



Disease Resistant Shrimps: Merging the Old with the Latest

M Salazar, J Cock, E Erazo, A Suarez, R Banger, O Hennig, M Rye

Genetica Spring Colombia

Akvaforsk Genetic Center Norway



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Benchmark
Genetics



ABCCC

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Mass selection



Resistance

Pathogen

Genomic selection

Tolerance

Heritability

Immune priming

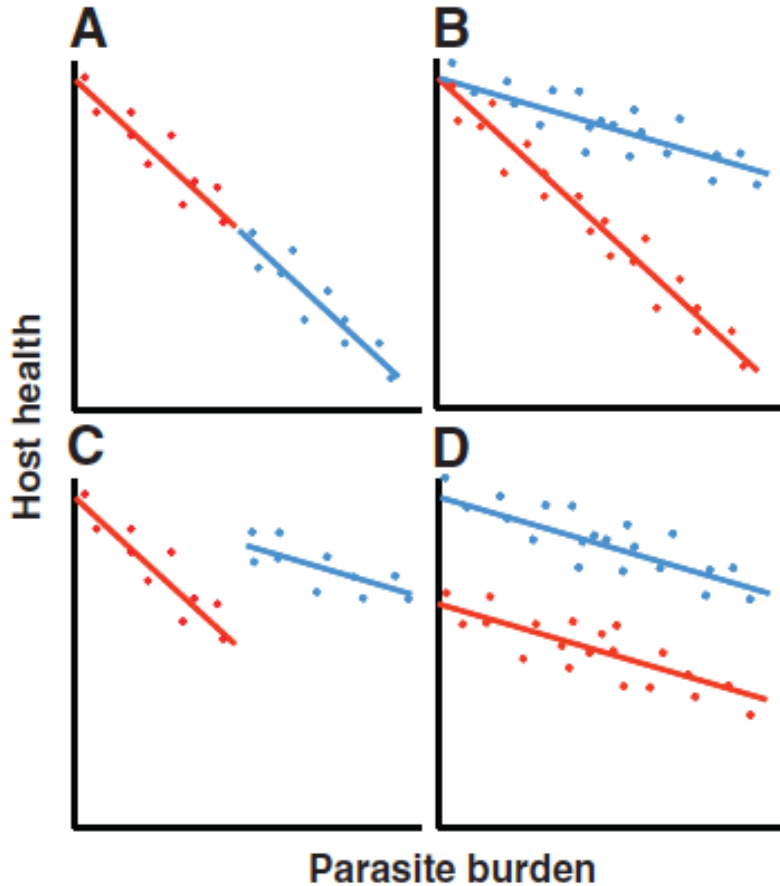
HOST DEFENSE

Resistance

Ability to limit
pathogen load.

Tolerance

Ability to “deal with” a
given pathogen load.

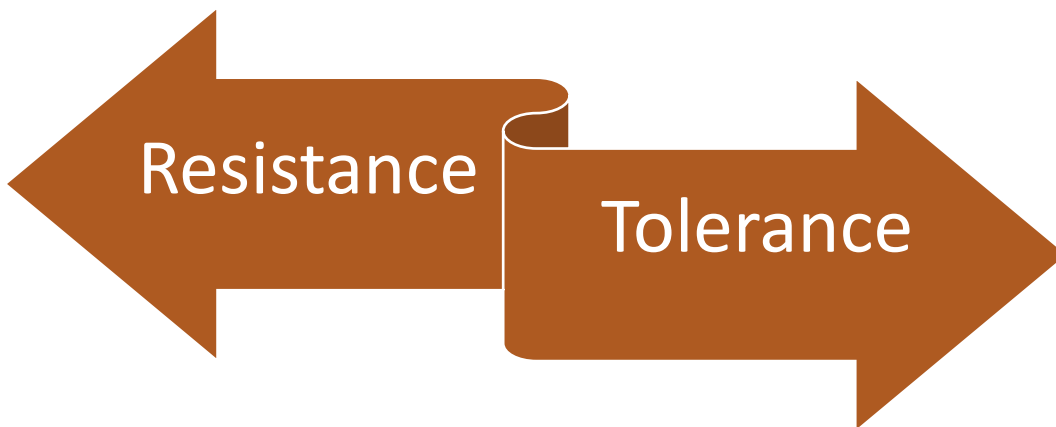


A = Diference in resistance

B = Diference in tolerance

C= Resistance and tolerance

D= No diferences in resistance
nor tolerance



Are they correlated ?

Evolutionary advantage ?



EVOLUTIONARY IMPLICATIONS

Resistance = negative effect on pathogen prevalence

Tolerance = neutral or positive



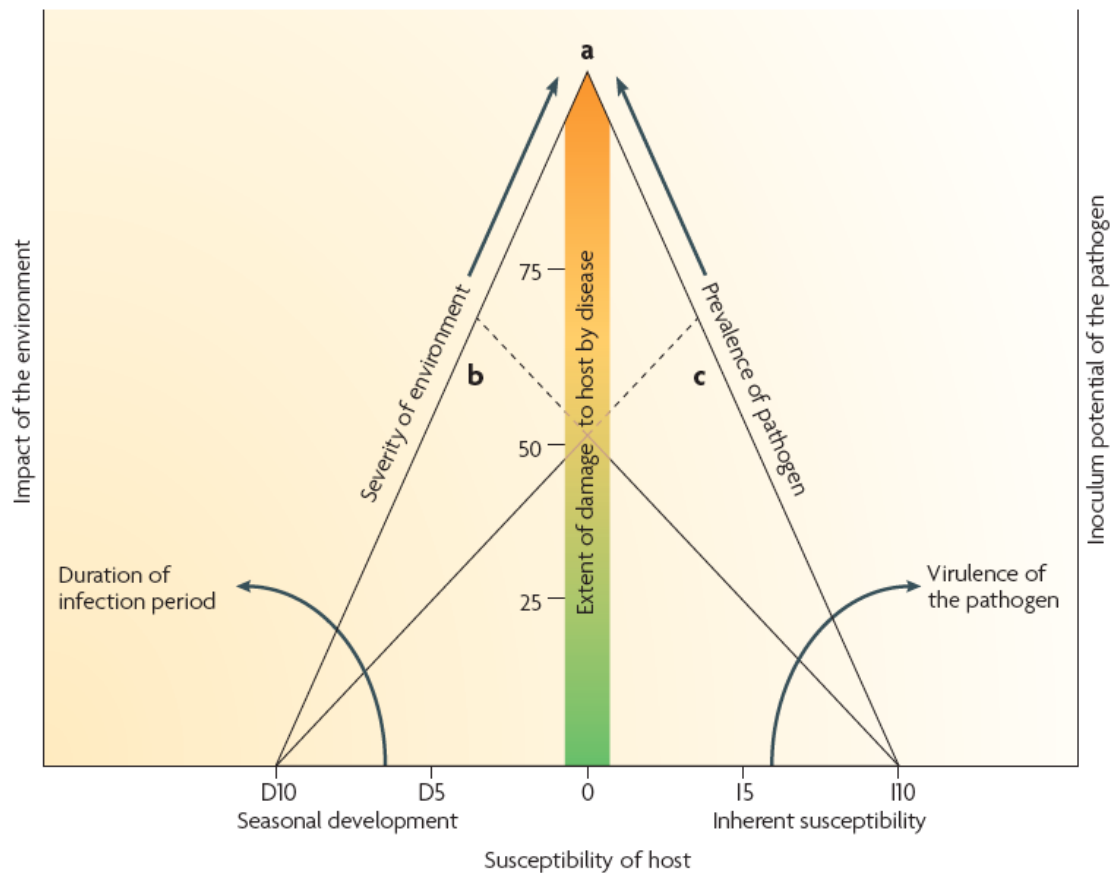
Host resistance selects for parasite adaptation which then selects for host resistance

= Evolutionary dynamics

A high rate of infection but low virulence should select for host tolerance, whereas the opposite should favour resistance (Restif & Koella 2004)

Tolerance is more likely to go to fixation than resistance (Roy & Kirchner 2000). Resistance mechanisms work by eliminating parasites, thus reducing the very selection pressures that favoured them in the first place.







Susceptible



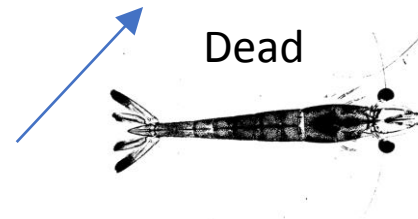
Latent



Acute



R_0



Dead



Chronic



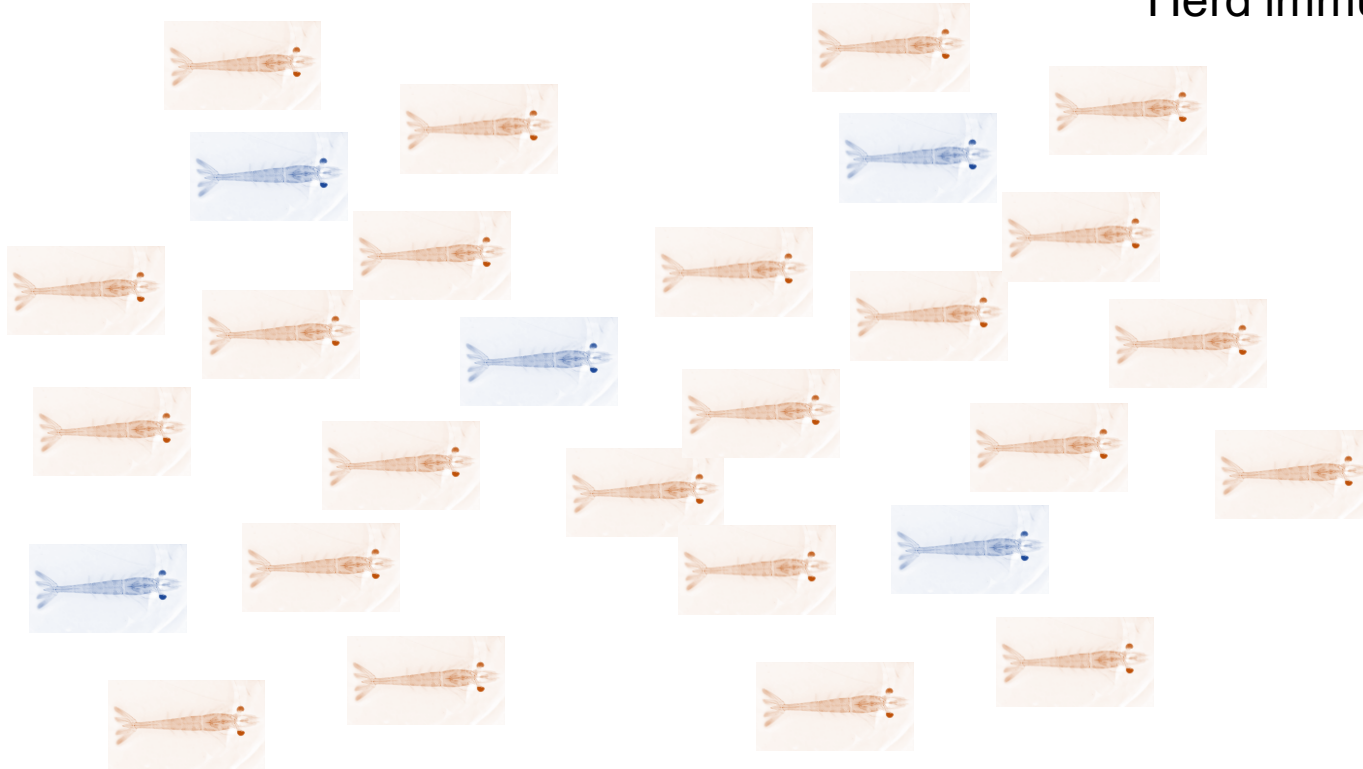
R0 EXAMPLES



Pathogen	R0	
Smallpox	3	www.pnas.org? cgi? doi? 10.1073? pnas.162282799
HIV	2.14-6.89	https://doi.org/10.1371/journal.pone.0083778
ZIKA	3.8	Epidemics . 2016 Dec;17:50-55. doi: 10.1016/j.epidem.2016.10.
TSV	92	Journal of Invertebrate Pathology 83 (2003) 168–176
WSSV	60	Journal of Invertebrate Pathology 83 (2003) 168–176

WHAT IF NOT ALL ANIMALS ARE SUSCEPTIBLE?

Herd immunity

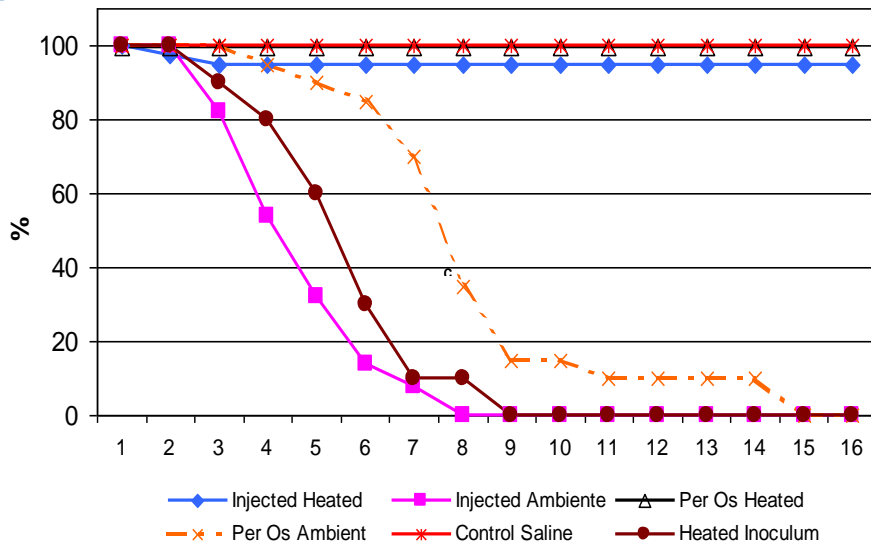


$$\text{HIT} = \frac{R_0 - 1}{R_0} \text{ or } 1 - \frac{1}{R_0}$$

$R_0=2$ HIT 50%

$R_0=4$ HIT 75%

$R_0=10$ HIT 90%



RO AND ENVIROMENT

PATHOGEN	TEMPERATURE	SALINITY	OXIGEN
WSSV	Inverse correlation	ND	Inverse correlation
IMNV	Direct Correlation		Inverse correlation
AHPND		Direct correlation	Inverse correlation

BREEDING FOR DISEASE R/T



REAL BENEFIT OF SELECTION



Genetic variation in resistance



Standardized methods for selection of R/T



Correlation with other traits

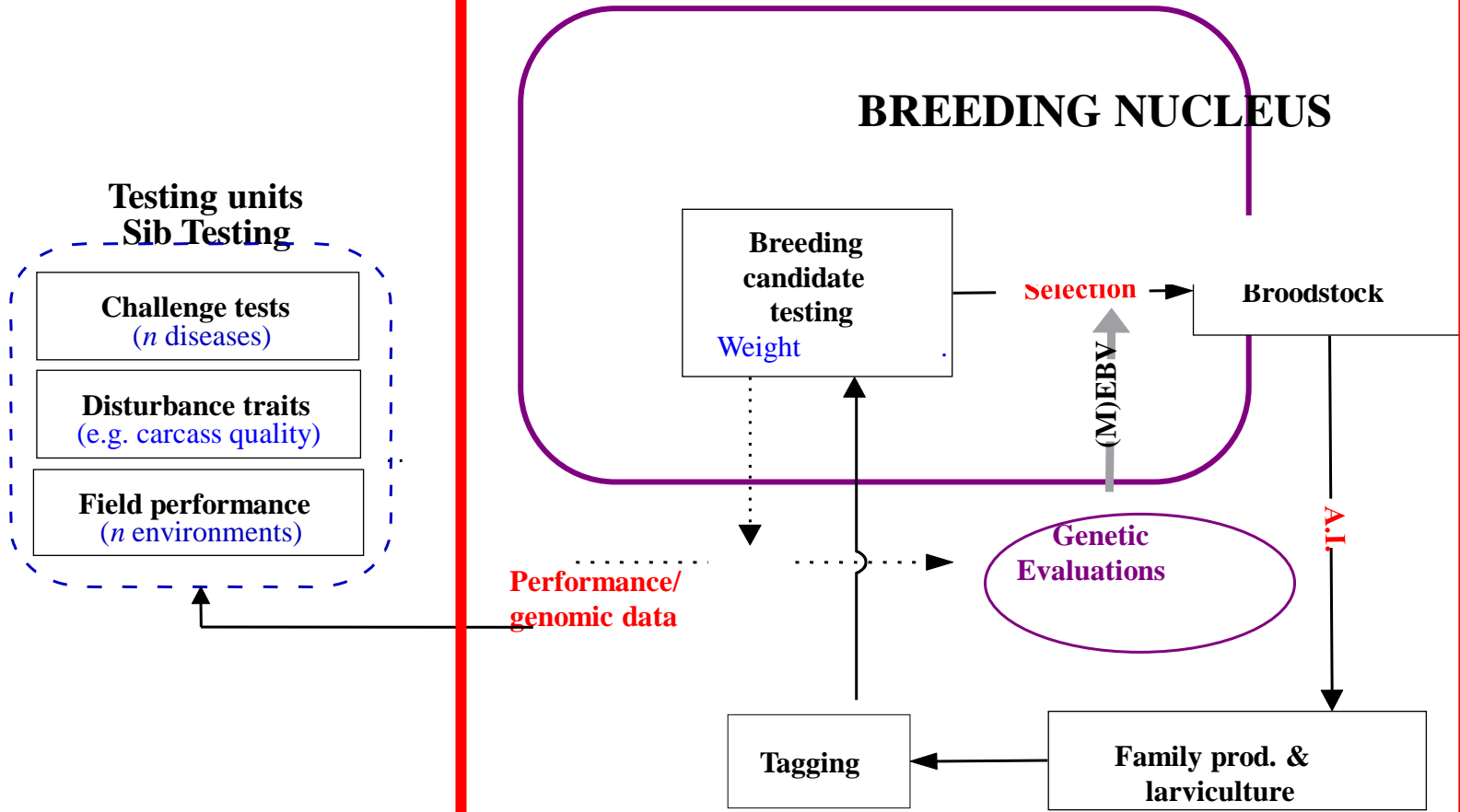


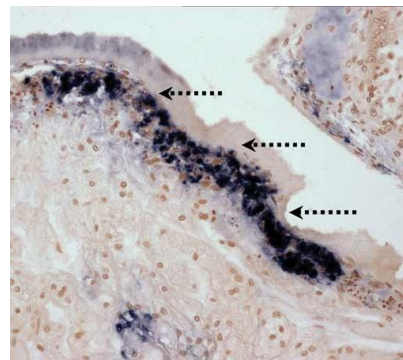
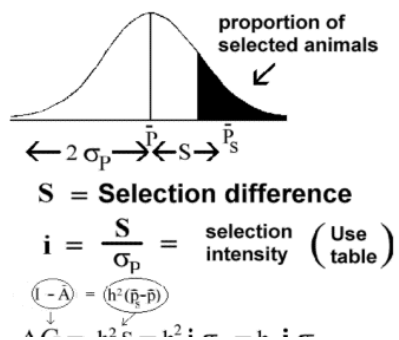
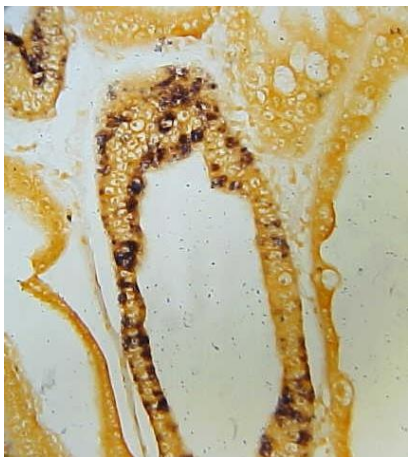
Pathogen response

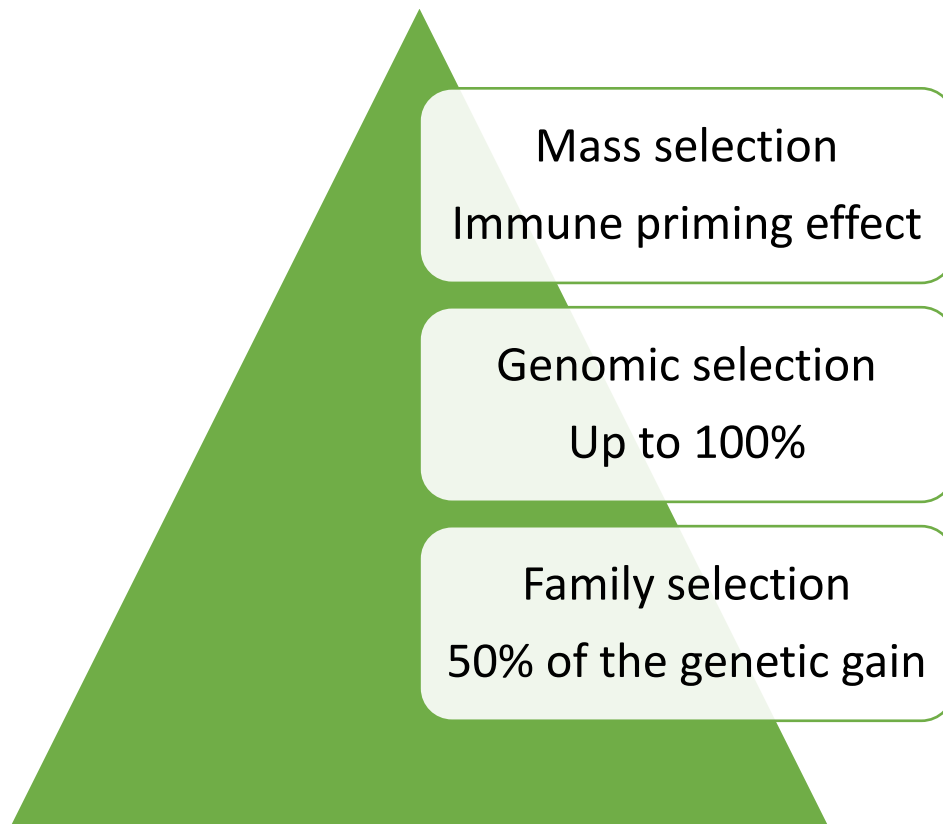
12/11/2018



INDUSTRY STANDARD: FAMILY BASED (SIB) SELECTION







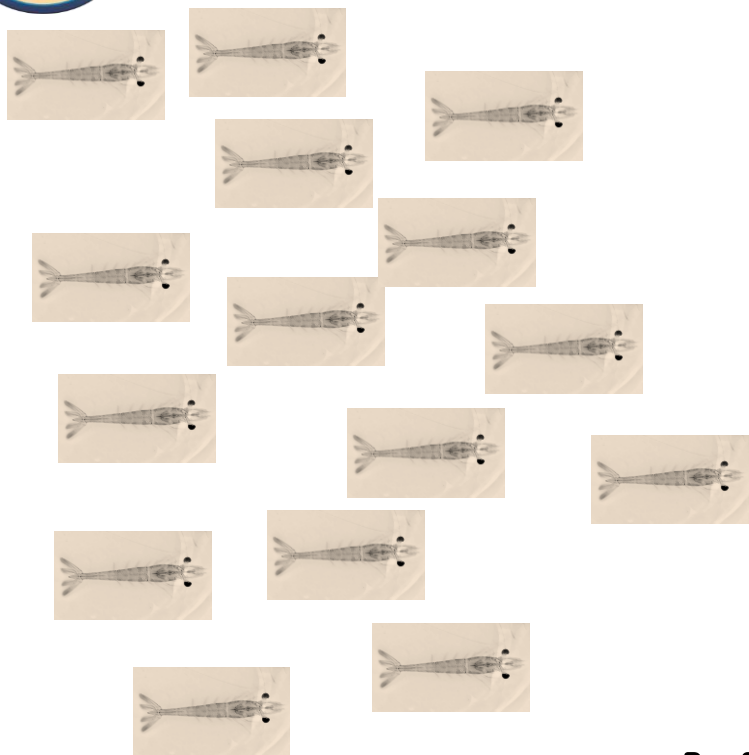


WHAT ABOUT BIOSECURITY

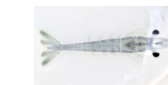


Family -
Genomic

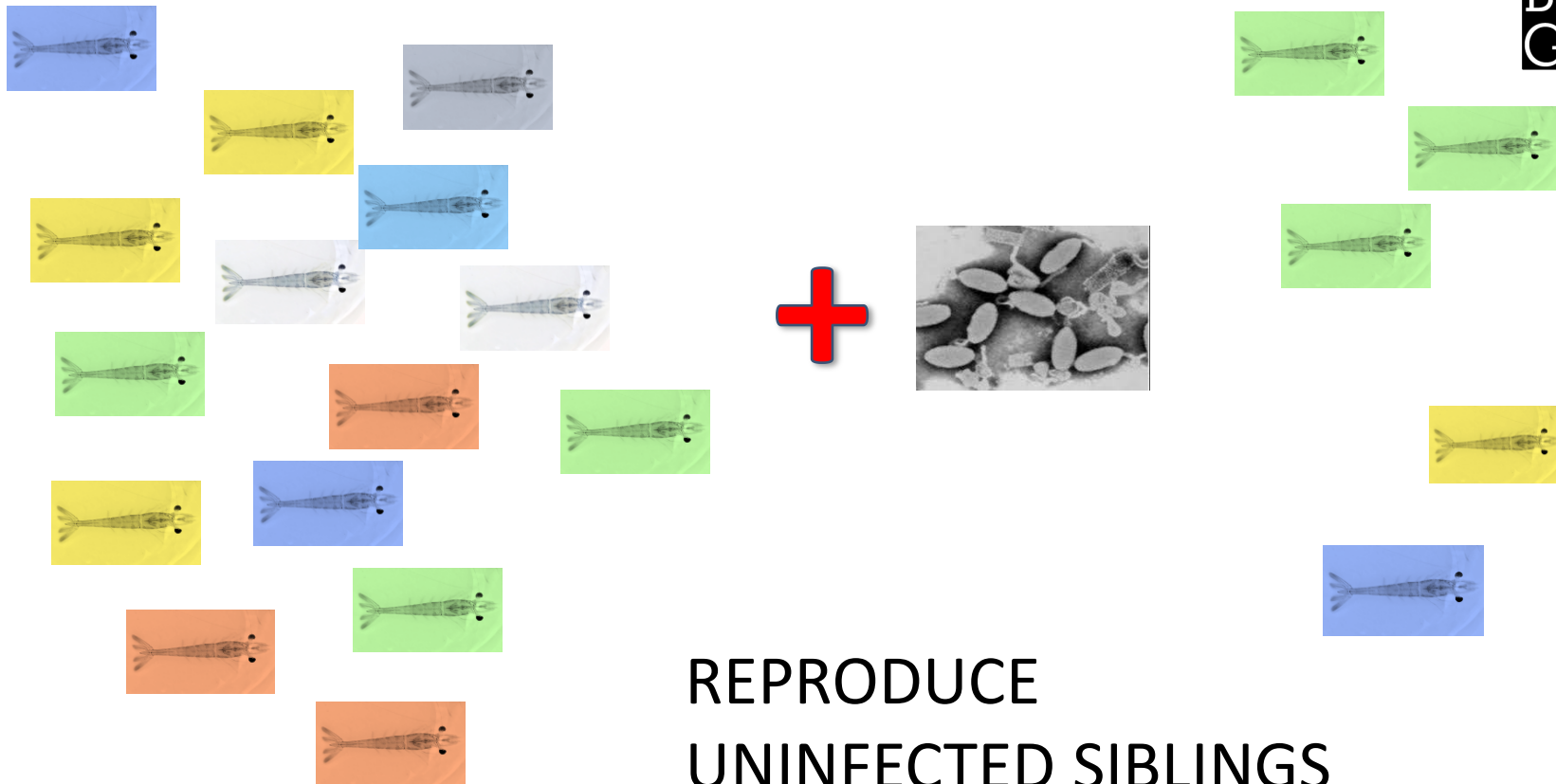
Mass



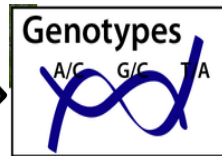
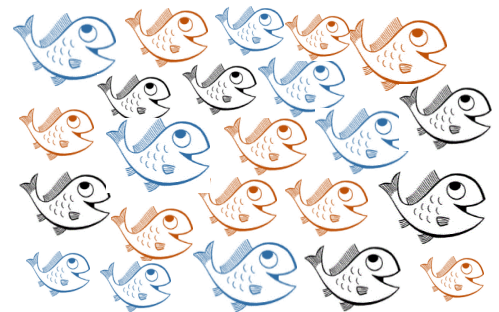
REPRODUCE
SURVIVORS



MASS SELECTION



Selection candidates



ATGCGTATA +0.1gr AGCTAATTG +0.07gr GATATAGAT +0.19gr

ATGCGTATA +0.1gr AGCTAACTG +0.2gr GATATAGAT -0.03gr



ATGCAATATA -0.12gr ATCTAATTG +0.07gr GATAGAGAT -0.03gr

ATGCAATATA -0.12gr ATCTAACTG +0.2gr GATATAGAT +0.19gr



ATGCGTATA +0.1gr AGCTAATTG +0.07gr GATAGAGAT -0.03gr

ATGCAATATA -0.12gr ATCTAATTG +0.07gr GATATAGAT +0.19gr

Picks up QTL effects of all SNPs across the Genome

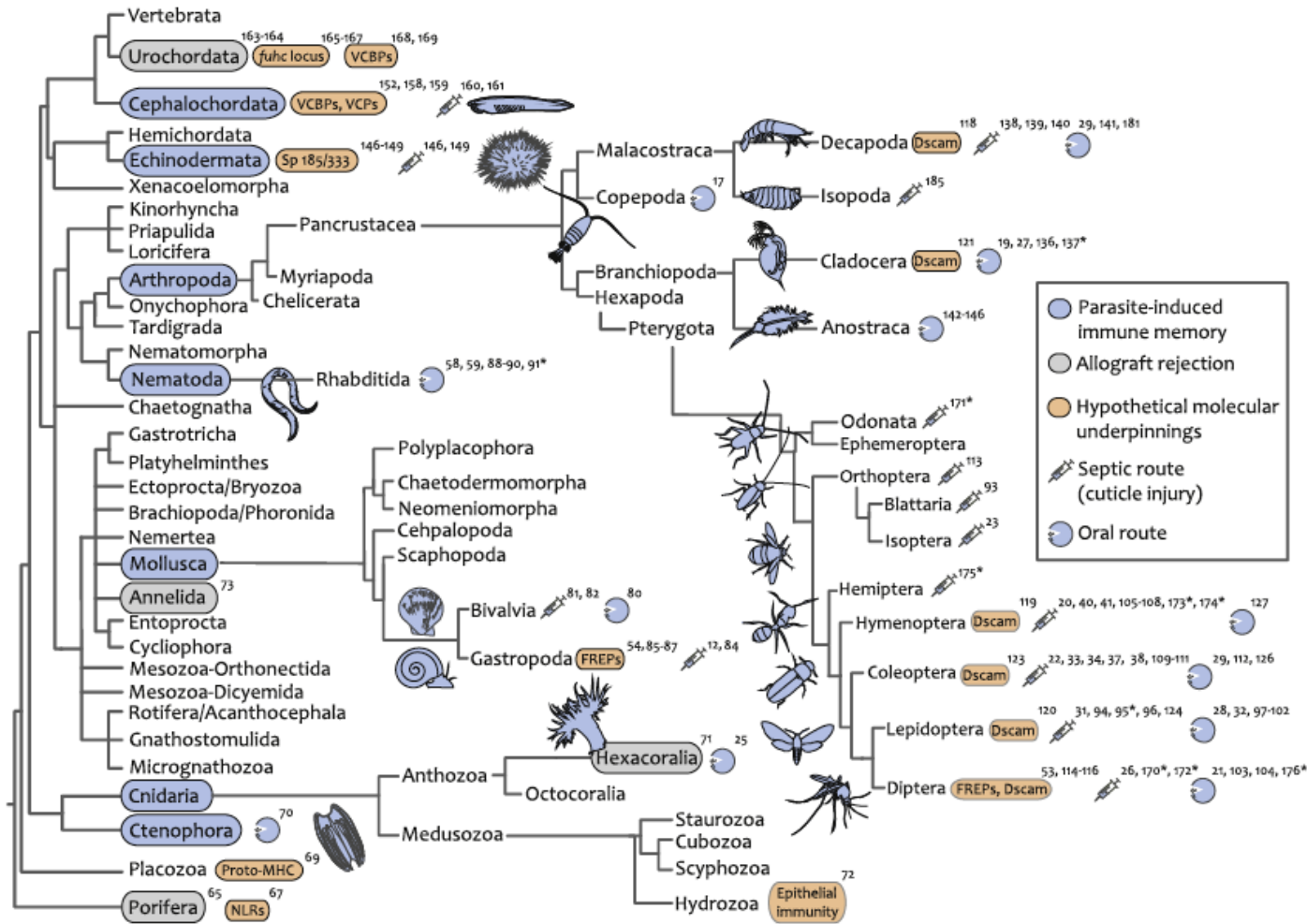
Increased genetic gains:

- Utilize the full genetic variance → selection differentials
- Increased accuracy of genetic predictors (EBV)
- Reduced accumulation of inbreeding



IMMUNE PRIMING. - IMMUNE MEMORY?

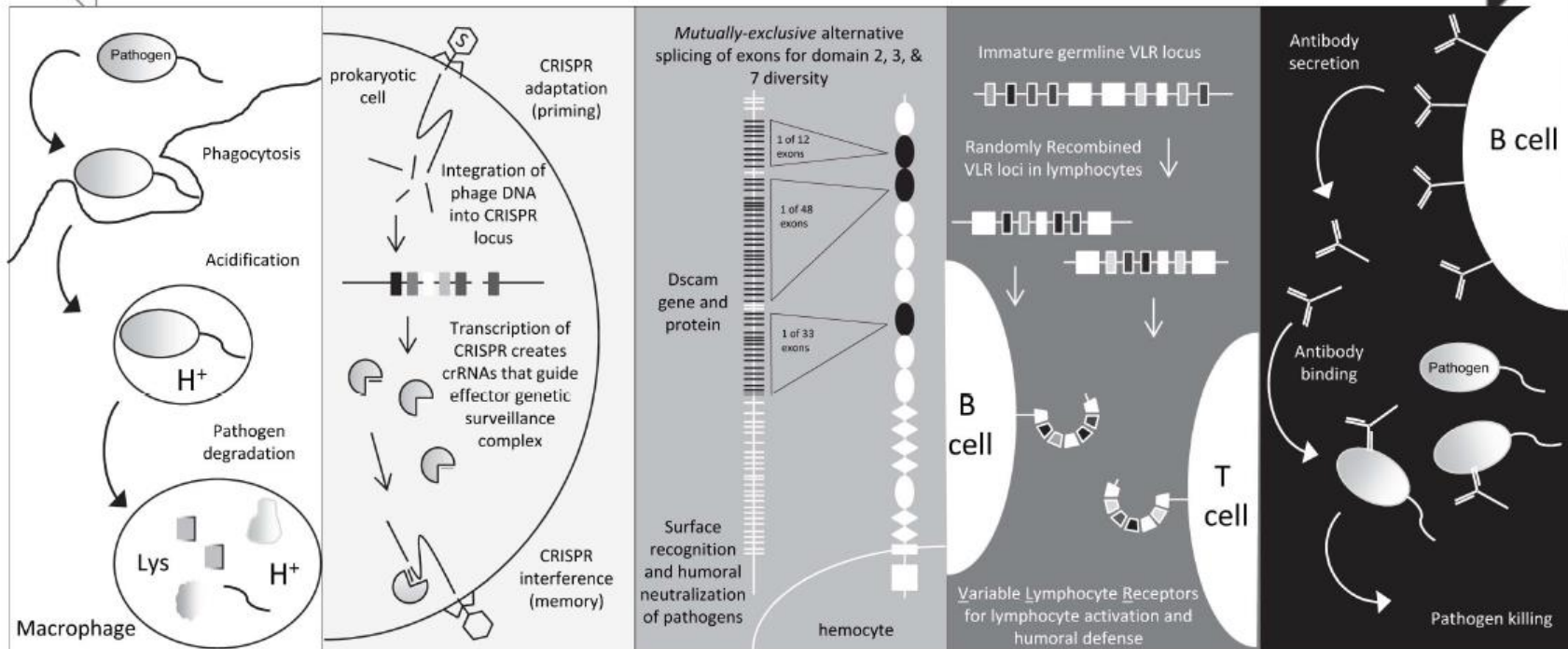
- Viral accommodation Tim Flegel
- Immune priming invertebrates
- Transgenerational immune priming
 - Male
 - Female
- Role of DSCAM molecules in response to different bacterial strains
- Epigenetics of Non lethal thermal stress in *A. franciscana*





Innate immunity

Adaptive immunity



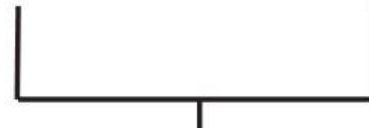
some form of innate immunity in all life

prokaryotes

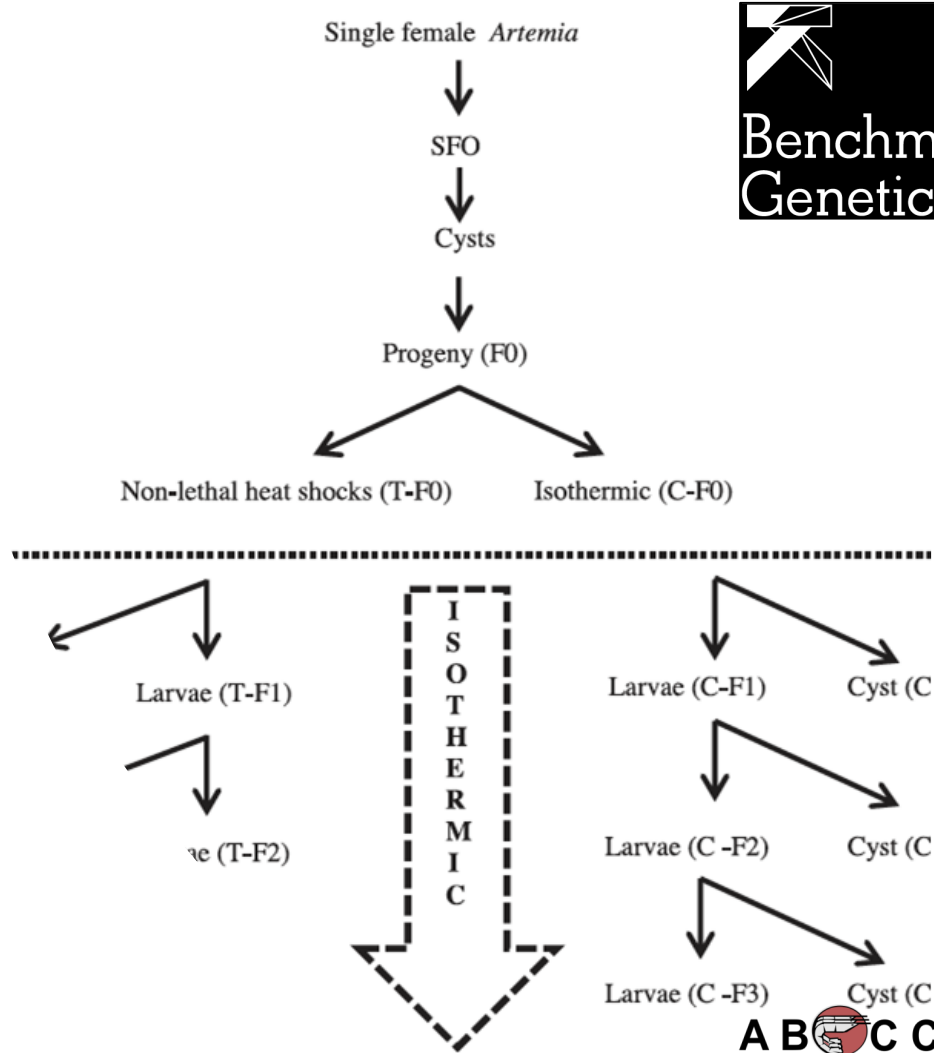
invertebrates

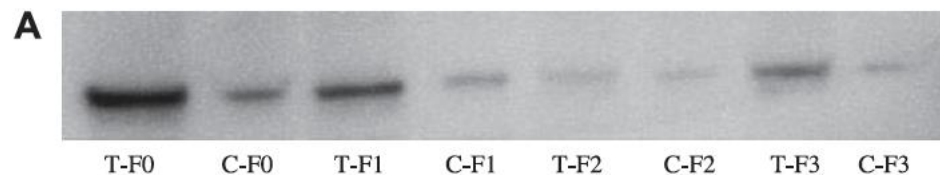
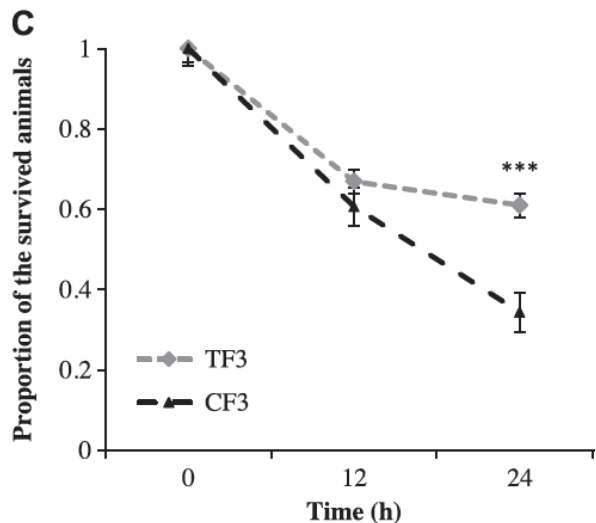
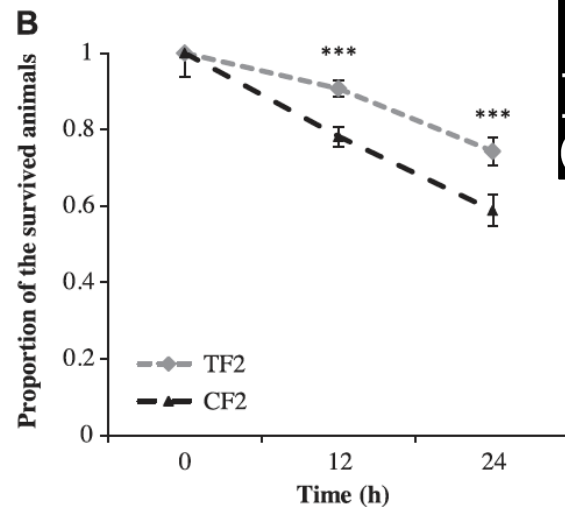
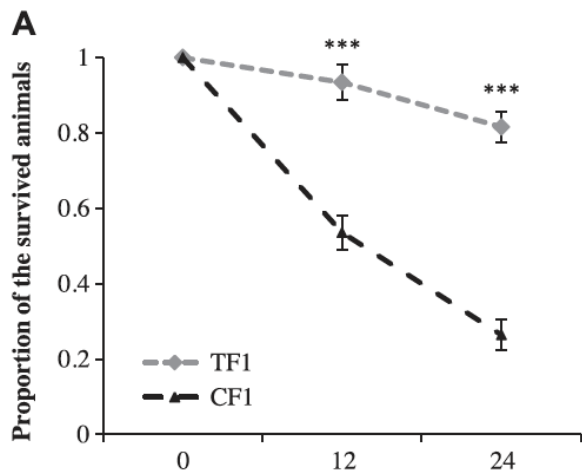
jawless vertebrates

jawed vertebrates



EPIGENETICS OF NON LETHAL HEAT SHOCK







Benchmark
Genetics

Carlos



Benchmark
Genetics

Selection for
TSV survival

1997

Family and within
family selection

Base population 8
countries

200 families/year

2002

Breeder selection
and dissemination
scheme for Colombia

Biosecure ponds for
breeders

2008

Mass selection
program for
tolerance to
WSSV

2013

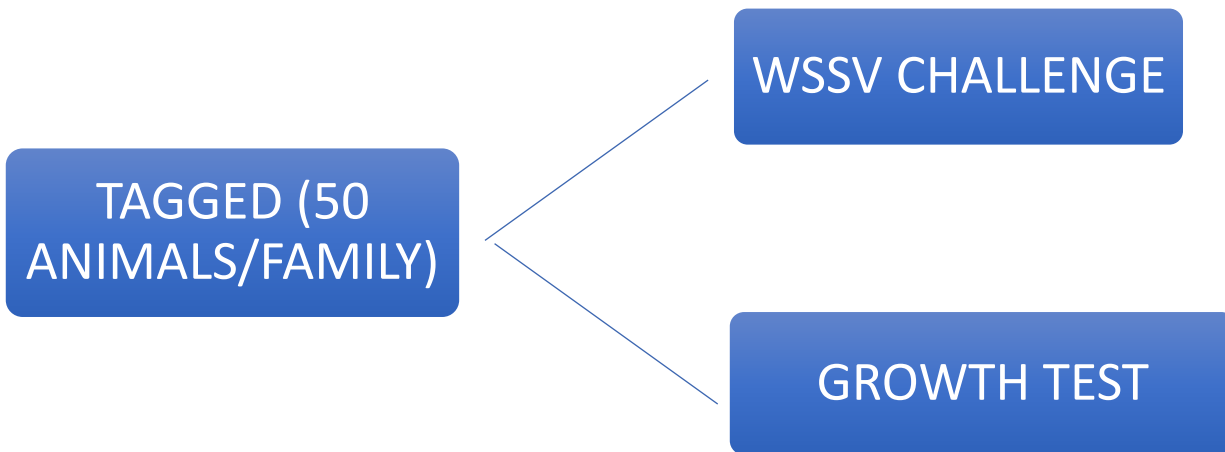
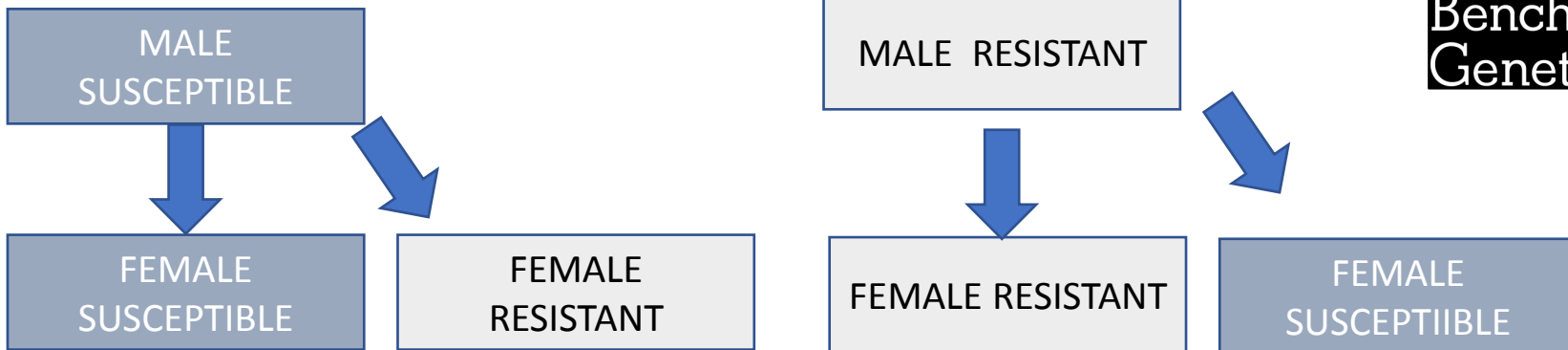
Evaluation of SNPs
for parentage
assignment

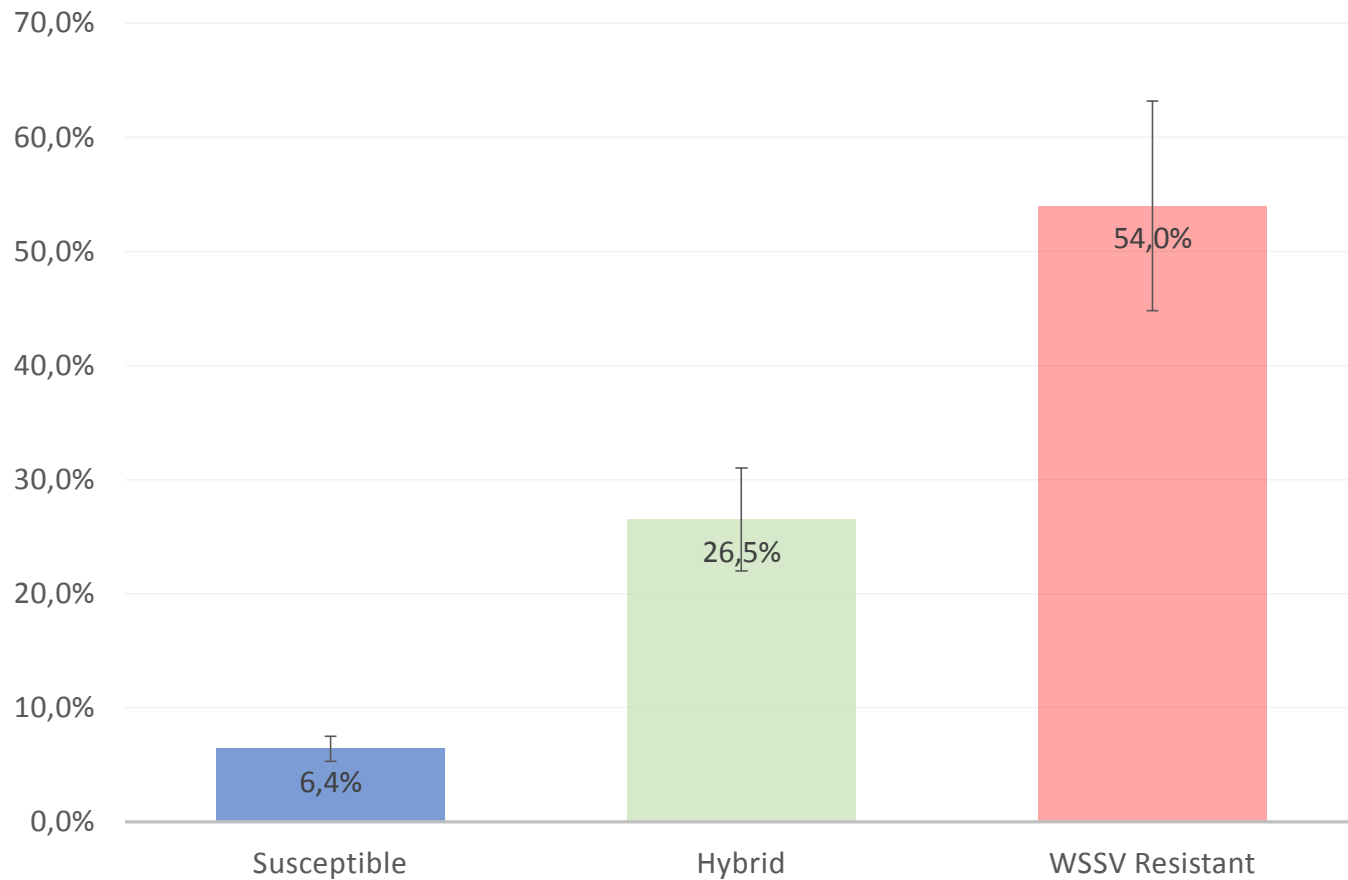
2017

Phenotypic
training data
disease resistance
for genomic work

2018

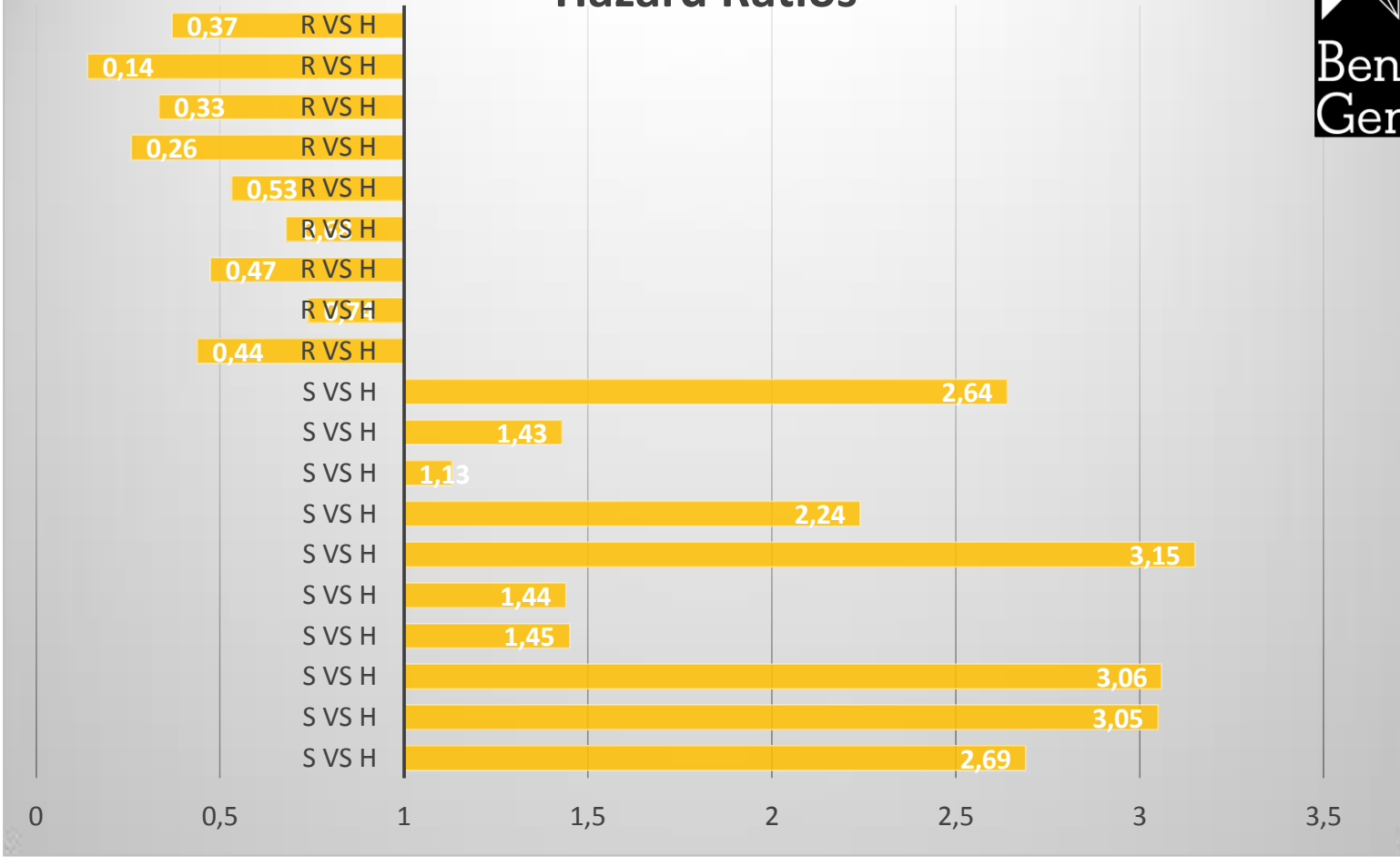
Development of S
chip – GWAS &
Genomic selection
for WSSV, EMS and
other diseases





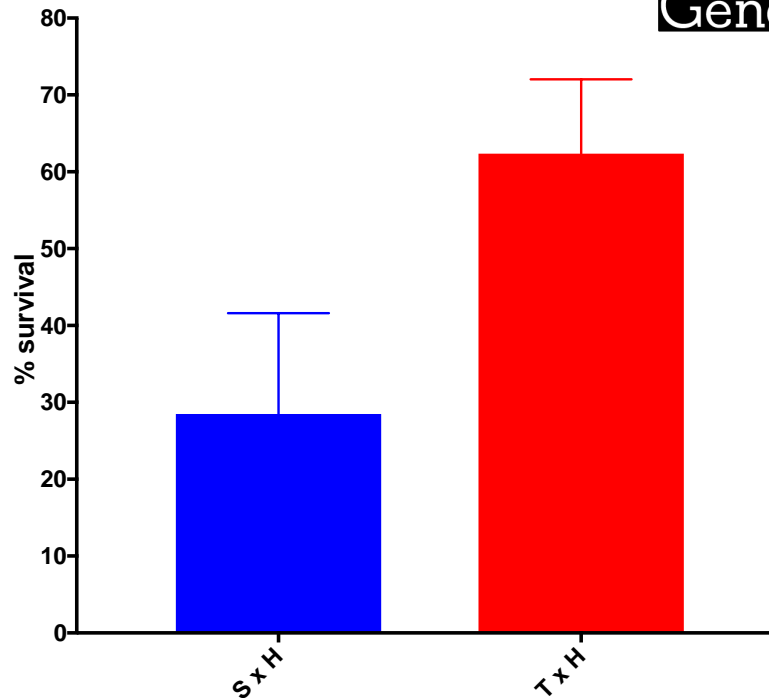
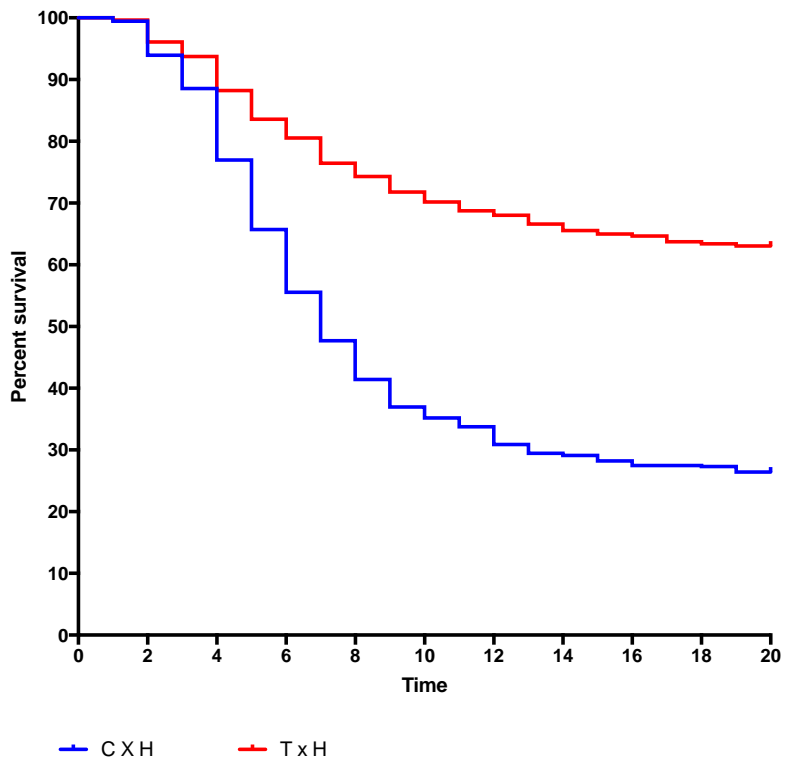


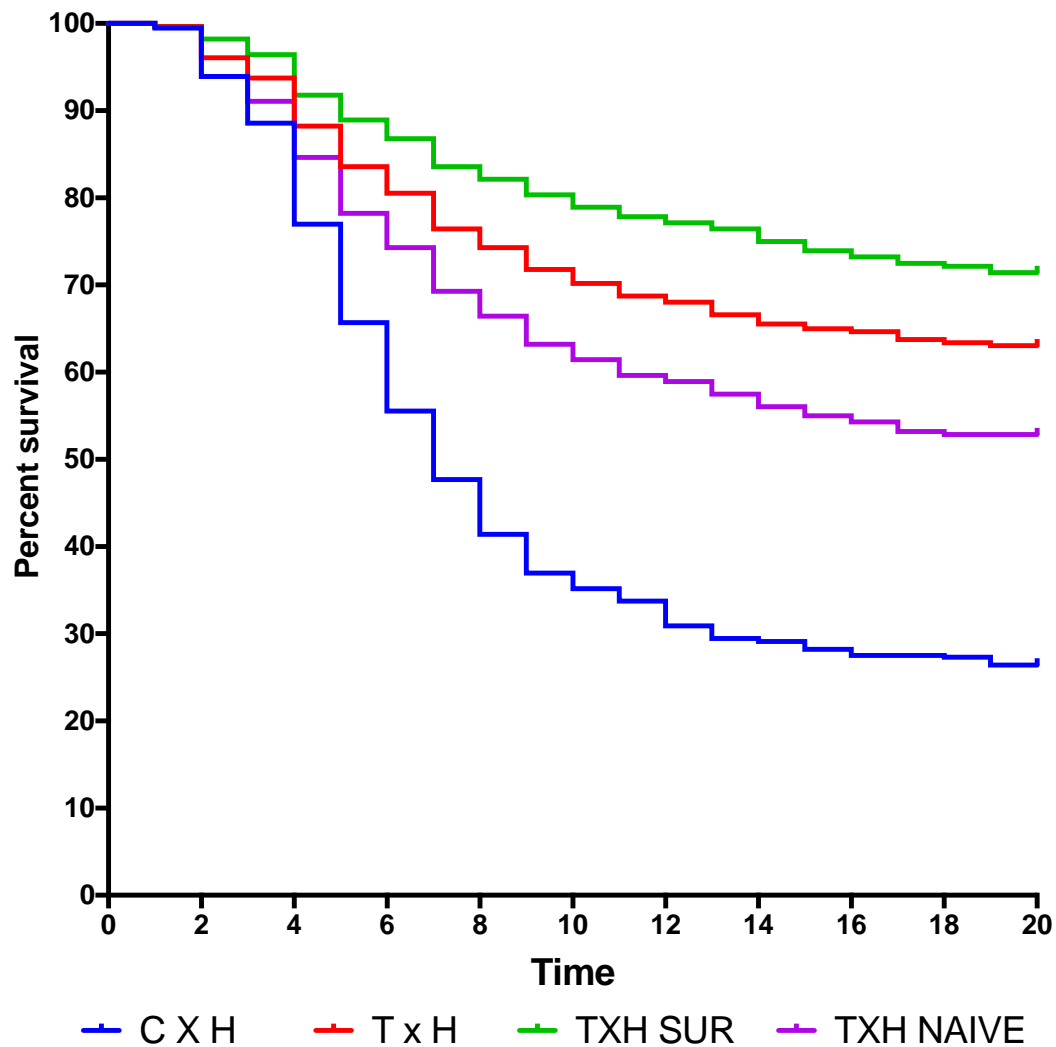
Hazard Ratios

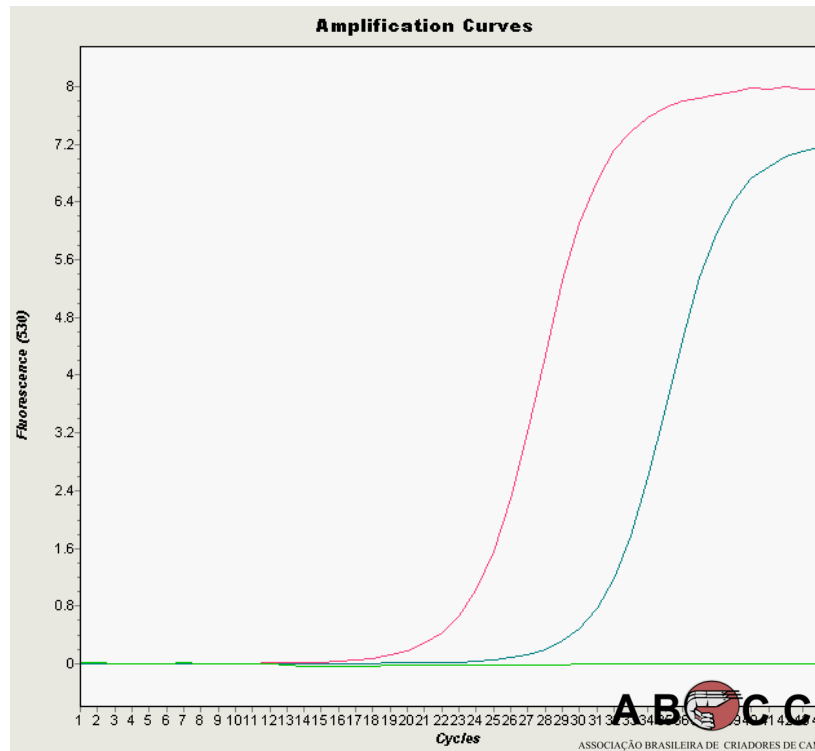
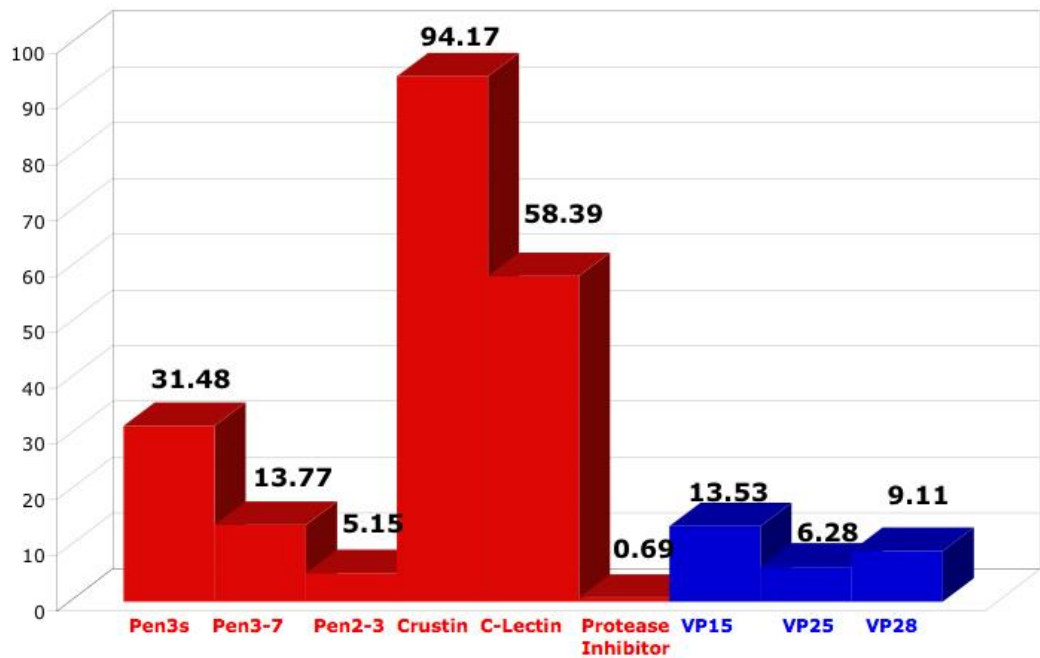




BACKCROSS F2









AHPND



Table 1. heritability estimates ($h^2 \pm se$) for AHPND resistance induced with Bacteria (Bc) and with Toxin (tox), Harvest weight (HW) and Pond Survival (S) on the diagonal. Genetic correlation between the same traits below the diagonal

individual Trait	AHPND Tox	AHPND Bac	HW	sS
AHPND Tox	0.37±0.17		PS	PS
AHPND Bac	0.58±0.28	0.32±0.18		
HW	0.03±0.22	0.06±0.1	0.58±0.07	
PS	-0.03±0.15	0.09±0.09	0.44±0.25	0.36±0.16

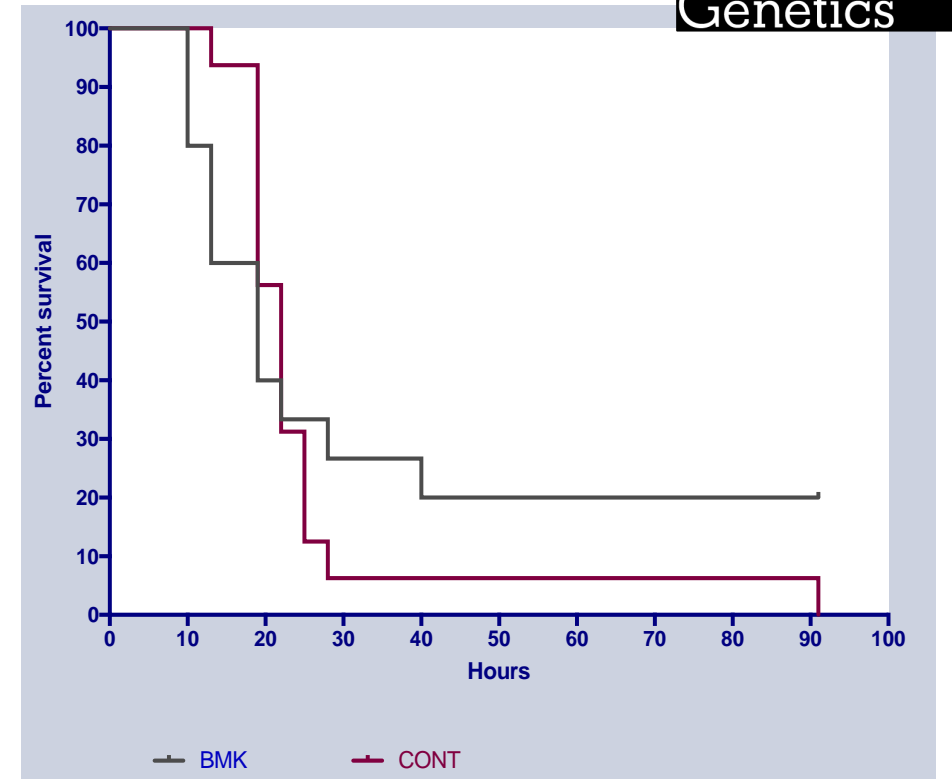
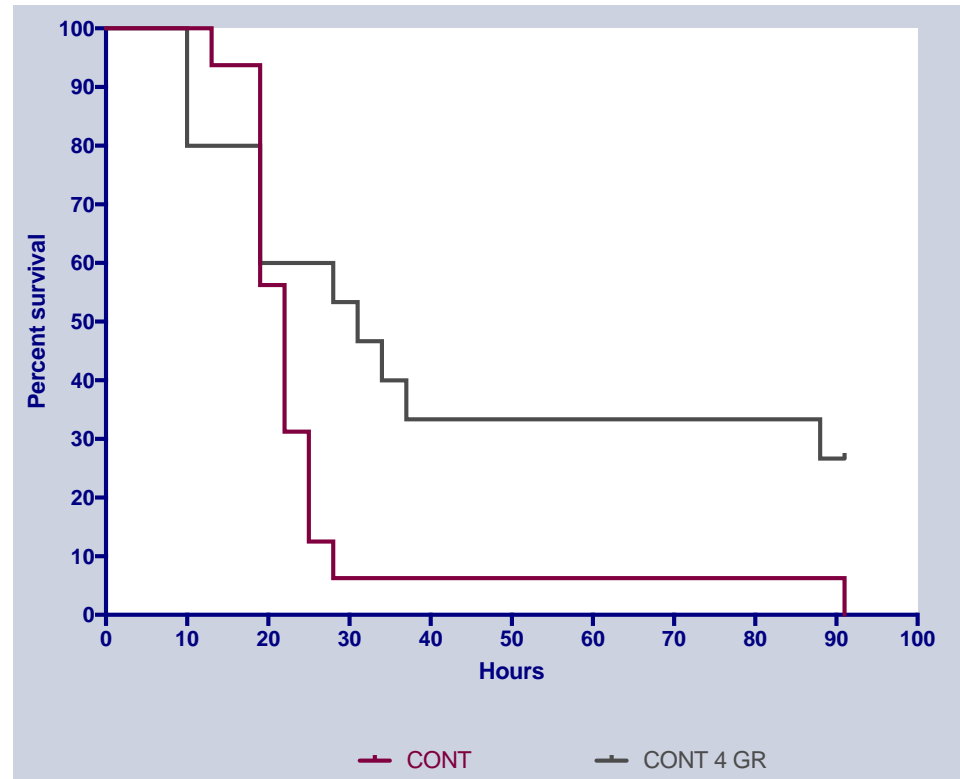
Gitterle et al. Aquaculture America 2018.

Trait	h^2	c^2
Harvest Weight	0.51± 0.02	0.07 ± 0.00
Growth Per week	0.27 ± 0.01	0.07 ± 0.00
Robustness	0.44 ± 0.22	-
AHPND	0.37± 0.02	-

Mexico AHPND $h^2 < 0.10$.

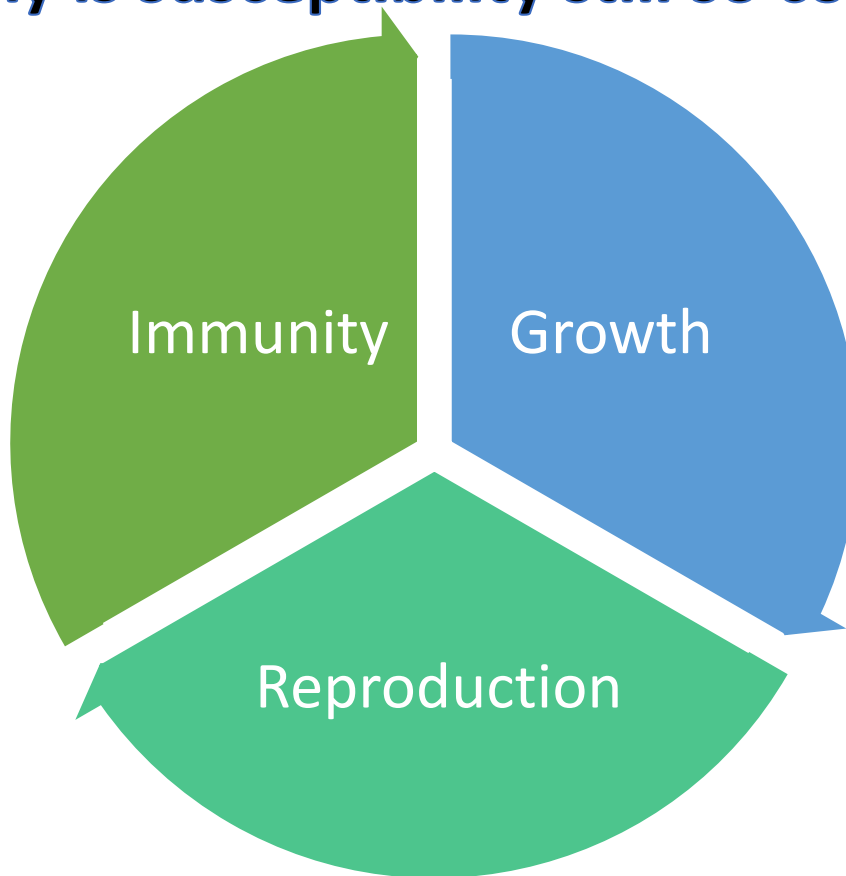
• <http://bioaqua.vn/en/genetic-variation-for-resistance-to-wss-ahpnd-in-pacific-white-shrimp/>







“ If disease resistance is so important for a population, why is susceptibility still so common



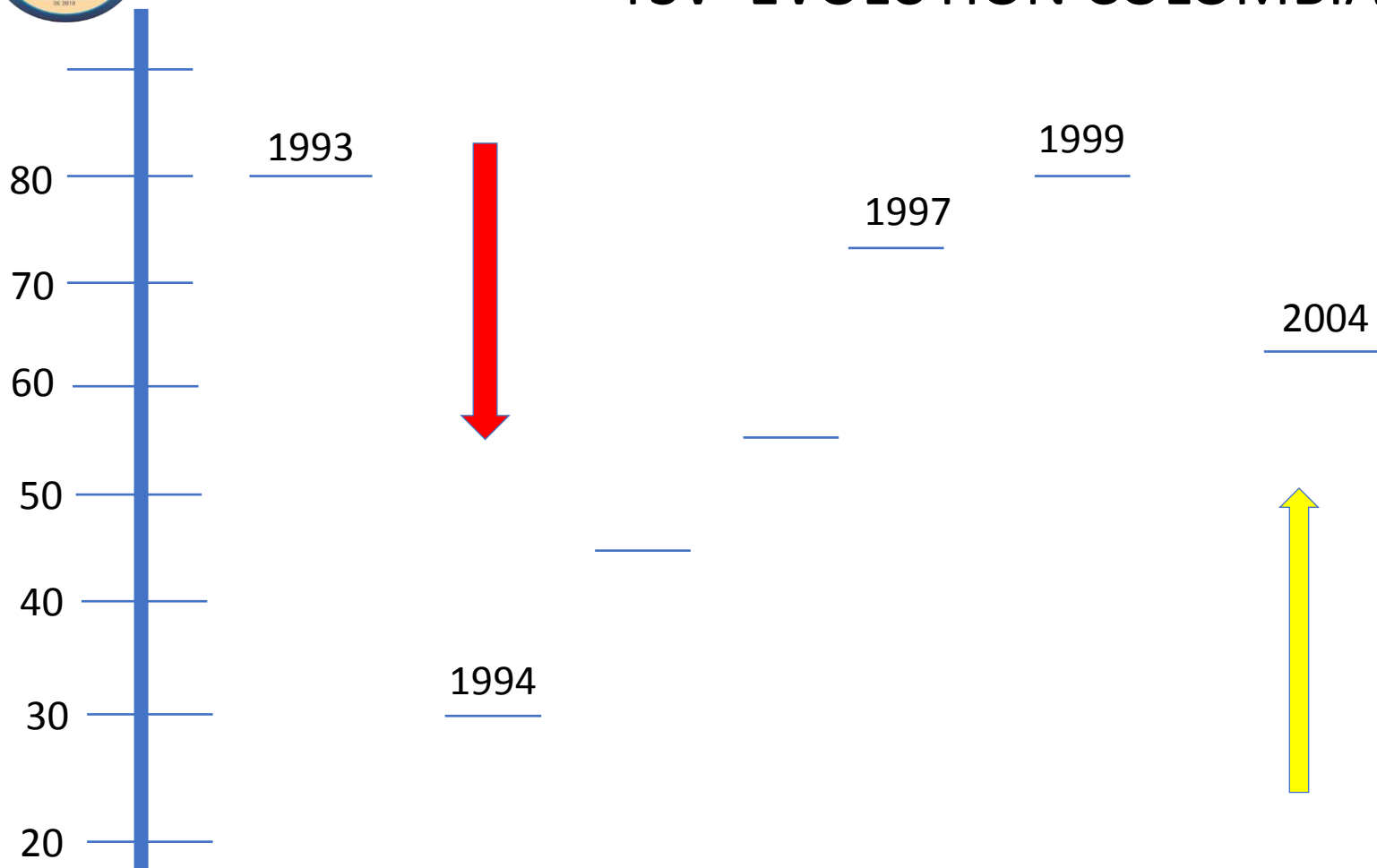


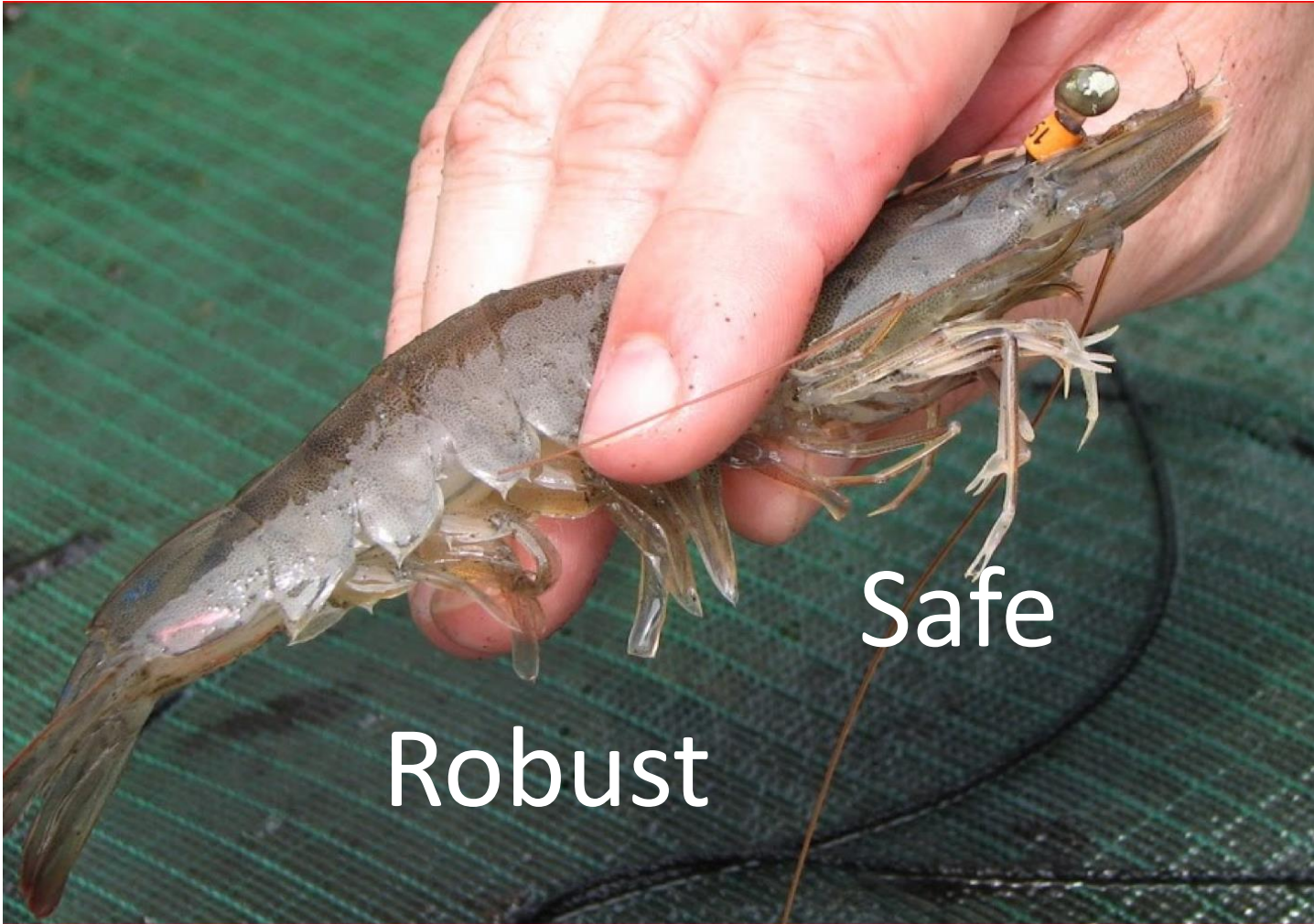
If resistance is negatively correlated with growth and reproductive capacity it will be rapidly lost from the breeding nucleus unless continuous selection pressure is maintained for resistance.





TSV EVOLUTION COLOMBIA





Safe

Robust



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OBRIGADA



- Harnessing biological control to drive sustainability and performance

ABOC C

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