

Update on the Molecular Genetics Projects at CCSI



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Current Projects

- Validation of useful genes and markers under Canadian conditions (ACAAF)
 - Ending March 2009
- Effect of SLC44A3 gene on pork colour (WSTA)
 - Ending November 2008
- Effect of IGF2 gene on sow productivity (WSTA)
 - Ending December 2008

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Update ...

- ACAA Molecular Genetics Project:
 - IGF2
 - Effect on carcass lean and uniformity
 - HFABP
 - Effect on intramuscular fat
 - MC4R, CAST & PRKAG3
 - Effects on a variety of traits
 - 50K SNP chip
 - Genomic selection

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IGF2

- IGF2 is a gene with large effect:
 - 15-30% phenotypic variation in muscle mass
 - 10-20% phenotypic variation in backfat thickness
 - Fat allele related to better sow productivity
 - Paternally imprinted

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IGF2 'A' allele frequencies in Canadian populations

	Overall	Slaughter pigs*	AI boars
Duroc	1.00 N=546	1.00 N=113	1.00 N=66
Landrace	0.77 N=469	0.68 N=136	0.82 N=42
Lacombe	0.35 N=52	0.26 N=42	
Yorkshire	0.90 N=704	0.90 N=268	0.95 N=65

* Random sample of purebred station-tested pigs

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Heart-type Fatty Acid Binding Protein: HFABP

- Role: Fatty acid metabolisms
- Alleles: Three RFLPs:
 - *HaeIII*, *HinfI* & *MspI*
- Effect: IMF and backfat
- Application: Increase IMF content without affecting backfat thickness
 - No difference in backfat thickness between HFABP alleles while there were significant differences in IMF
 - Difference between homozygous genotypes can reach 0.4% IMF content in two Duroc populations
 - Fast growing leaner market hogs with desirable level of IMF content

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HFABP: *Hae* III Frequency

Freq	DD	Dd	dd	D	d	SUM
YO	54	197	113	0.42	0.58	364
DU	41	131	80	0.42	0.58	252
LA	10	84	119	0.24	0.76	213
LC	1	1	13	0.10	0.90	15
SUM	106	413	325			844

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HFABP: *Msp* I Frequency

Freq	HH	Hh	hh	H	h	SUM
YO	293	60	11	0.89	0.11	364
DU	144	86	22	0.74	0.26	252
LA	158	49	6	0.86	0.14	213
LC	13	1	1	0.90	0.10	15
SUM	608	196	40			844

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HFABP: *Hinf* I Frequency

Freq	AA	Aa	aa	A	a	SUM
YO	350	13	1	0.98	0.02	364
DU	39	119	94	0.39	0.61	252
LA	159	52	2	0.87	0.13	213
LC	13	1	1	0.90	0.10	15
SUM	561	185	98			844

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Melanocortin-4 Receptor: MC4R

- **Expression:** Brain of mammals
- **Role:** Energy homeostasis
- **Effect:** Controlling several growth and performance traits in pigs
- **Association of alleles:**
 - Asn298:
 - Higher Average Daily Gain (ADG)
 - Higher backfat thickness
 - Asp298:
 - Lean growth
 - High feed conversion rate

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MC4R Frequency

MC4R	Frequency	Percent	Cumulative Frequency	Cumulative Percent
AA	182	25.71	182	25.71
GG	200	28.25	382	53.95
AG	326	46.05	708	100.00

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protein kinase, AMP-activated, gamma 3 non-catalytic subunit: PRKAG3

- **Role:** Regulation of energy homeostasis
- **Effect:** Meat quality by affecting the glycogen content in muscle
- **Mutation: I199V**
 - Present in all breeds
- **Association:**
 - Favorable allele (199I) is associated with lower glycogen, higher ultimate pH and favorable color
- **Application:** Considerable improvement can be made by selecting the 199I allele

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PRKAG3 Frequency

PRKAG3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
AA	35	4.94	35	4.94
GG	440	62.15	475	67.09
AG	233	32.91	708	100.00

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Calpastatin: CAST

- **Role:** A specific inhibitor of μ - and m-calpain proteases
- **Effect:** Post mortem activity is highly related to meat tenderness
- **Association:** Firmness, juiciness, Instron force, chewiness, and tenderness scores
- **Mutations:** Two missense
 - **CAST Hpy188I or Arg249Lys**
 - 249Arg: Associated with higher tenderness, lower cooking loss and Instron force
 - **CAST Pvull or Arg638Ser**
 - 638Arg: Associated with higher moisture in the cured ham

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CAST Hpy188I Frequency

Hpy188I	Frequency	Percent	Cumulative Frequency	Cumulative Percent
AA	149	21.05	149	21.05
GG	230	32.49	379	53.53
AG	329	46.47	708	100.00

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CAST Pvull Frequency

Pvull	Frequency	Percent	Cumulative Frequency	Cumulative Percent
AA	299	42.23	299	42.23
CC	112	15.82	411	58.05
AC	297	41.95	708	100.00

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Incorporation in Breeding Programs

- Estimation of genotype probabilities
- Inclusion of probabilities as covariates in BLUP models
- Use of major gene effect, polygene effect and genotype probabilities in mating plans
- Genomic selection using SNP panels

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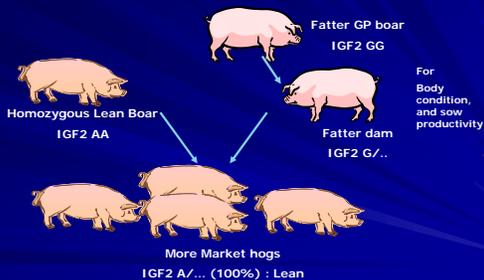
WSTA Molecular Genetics Projects

- **IGF2 & Sow Productivity:**
 - Effect of paternal allele of heterozygote sire (AG) on the reproductivity of the daughter



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Producing more and leaner market hogs from fatter dams



No effect of the dam's genotype due to paternal imprinting

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WSTA Molecular Genetics Projects

- SLC44A3 (Colour Gene) effect on meat quality traits:
- Associations of SNPs within the SLC44A3 gene with meat quality traits



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SLC44A3

- Population structure:
- ~500 animals: Different breeds in Alberta

Breed	Frequency	Percent
LC	44	8.82
LA	47	9.42
DU	95	19.04
YO	107	21.44
XX	206	41.28
SUM	499	100

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Choosing SNP of SLC44A3 Where, Frequency, MAF?

Discovery of SNP in SLC44A3				
SNP	bp position	11	12	22
1	122	AA	AT	TT
2	133	AA	AT	TT
3	215	CC	CT	TT
4	234	CC	CT	TT
5	314	CC	CT	TT
6	316	CC	CT	TT
7	330	CC	CG	GG
8	381	AA	AG	GG
9	386	CC	CT	TT
10	389	CC	CT	TT
11	396	CC	CT	TT
12	410	CC	CG	GG
13	473	AA	AG	GG

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Frequency of alleles in the population

SNP	bp position	11	12	22
1	122	AA	AT	TT
		0	1	499
2	133	AA	AT	TT
		0	1	499
3	215	CC	CT	TT
		232	184	84
4	234	CC	CT	TT
		84	184	232
5	314	CC	CT	TT
		499	1	0
6	316	CC	CT	TT
		232	184	84
7	330	CC	CG	GG
		0	3	497
8	381	AA	AG	GG
		171	207	121
9	386	CC	CT	TT
		216	182	102
10	389	CC	CT	TT
		499	1	0
11	396	CC	CT	TT
		123	206	171
12	410	CC	CG	GG
		497	1	2
13	473	AA	AG	GG
		2	27	471

Percentage of each allele in the population

SNP	bp position	11	12	22
1	122	AA	AT	TT
		0.00	0.20	99.80
2	133	AA	AT	TT
		0.00	0.20	99.80
3	215	CC	CT	TT
		46.40	36.80	16.80
4	234	CC	CT	TT
		16.80	36.80	46.40
5	314	CC	CT	TT
		99.80	0.20	0.00
6	316	CC	CT	TT
		46.40	36.80	16.80
7	330	CC	CG	GG
		0.00	0.60	99.40
8	381	AA	AG	GG
		34.20	41.40	24.20
9	386	CC	CT	TT
		43.20	36.40	20.40
10	389	CC	CT	TT
		99.80	0.20	0.00
11	396	CC	CT	TT
		24.60	41.20	34.20
12	410	CC	CG	GG
		99.40	0.20	0.40
13	473	AA	AG	GG
		0.40	5.40	94.20

Alleles chosen for the analysis					
SNP	bp position	11	12	22	%MAF
1	122	AA	AT	TT	
		0.00	0.20	99.80	0.10
2	133	AA	AT	TT	
		0.00	0.20	99.80	0.10
3	215	CC	CT	TT	
		46.40	36.80	16.80	35.20
4	234	CC	CT	TT	
		16.80	36.80	46.40	35.20
5	314	CC	CT	TT	
		99.80	0.20	0.00	0.10
6	316	CC	CT	TT	
		46.40	36.80	16.80	35.20
7	330	CC	CG	GG	
		0.00	0.60	99.40	0.30
8	381	AA	AG	GG	
		34.20	41.40	24.20	44.90
9	386	CC	CT	TT	
		43.20	36.40	20.40	38.60
10	389	CC	CT	TT	
		99.80	0.20	0.00	0.10
11	396	CC	CT	TT	
		24.60	41.20	34.20	45.20
12	410	CC	CG	GG	
		99.40	0.20	0.40	0.50
13	473	AA	AG	GG	
		0.40	5.40	94.20	3.10

Acknowledgements

Regional centres



Western Swine Testing Association



Ontario Swine Improvement



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Atlantic Swine Centre
du porc du Québec

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ALIDF 

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