat production. The ESR Gene Test is a simple and accurate way to identify the presence of this gene in your piglets. It is a simple and accurate way to identify the presence of this gene in your piglets. It is a simple and accurate way to identify the presence of this gene in your piglets.

Mutational Candidate Genes

- ❖ These are genes that are suggested to be candidates based on knockout studies in mice or naturally occurring major mutations in other species.
 - Myostatin
- ❖ Look for mutations of smaller magnitude but of economic value.

Gene Identification for Traits: MC4R

Knockout mouse and sib

Does a MC4R mutation exist in this pig?

MC4R mutation and Test (Kim et al., Mammal Genome 2000)

a

Allele 1 homozygote sequence: C...N...S...I...D...L...Y...
 Allele 2 homozygote sequence: C...N...S...I...N...L...Y...

b

1/1 2/2 1/2

542
466

Comparison of Homozygotes in Commercial Lines

Genotype	Number of Pigs	Backfat (mm)	Shoulder fat (mm)	Loin depth (mm)	Daily Gain (g/d)	Daily Feed Intake (kg/d)
11 vs. 22 Commercial genotypes ^a	679	-1.3	-1.4	+1.4	-26.0	-0.15
P value		<.05	<.05	<.10	<.10	<.05
11 vs. 22 Pure Line Data	2,366	-1.1	n/d	n/d	-28.0	-0.17
P value		<.0001			<.0001	<.01

^a No significant interaction with genotype.

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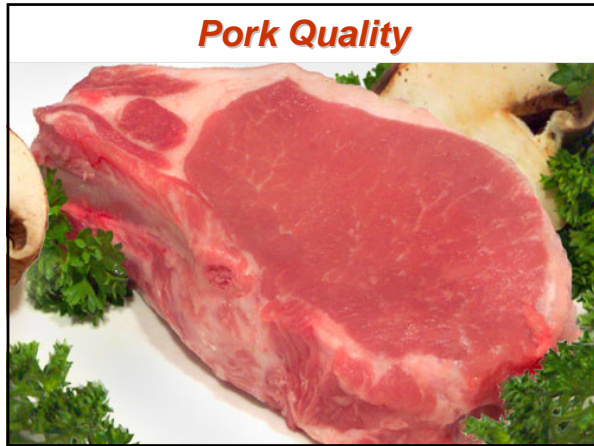
Other benefits: Reduced waste management

Use of this genetic marker in a sire's lifetime

- ❖ 28 tons less feed is needed to finish the 6000 progeny
- ❖ A reduction of 33,600 gallons of manure

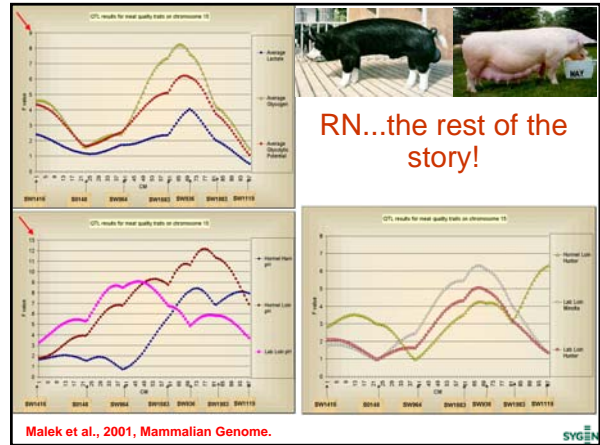
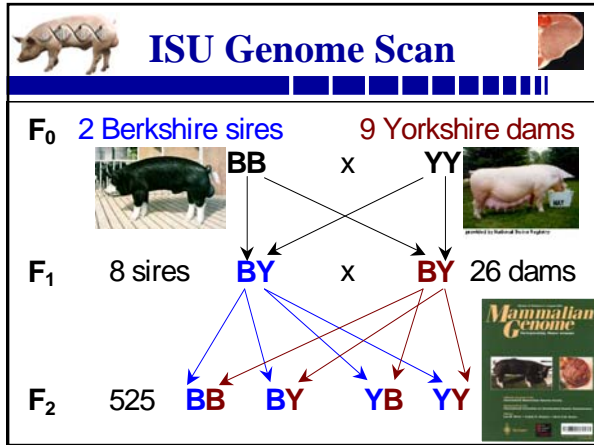
Per 10,000 sows per year

- ❖ 930 tons less feed
- ❖ 1,100,000 less gallons of manure



Rendement Napole (RN-)

- ❖ High frequency in Hampshire pigs.
- ❖ Increase ~70% in muscle glycogen
- ❖ Negative effects on ham processing yield and pork quality.
- ❖ Mapped on chromosome 15 (Milan et. al., 1996; Mariani et al., 1996).
- ❖ Causative mutation for RN- in the Protein Kinase AMP-Activated Gamma 3 subunit (*PRKAG3*) gene (Milan et al., 2000).



Polymorphisms in *PRKAG3* Gene

- Missense mutations:
 - T30N - exon 1
 - G52S - exon 1
 - I199V - exon 3
- SINE

Original RN- mutation (R200Q) was absent in the B x F2!
Ciobanu et al., 2001, *Genetics*.

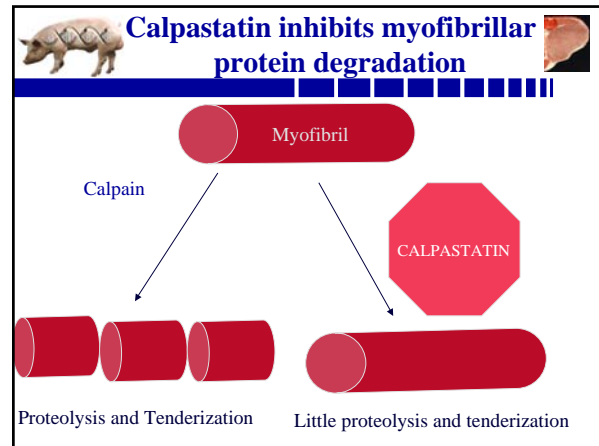
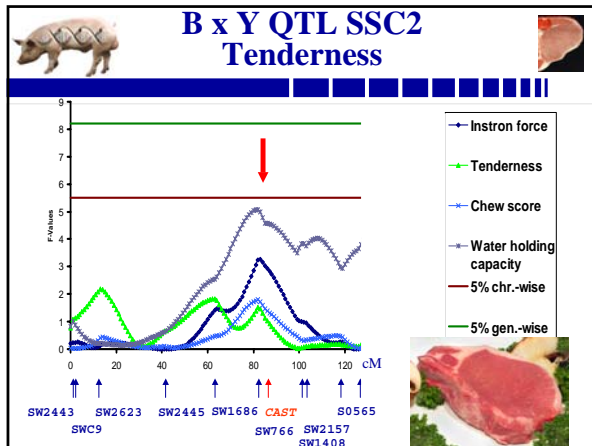
Association results between the genotypes at I199V substitution site of the *PRKAG3* gene and meat quality traits across five commercial lines.

Ciobanu et al., 2001 Genetics

TRAITS	II	IV	VV
Ham pH	5.81 (.01) ^e	5.74 (.01) ^{f,e}	5.71 (.01) ^f
Ham MinL	44.9 (.37) ^e	46.5 (.27) ^f	46.9 (.26) ^f
Loin pH	5.78 (.01) ^e	5.74 (.01) ^{f,e}	5.71 (.01) ^f
Loin MinL	44.2 (.26) ^e	44.7 (.18) ^a	45.2 (.18) ^{f,b}

Significant differences: a-b p<.05; c-d p<.005; e-f p<.0005.

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Associations of CAST Hpy188I and meat quality traits in BxY F₂

TRAITS	Genotypes			P
	11	12	22	
Firmness	3.21 ^{e,c}	3.44 ^f	3.43 ^d	0.001
Juiciness	6.23 ^a	6.05	5.76 ^b	0.05
Tenderness	8.01 ^a	7.74 ^b	7.75	0.11
Chew score	2.32	2.51	2.54	0.11
Avg. Instron Force (kg)	4.39 ^a	4.45 ^a	4.63 ^b	0.05

Higher Juiciness score, Tenderness score and lower Chew score preferred. Lower Instron force preferred.

Significant differences: a-b p<.05; c-d p<.005; e-f p<.0005
 n=136 (11), 228-233 (12) and 129-130 (22).

PRKAG3 and CAST

Ciobanu et al., 2001, Genetics; Ciobanu et al., 2004, JAS

Higher pH and more moisture means

- ❖ Appearance ++
- ❖ Color ++
- ❖ Tenderness ++
- ❖ Aroma +
- ❖ Juiciness ++
- ❖ Flavor ++

Dried Hams

What is the role of CAST in dried, processed pork products?

What value do they have?

- ❖ Individual genes - depends on the frequency of alleles, size of the effect and the trait value.
- ❖ Value can be significant in “real” dollars and in “marketing” value.



Where we are today?

Table 1. Candidate genes and gene tests identified and used in the industry

Candidate genes	Traits	Industry use
HAL	meat quality/stress	yes
KIT	white color	yes
MC1R	red/black color	yes
MC4R	growth and fatness	yes
RN, PRKAG3	meat quality	yes
AFABP, HFABP	intramuscular fat	??
CAST	tenderness	yes
IGF2	carcass composition	yes
ESR, PRLR, RBP4	litter size	yes
FSHB	reproduction	unknown
NRAMP, SLA	disease susceptibility	unknown
FUT1	disease susceptibility	yes
Trade secret tests	several traits	yes

Where we are today?

Position of Industry Leaders

Number of markers used 20-50

Markers under development >100 and <700,000

Time to market use 18 months or less

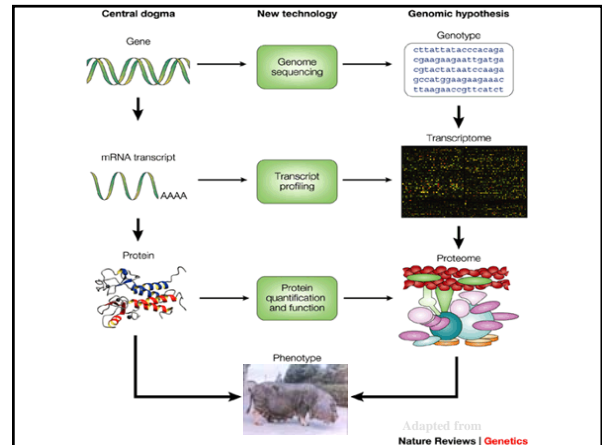
Strategies for use of QTL in selection

- ❖ Two-stage QTL selection 1° Select on QTL
2° Select on polygenic EBV
- ❖ QTL index selection

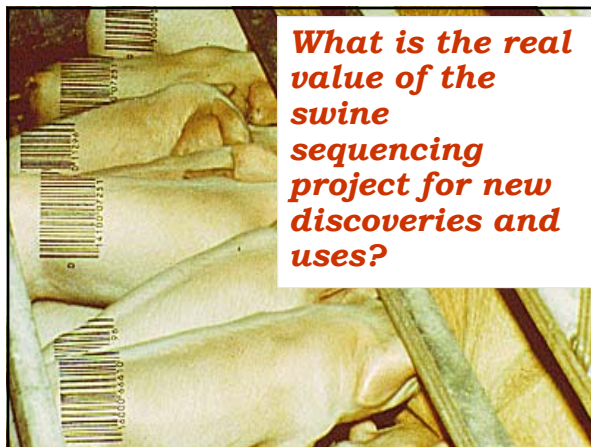
Genotypic data Phenotypic data

↓ ↓

Overall EBV = QTL EBV + Polygenic EBV



What is the real value of the swine sequencing project for new discoveries and uses?



Expected outcomes

- ❖ Increased discovery yields better products.
 - First delivery through marker/gene assisted selection.
 - Better genetic lines – better products for producers, packers and consumers
 - Genomics only modifies basic product and can't change route to market immediately.
- ❖ Increased pressure to sell “genomics” to pay for expenditures.
- ❖ Potential for GM products: depending on acceptability.
- ❖ “Value” of pig genome for animal and human health can be exploited.