



AquaGen

# Selective breeding for CMS resistance reduces PMCV viral loads and alters host response

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# Global activity



# Genetics of disease resistance



- Disease resistance traits are often heritable
- The table displays heritabilities of resistance to viruses, bacteria, or parasites/etc (results from the AquaGen salmon strain)

Disease	$h^2$	QTL
IPN	0.7	yes
CMS	0.5	yes
flavobacteriosis	0.45	yes
HSMI	0.31	yes
pox virus	0.3	no
yersiniosis	0.3	yes
furunculosis	0.3	no
PD	0.27	yes
SRS	0.25	no
BKD	0.25	no
AGD	0.22	no
CGD	0.2	no
salmon lice	0.2	no
winter ulcer	0.15	no
ISA	0.08	no

# CMS in AquaGen



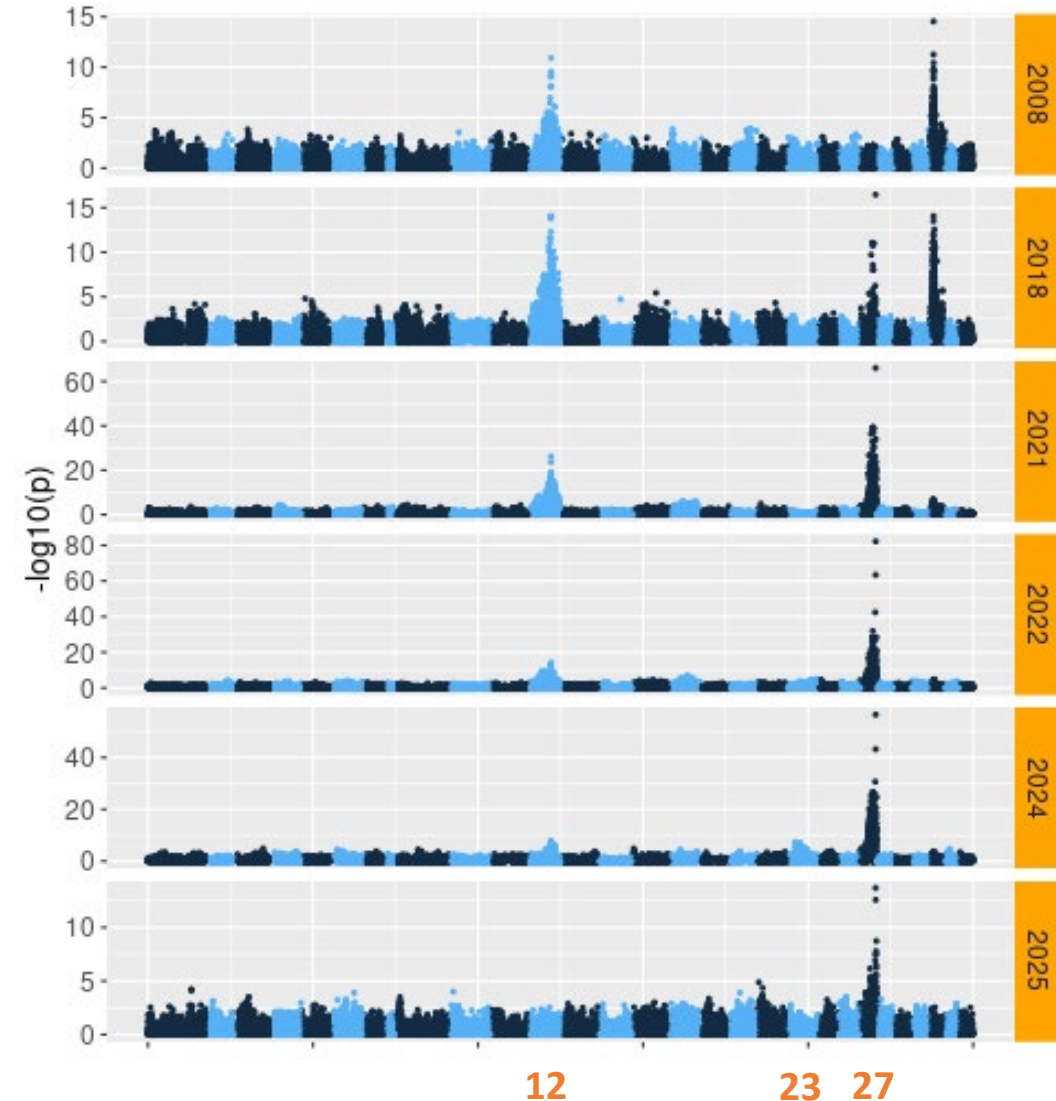
- 2010: PMCV-levels were measured in AquaGen fish at ~5 kg, 2 months after CMS outbreak
- PMCV-levels were found to be heritable
- Selective breeding from 2012 to 2018, using 2 QTLs
- From 2018: genomic selection based on controlled challenge tests at VESO Aqualab

Year class	Data from	Heritability ( $\pm$ SE)
2008	Field	0.25 $\pm$ 0.06
2018	Challenge test	0.42 $\pm$ 0.05
2021	Challenge test	0.46 $\pm$ 0.04
2022	Challenge test	0.50 $\pm$ 0.04
2024	Challenge test	0.42 $\pm$ 0.05
2025	Challenge test	0.25 $\pm$ 0.08

# Genetic control of CMS-resistance

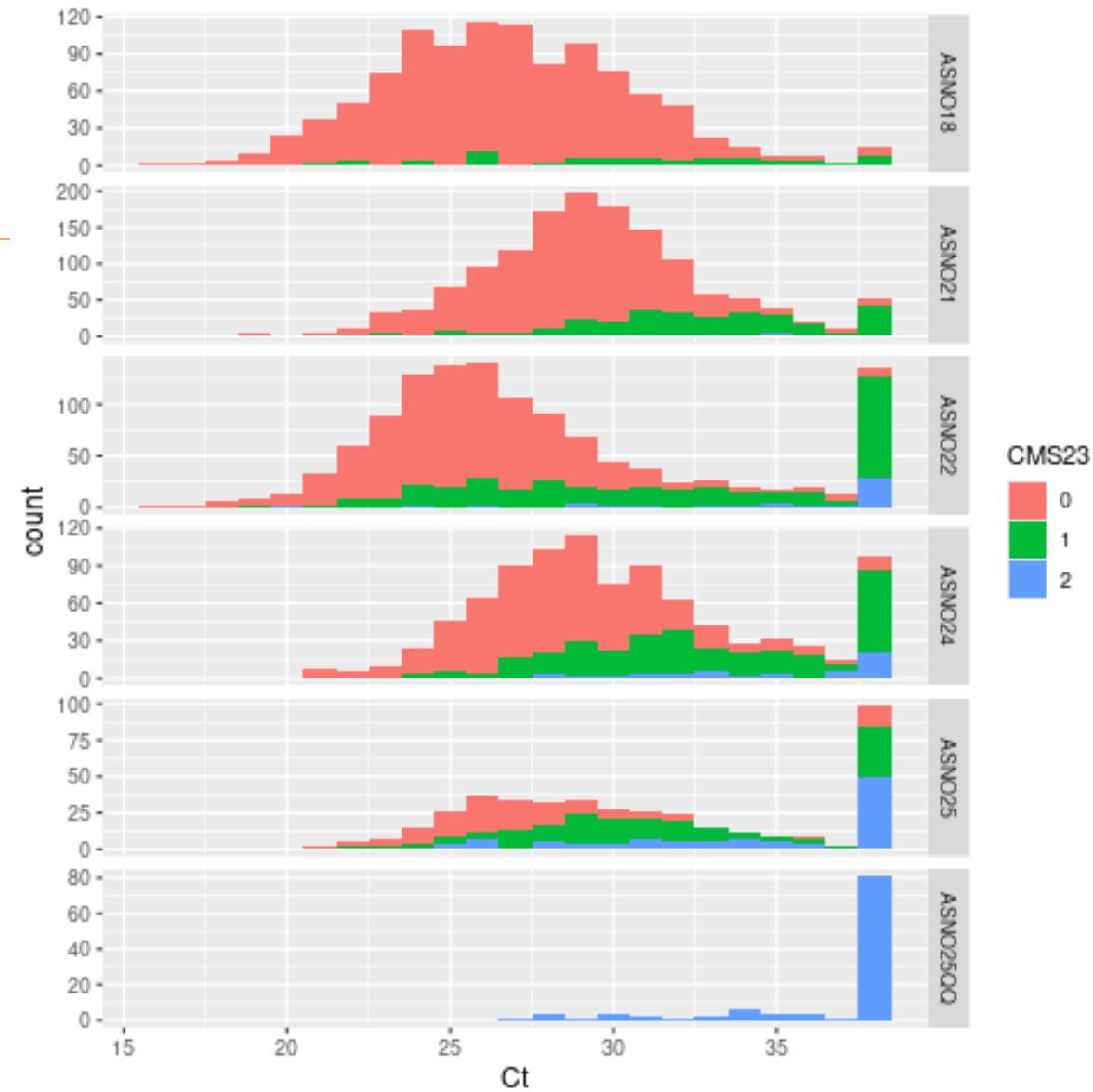


- In the AquaGen-strain, CMS-resistance is determined largely by three QTLs, on chromosome 23, 12, and 27
- The QTL on chr. 23 (CMS23) is most important, currently explaining 70% of the genetic variation
- The resistance allele at CMS23 has low but increasing frequency



# Genetic improvement

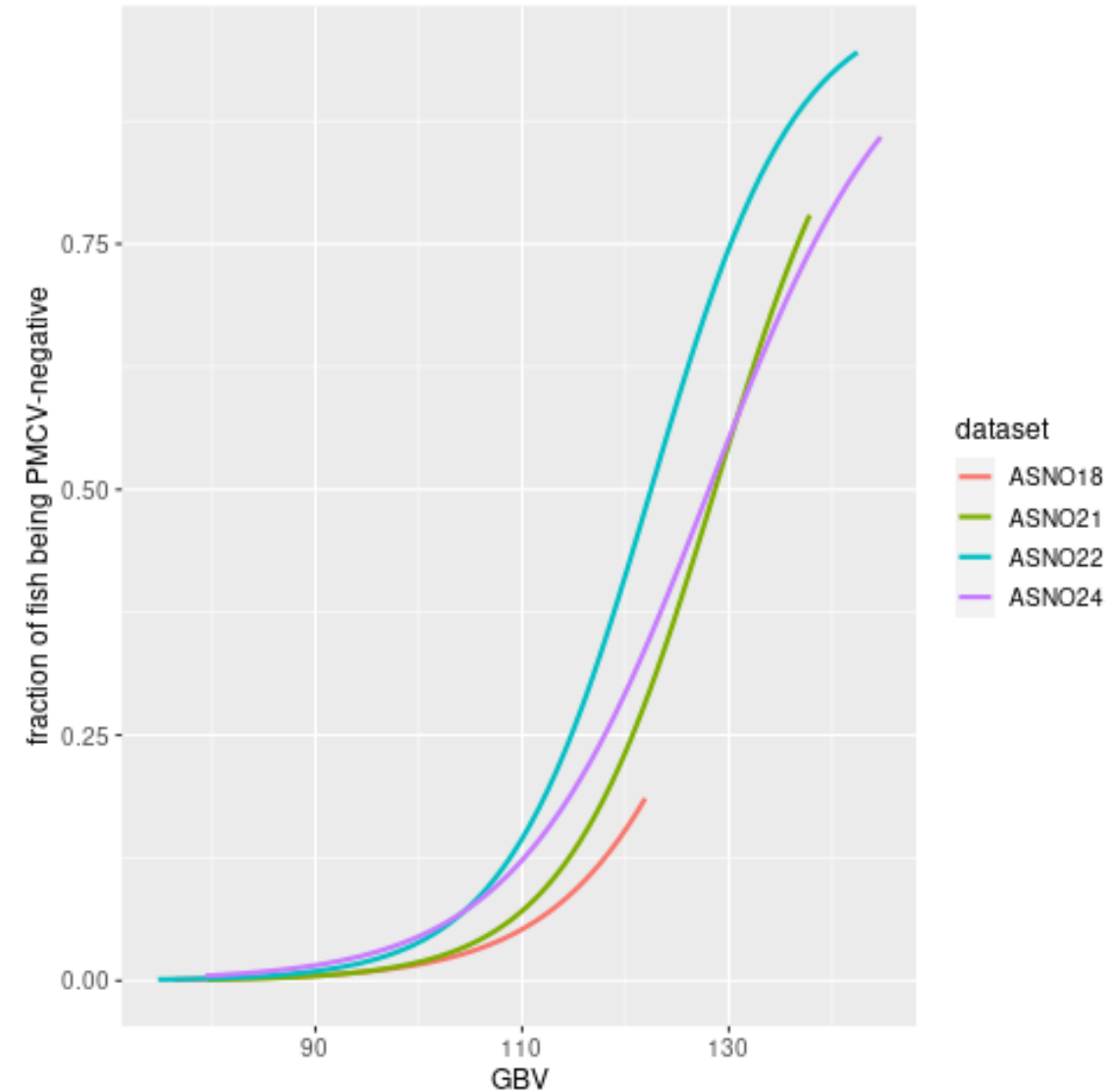
- The distribution of Ct-values (at end of challenge test) is shifting towards higher values (=> less virus)
- In a strongly selected test group, 75% of the fish were PMCV-negative



PMCV-  
negative fish

# Genetic improvement

- CMS-resistance is selected for in the breeding nucleus, using genomic selection
- Genomic selection is trained in challenge test data
- Gradual increase in resistance, year by year



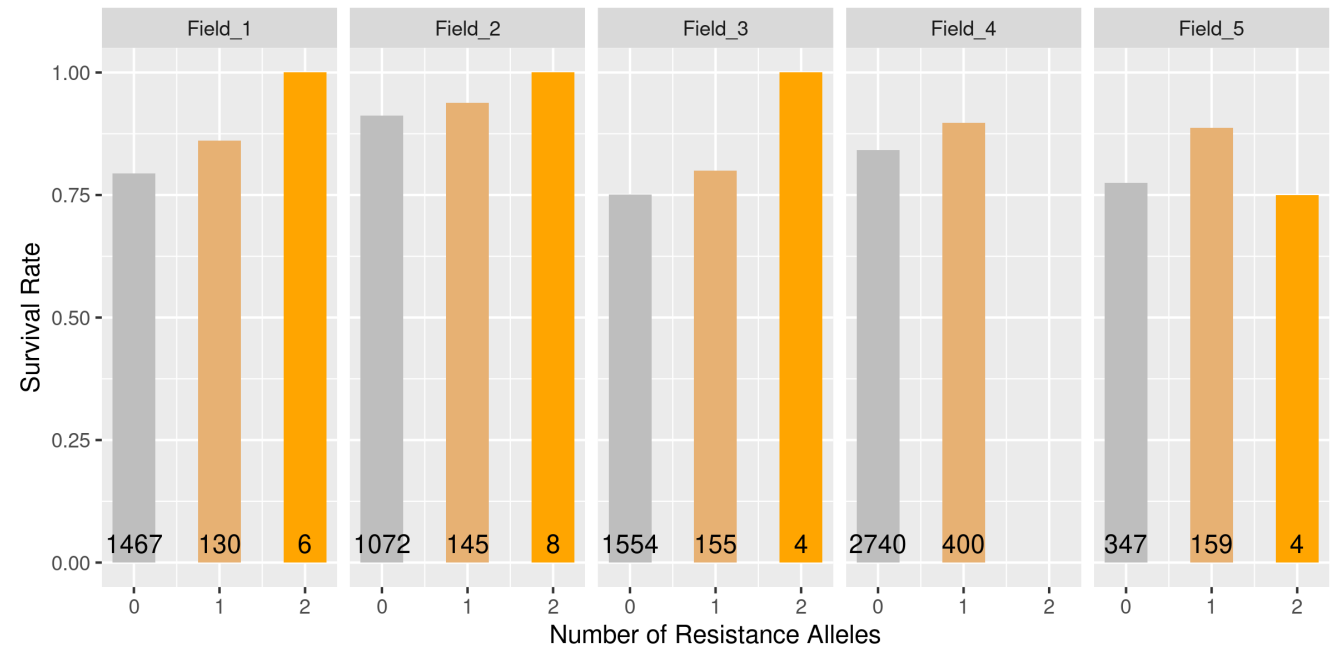
# High responders versus low responders

- Fish with low breeding values (GBVS) have gene expression profiles similar to High Responders (as defined by Timmerhaus et al, 2012)
- ...and vice versa
- => Fish with 'good genes' tend to get rid of PMCV and have a controlled immune response

Source	Gene set name	N genes	Direction	P -value
Timmerhaus 2012	late_HR	86	Down	2.6E-29
	late_LR	20	Up	0.38
Sun 2024	HR	984	Down	1.1E-42
	LR	496	Up	0.009

# Field validation

- The genetic correlation between challenge tests and CMS field outbreaks is relatively high (0.60 on average)
- ..meaning that selection gives higher survival in the field
- The figure displays relationship between CMS23 (number of resistance alleles) and survival in field
- Group protection comes on top of this



In this dataset the y is «PMCV-negativity», not survival

# GEN-innOva CMS Edge

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Superior CMS-resistance

- ✓ Premium product for Atlantic salmon
- ✓ Developed exclusively to strengthen the natural defense against CMS
- ✓ QTL selection
- ✓ Healthy growth performance
- ✓ Reduce disease-related losses
- ✓ Achieve healthier, more robust harvests
- ✓ High selection standards
- ✓ Limited-edition product





AquaGen

# The good genes

Responsible breeding since 1971