

# **Identification of SNPs Associated with Bacterial Cold Water Disease and Spleen Index in Rainbow Trout**

**Sixin Liu**

**USDA/ARS, National Center for Cool and Cold Water Aquaculture  
Kearneysville, West Virginia**

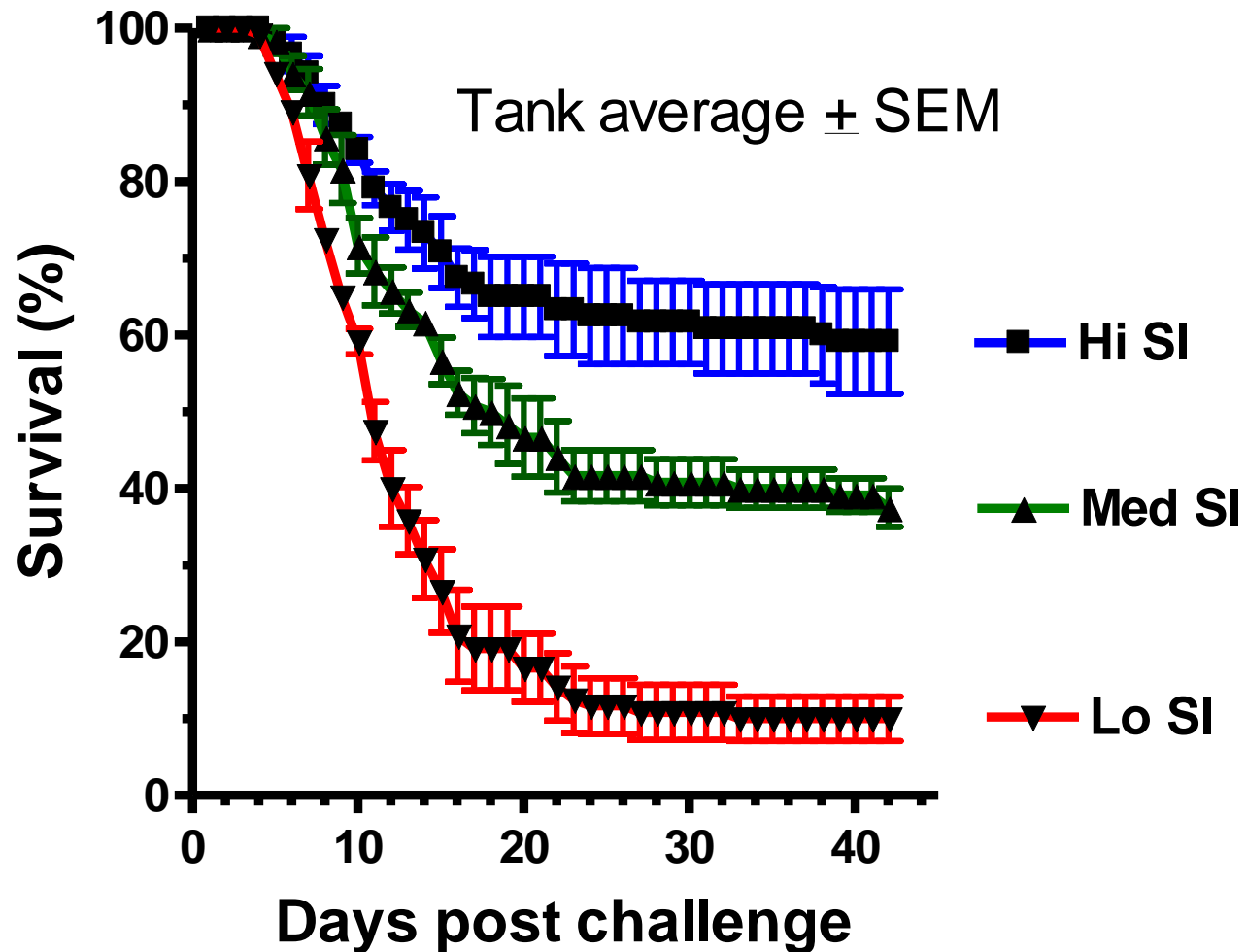


# Bacterial Cold Water Disease (BCWD)

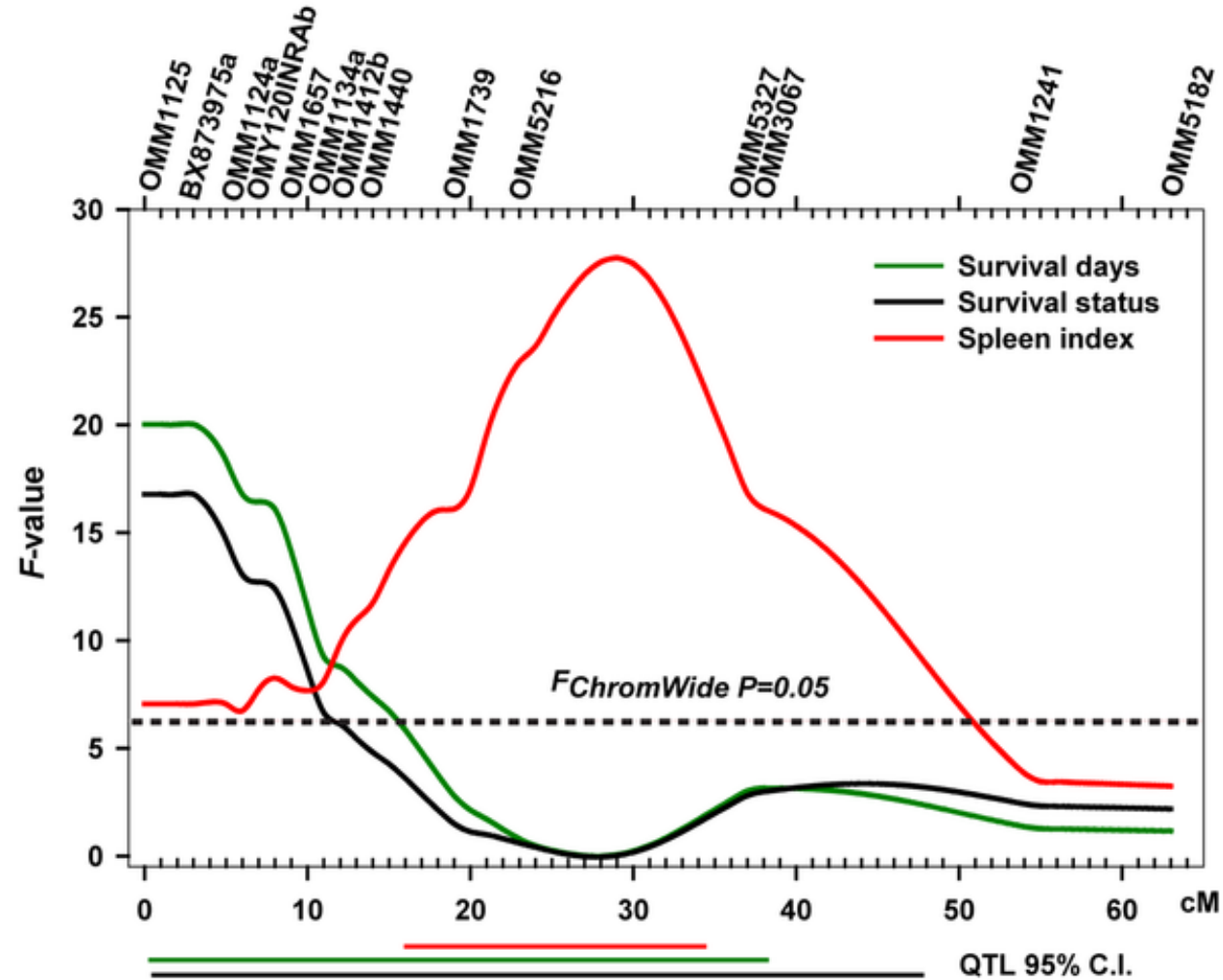
- Also called rainbow trout fry syndrome
- Caused by *Flavobacterium psychrophilum*
- Frequent cause of elevated mortality in rainbow trout
- BCWD Signs: Fry - lethargy, lack of feeding, darkened skin, enlarged spleen, anemia and high mortality
- No licensed commercial vaccine
- Use of antibiotics is a concern for emergence of antibiotic resistant pathogen
- NCCCWA initiated a selective breeding program for BCWD resistance in 2005



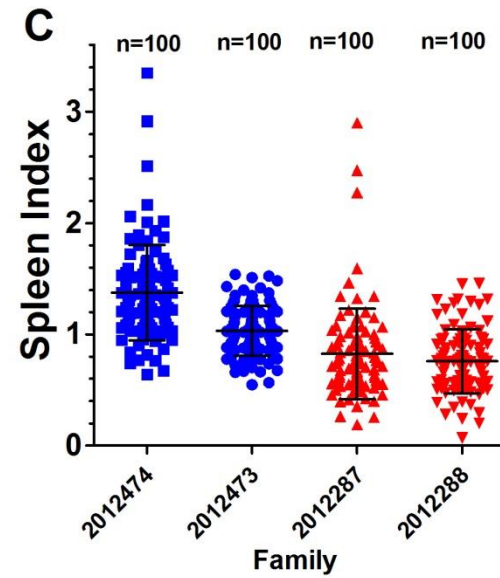
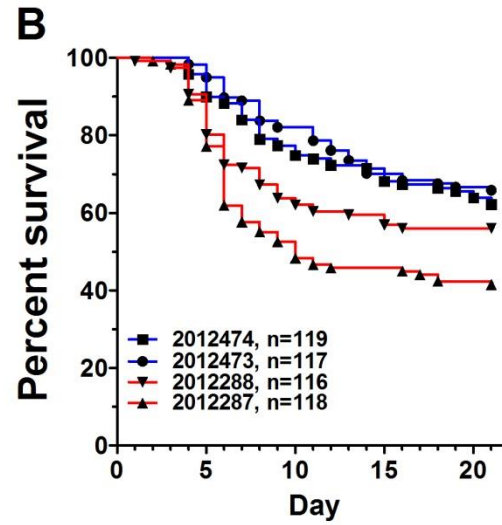
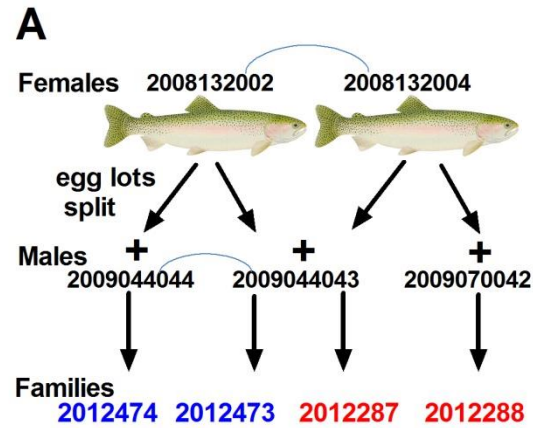
# Spleen Size Predicts BCWD resistance



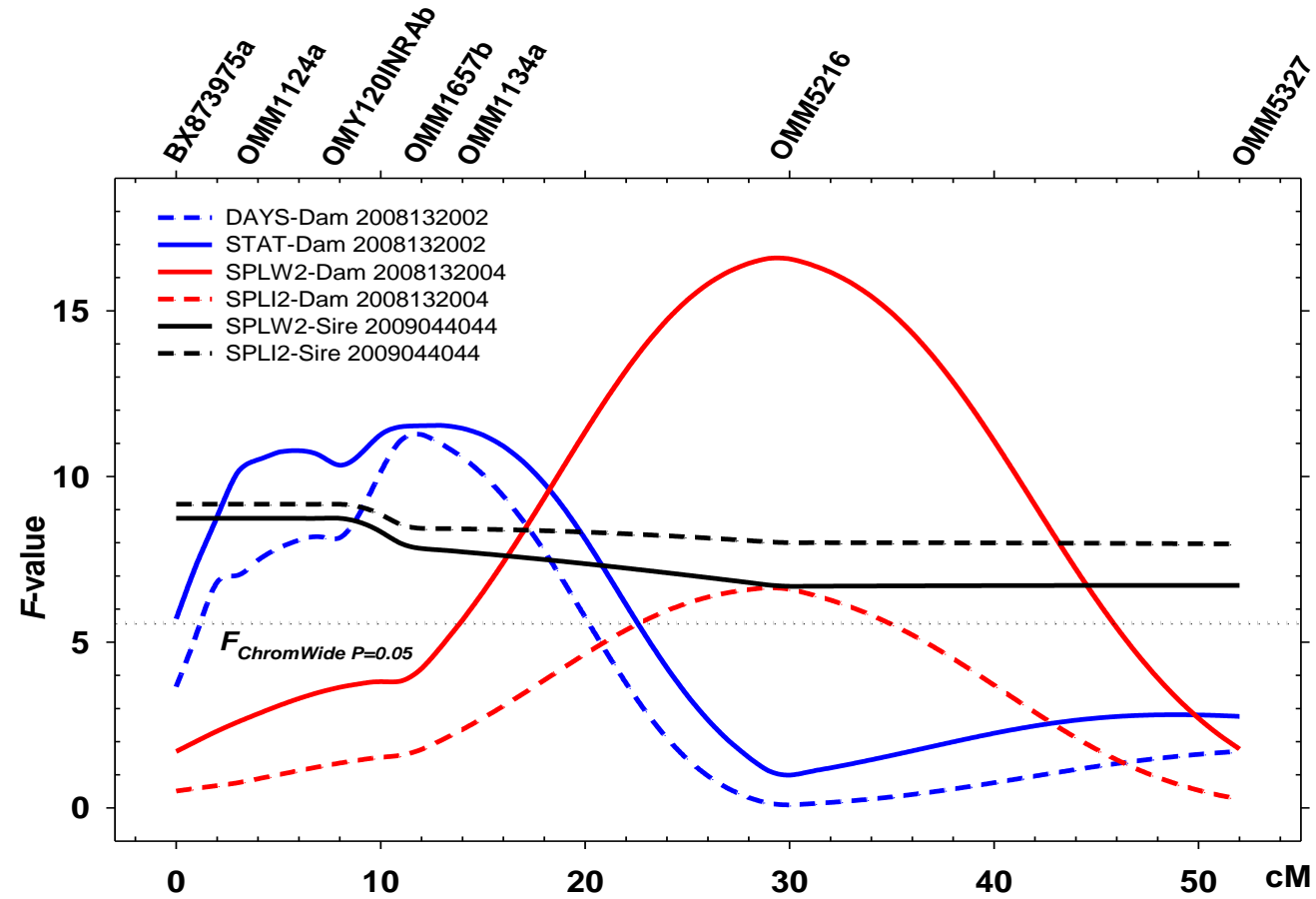
# QTL for BCWD resistance and SI on Omy19 identified in mapping family 2008132



# 2012 QTL Validation Mapping Populations



# Two Separate QTL for BCWD Resistance and SI



# **Objective**

**Identify SNPs associated with BCWD resistance and SI using GWAS and QTL mapping approaches**

# Materials and Methods

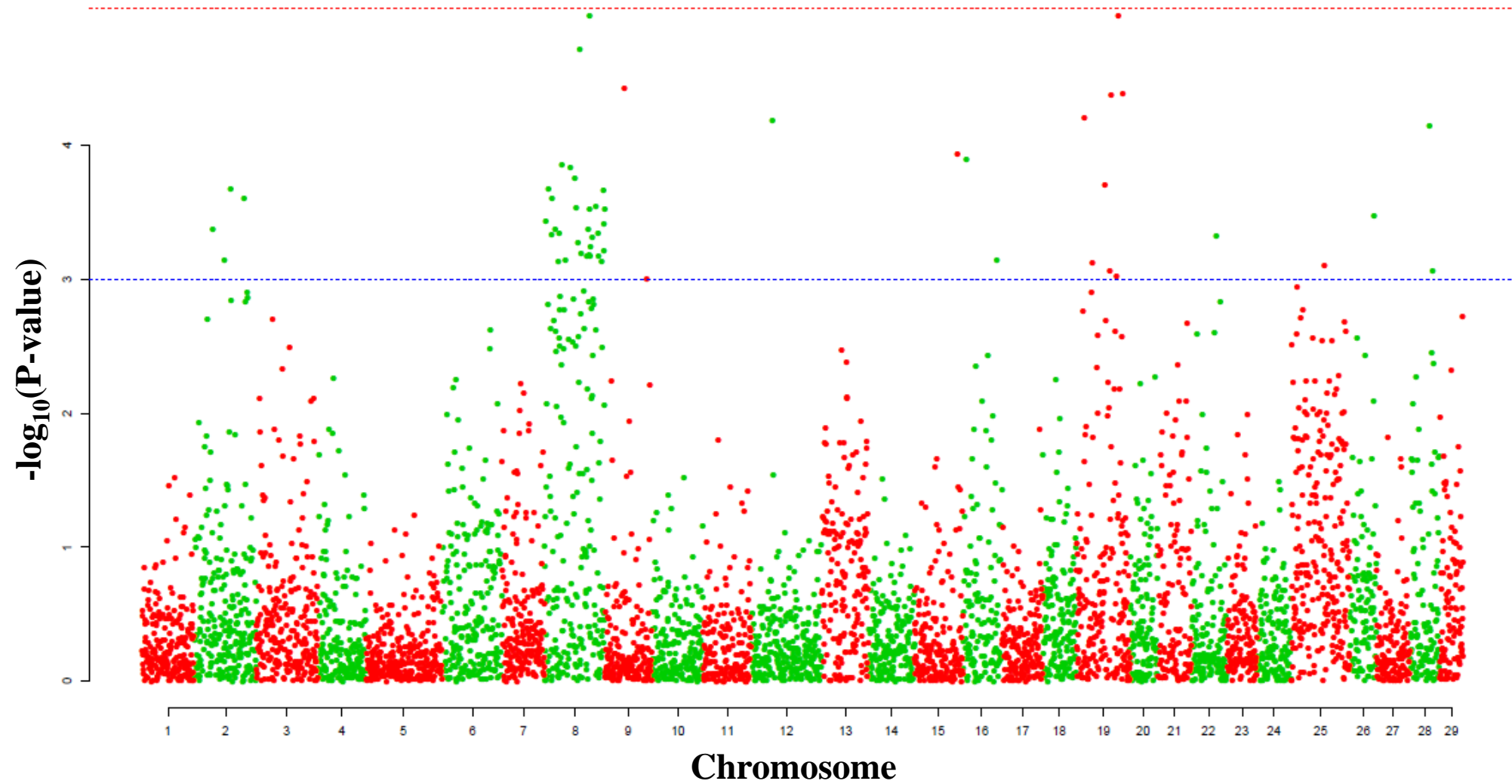
- **Mapping families**
  - 2012473**                      **100 fish for BCWD challenge**
  - 2012474**                      **100 fish for BCWD challenge and 98 fish for spleen index**
- **RAD genotyping**
  - SbfI digestion**   **Novoalign and perl scripts**
- **Genetic mapping**
  - MULTIMAP**   **LOD10**                      **SNPs were mapped to the reference genome**
  - Sex-specific linkage maps**
- **GWAS**
  - Grammar-Gamma method implemented in the R package GenABEL**
- **Half-sib QTL mapping**
  - GridQTL**



# SNP Identification and Linkage Mapping

- **7,849 SNPs were identified**
- **7,595 SNPs were assigned to chromosomes**
- **Female map      638 SNPs      5483      8.6/SNP**
- **Male map        438 SNPs      2964      6.8/SNP**

# GWAS for Survival Status with GenABEL-Grammar-Gamma



# SNPs associated with BCWD resistance based on GWAS

SNP	Omy	Allele 1	Allele 2	Survival Status		Survival Days	
				Effect	P	Effect	P
RTRAD89NT118565	2	T	C	-0.36	2.15E-04	-4.95	1.49E-04
RTRAD89NT095147	2	A	G	-0.34	4.30E-04	-4.29	9.68E-04
RTRAD89NT110567	2	G	T	-0.33	7.24E-04	-4.68	3.31E-04
RTRAD89NT131357	8	C	T	0.33	1.10E-05	3.70	2.72E-04
RTRAD89NT116978	8	G	C	0.40	1.93E-05	4.37	4.77E-04
RTRAD89NT103341	8	T	C	0.45	1.47E-04	5.44	5.53E-04
RTRAD89NT078368	8	A	C	0.42	2.15E-04	5.07	9.48E-04
RTRAD89NT148358	8	C	T	0.36	2.17E-04	4.43	7.16E-04
RTRAD89NT140425	8	A	G	0.44	2.87E-04	5.72	3.98E-04
RTRAD89NT112550	8	G	T	0.42	2.92E-04	5.23	8.18E-04
RTRAD89NT139370	15	G	C	0.38	1.17E-04	4.50	7.63E-04
RTRAD89NT135689	19	C	T	0.43	1.09E-05	5.09	8.76E-05
RTRAD89NT141241	19	G	A	-0.40	4.13E-05	-4.39	7.07E-04
RTRAD89NT125108	19	G	A	0.40	4.21E-05	5.29	5.22E-05
RTRAD89NT127892	22	T	C	-0.23	4.78E-04	-3.03	8.41E-04
RTRAD89NT142090	26	G	A	-0.30	3.36E-04	-3.83	6.82E-04
RTRAD89NT128385	28	G	A	-0.46	7.26E-05	-5.93	1.23E-04
RTRAD89NT137710	28	C	T	-0.26	8.68E-04	-3.77	2.43E-04

# SNPs associated with spleen index based on GWAS

SNP	Omy	Allele 1	Allele 2	Effect	P
RTRAD89nt147353	4	G	A	-0.97	1.42E-05
RTRAD89nt107990	4	G	T	-0.79	1.40E-04
RTRAD89nt148293	4	G	A	-0.82	1.69E-04
RTRAD89nt134509	5	A	G	0.85	9.21E-05
RTRAD89nt114301	5	G	T	0.62	1.14E-04
RTRAD89nt091881	5	T	C	0.80	2.69E-04
RTRAD89nt085023	5	C	T	0.78	3.47E-04
RTRAD89nt109036	5	T	G	0.78	3.63E-04
RTRAD89nt137156	5	A	G	-0.79	3.66E-04
RTRAD89nt089304	5	A	G	0.81	5.31E-04
RTRAD89nt127451	5	G	T	0.80	6.62E-04
RTRAD89nt081765	5	C	A	-0.74	6.99E-04
RTRAD89nt142812	5	C	T	0.52	8.70E-04
RTRAD89nt109928	5	T	C	0.74	8.82E-04
RTRAD89nt112119	12	C	A	-0.75	4.09E-04
RTRAD89nt110052	12	A	T	0.52	9.22E-04
RTRAD89nt109171	23	T	C	-0.50	2.99E-04
RTRAD89nt140132	24	G	A	0.81	4.59E-04
RTRAD89nt142053	27	T	C	0.47	8.56E-04
RTRAD89nt072289	29	C	T	0.98	7.88E-05

# QTL for BCWD resistance identified by half-sib QTL mapping

								Flanking Markers	
Category	Omy	Trait	Position (cM)	F	F <sub>ChrWide</sub> p=0.05	F <sub>ExpWide</sub> p=0.05	h <sup>2</sup>	Left	Right
Dam HS Analysis	19	STATUS	22	15.41**	7.8	15.3	0.29	RTRAD89nt135689	RTRAD89nt125108
	19	DAYS	24	14.96*	8.08	15.09	0.28	RTRAD89nt135689	RTRAD89nt125108
Sire HS Analysis	8	STATUS	6	21.46**	4.17	8.44	0.72	RTRAD89nt077533	RTRAD89nt148358
	8	DAYS	16	12.45**	4.1	8.56	0.45	RTRAD89nt148358	RTRAD89nt142845
	25	STATUS	64	6.8*	4.81	8.44	0.26	RTRAD89nt085710	RTRAD89nt120059
	25	DAYS	65	9**	4.75	8.56	0.34	RTRAD89nt085710	RTRAD89nt120059

# QTL for spleen index identified by half-sib QTL mapping

							Flanking Markers	
Category	Omy	Position (cM)	F	F <sub>ChrWide</sub> p=0.05	F <sub>ExpWide</sub> p=0.05	h <sup>2</sup>	Left	Right
Dam HS analysis	5	3	11.36*	7.7	14.64	0.43	RTRAD89nt108265	RTRAD89nt137156
	7	130	8.54*	8.14	14.64	0.33	RTRAD89nt136795	RTRAD89nt071431
	26	152	8.67*	7.39	14.64	0.34	RTRAD89nt099530	RTRAD89nt148730
	27	22	7.82*	7.25	14.64	0.31	RTRAD89nt113238	RTRAD89nt132122
Sire HS analysis	2	6	17.6**	6.59	13.1	0.63	RTRAD89nt119684	RTRAD89nt149352
	6	22	9.28*	5.95	13.1	0.36	RTRAD89nt089147	RTRAD89nt077857
	17	52	8.79*	6.71	13.1	0.34	RTRAD89nt074950	RTRAD89nt090428
	19	27	8.88*	5.63	13.1	0.35	RTRAD89nt094659	RTRAD89nt149131
	22	96	7.36*	6.53	13.1	0.29	RTRAD89nt138842	RTRAD89nt109237

# Conclusions

- **18 SNPs associated BCWD resistance and 20 SNPs associated with spleen index were identified. However, there is no shared significant SNPs for these two traits.**
- **In addition to the significant QTL for BCWD resistance on chromosome Omy19, two significant BCWD QTL on chromosomes Omy8 and Omy25 derived from the sires were identified.**
- **There was no QTL for spleen index derived from the dam 2008132002 on chromosome Omy19, which confirms previous finding that two separate QTL on chromosome Omy19 control BCWD resistance and spleen index, respectively.**

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# QTL for BCWD resistance identified by half-sib QTL mapping

								Flanking Markers	
Category	Omy	Trait	Position (cM)	F	F <sub>ChrWide</sub> p=0.05	F <sub>ExpWide</sub> p=0.05	h <sup>2</sup>	Left	Right
Dam HS analysis	2	STATUS	20	10.31*	8.44	15.3	0.20	RTRAD89nt135931	RTRAD89nt118565
	16	STATUS	121	8.79*	7.75	15.3	0.17	RTRAD89nt079624	RTRAD89nt086508
	19	STATUS	22	15.41**	7.8	15.3	0.29	RTRAD89nt135689	RTRAD89nt125108
	25	STATUS	96	11.42*	7.64	15.3	0.22	RTRAD89nt088553	RTRAD89nt114044
	28	STATUS	53	7.46*	7.4	15.3	0.15	RTRAD89nt093730	RTRAD89nt148989
	2	DAYS	24	9.96*	8.18	15.09	0.19	RTRAD89nt135931	RTRAD89nt118565
	19	DAYS	24	14.96*	8.08	15.09	0.28	RTRAD89nt135689	RTRAD89nt125108
	20	DAYS	58	7.31*	7.09	15.09	0.14	RTRAD89nt138373	RTRAD89nt137053
Sire HS analysis	8	STATUS	6	21.46**	4.17	8.44	0.72	RTRAD89nt077533	RTRAD89nt148358
	13	STATUS	131	5.11*	4.49	8.44	0.20	RTRAD89nt116690	RTRAD89nt117459
	25	STATUS	64	6.8*	4.81	8.44	0.26	RTRAD89nt085710	RTRAD89nt120059
	26	STATUS	20	5.35*	4.15	8.44	0.21	RTRAD89nt102658	RTRAD89nt096484
	28	STATUS	80	5.76*	4.33	8.44	0.22	RTRAD89nt083376	RTRAD89nt128385
	8	DAYS	16	12.45**	4.1	8.56	0.45	RTRAD89nt148358	RTRAD89nt142845
	12	DAYS	7	4.7*	4.31	8.56	0.18	RTRAD89nt108132	RTRAD89nt076924
	13	DAYS	132	6.34*	4.54	8.56	0.24	RTRAD89nt116690	RTRAD89nt117459
	25	DAYS	65	9**	4.75	8.56	0.34	RTRAD89nt085710	RTRAD89nt120059
	28	DAYS	80	6.25*	4.29	8.56	0.24	RTRAD89nt083376	RTRAD89nt128385