The Paradox of Faster Growing Wild Fish Maturing at Older Ages Than Slower Growing Hatchery Fish

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Objectives:

- Describe two predictions made from Life History Theory
- Results from the High and Low Feed Ration study and compare them with the Life History Theory predictions
- Describe the Growth/Maturation Paradox
- Results from 2007 and 2008 for NO, SH and HC populations
- What processes are in here play that result in empirical results that are contradictory to the predictions one would make from LHT?
- Examples of other correlated life history or fitness related traits

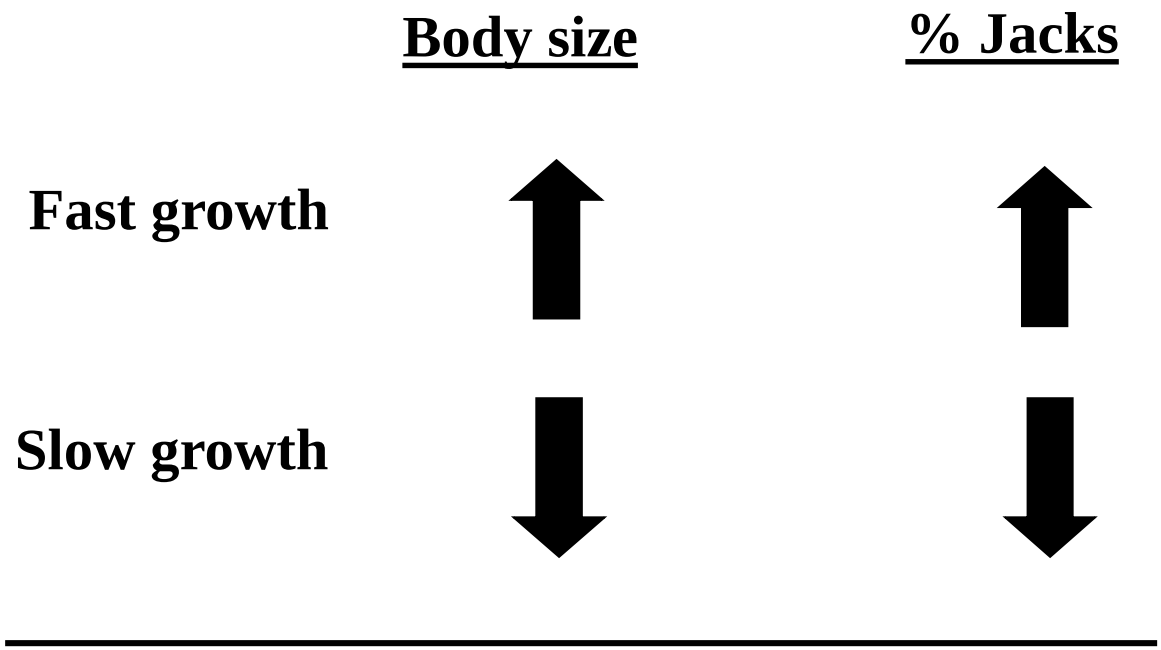
Two basic predictions made from Life History Theory:

- When a population experiences increased growth in body size then fish should

1. mature at younger ages and

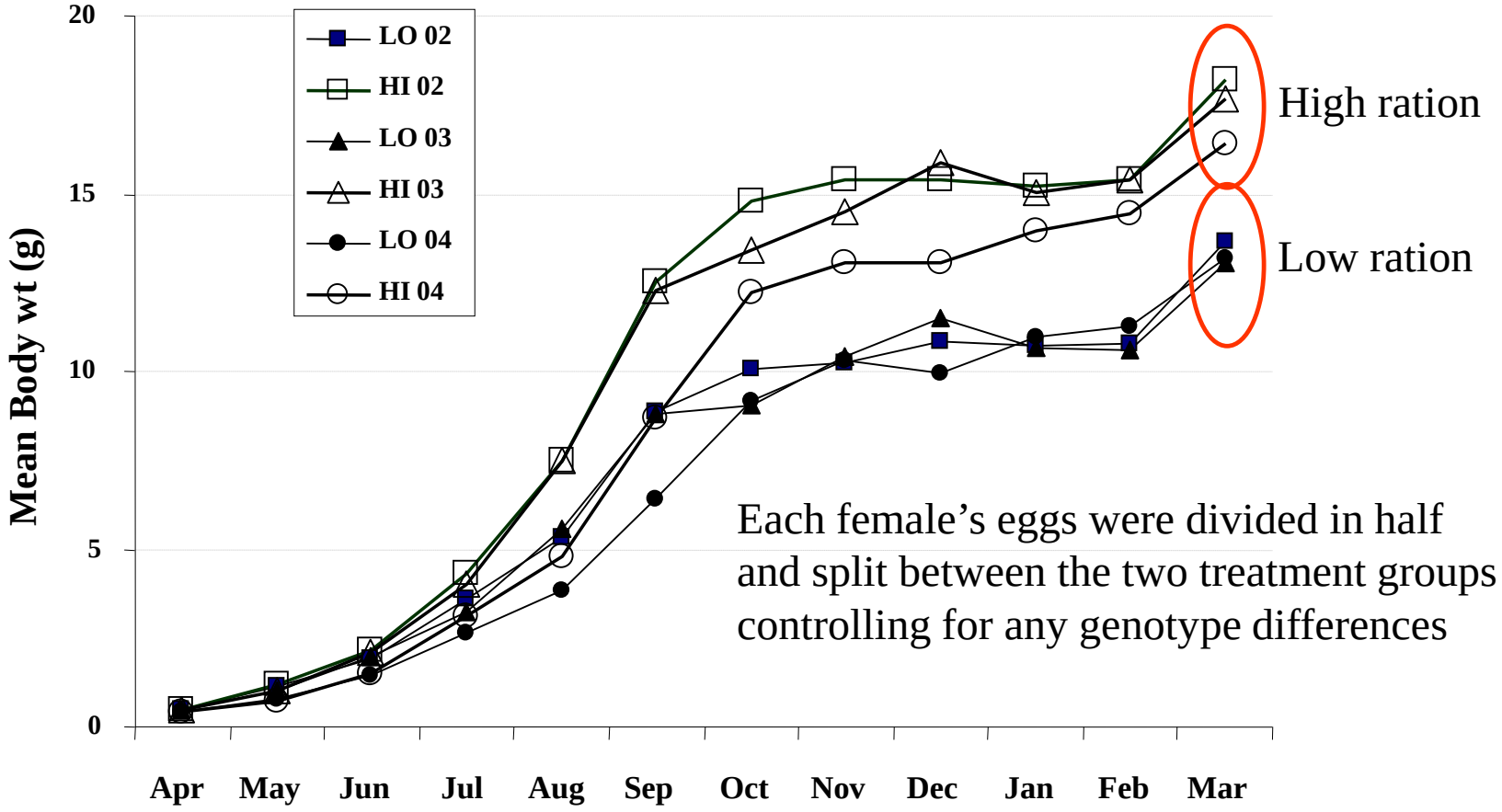
2. at larger size-at-age.

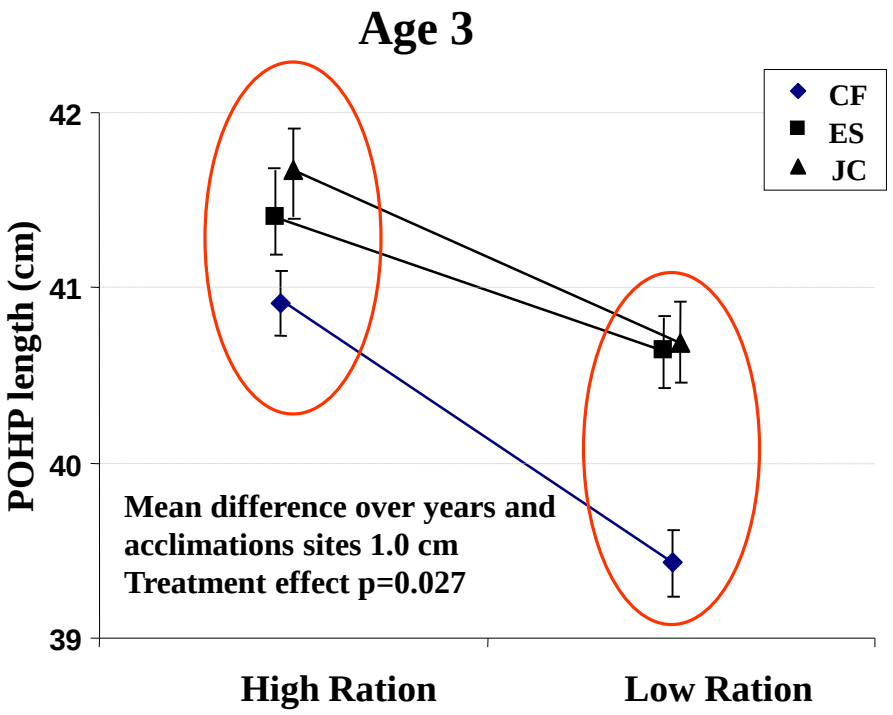
Life History Predictions

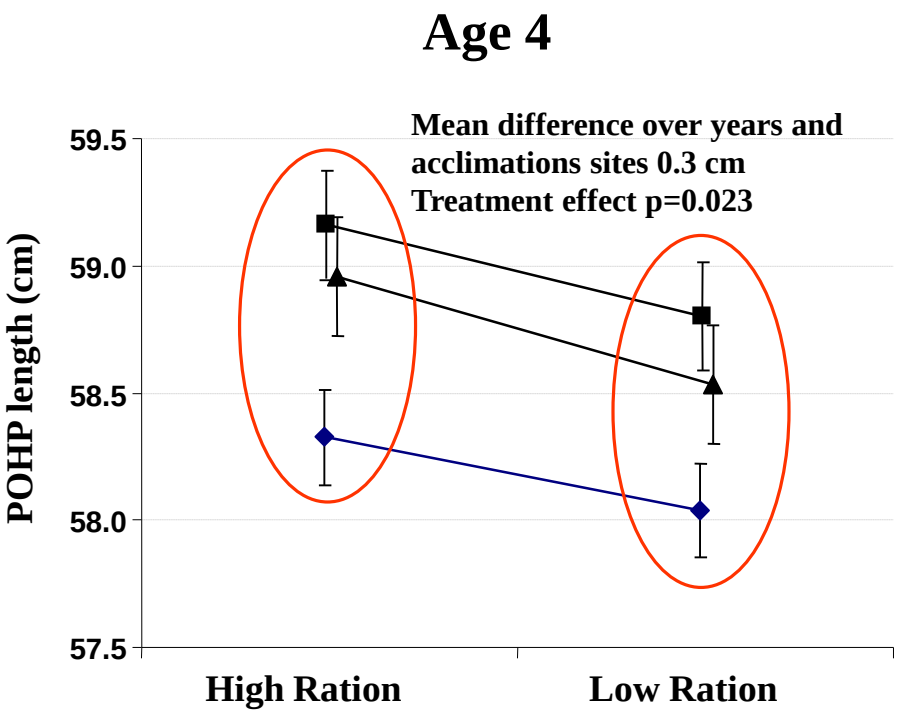


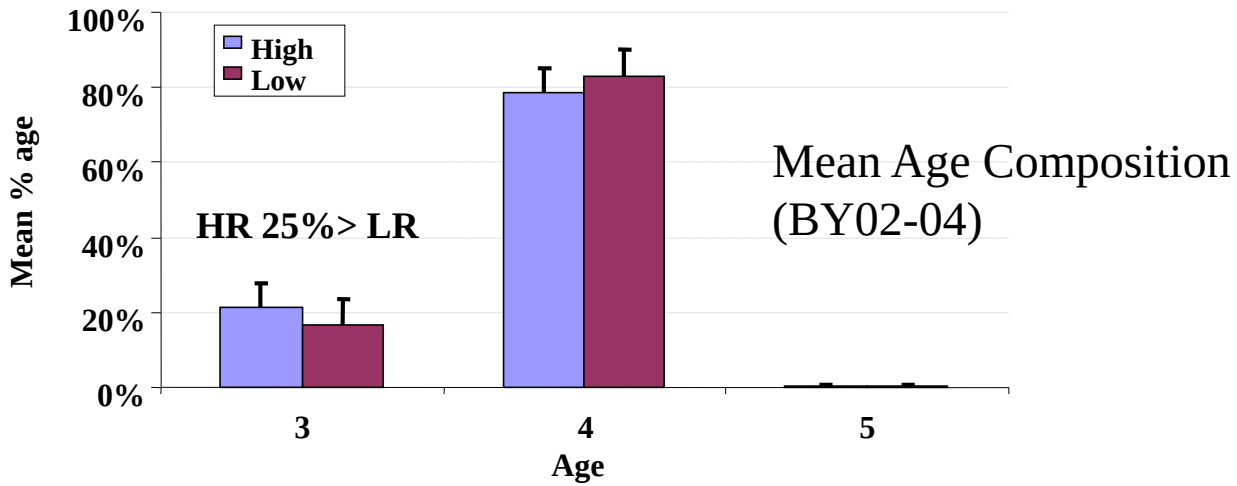
- High and Low Feed Ration study results, then compare them with the Life History Theory predictions

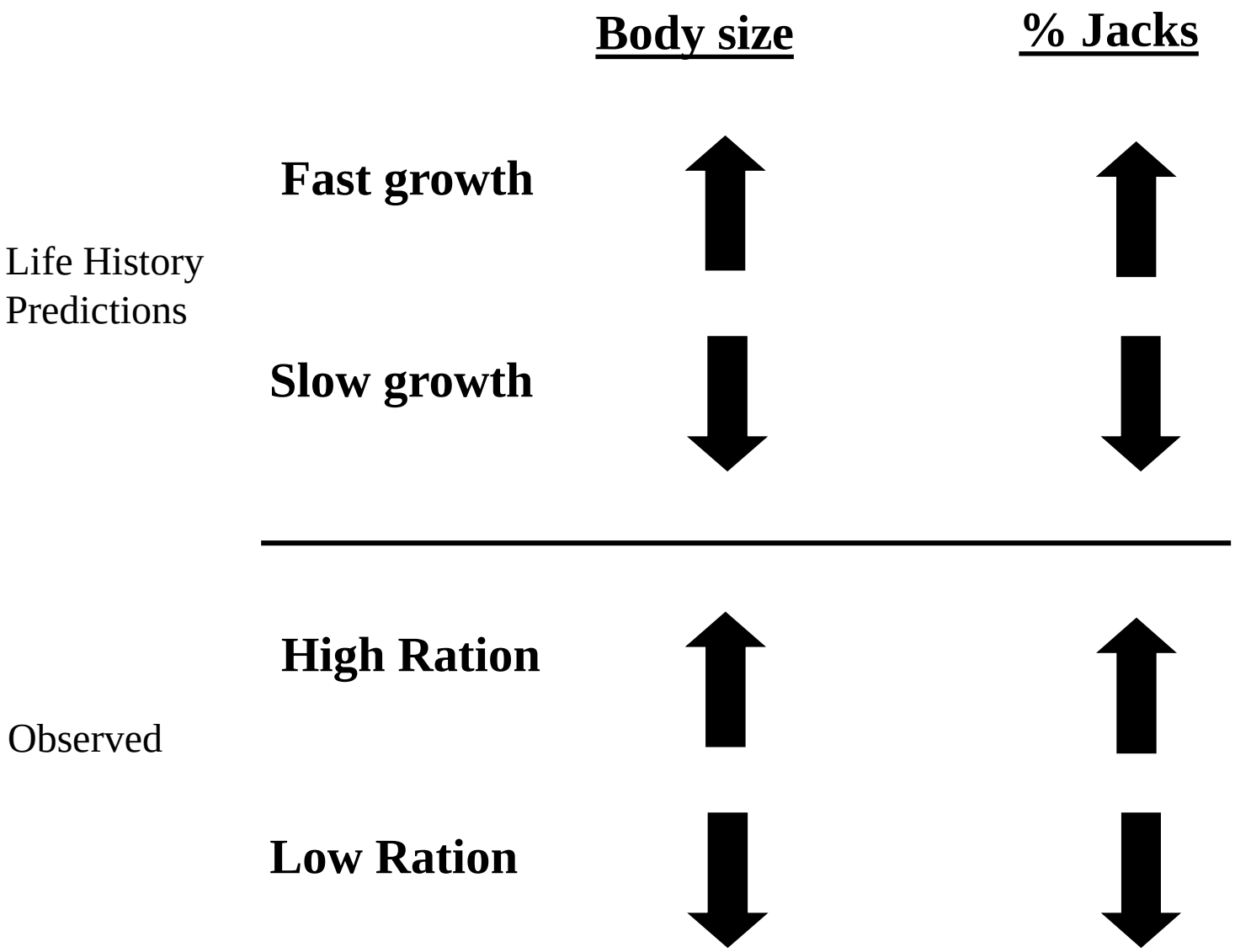
Juvenile body weight over time up to volitional release BY02-04




Age 3
CF
ES
JC
POHP length (cm)
42
41
40
39
Mean difference over years and
acclimations sites 1.0 cm
Treatment effect p=0.027
High Ration
Low Ration

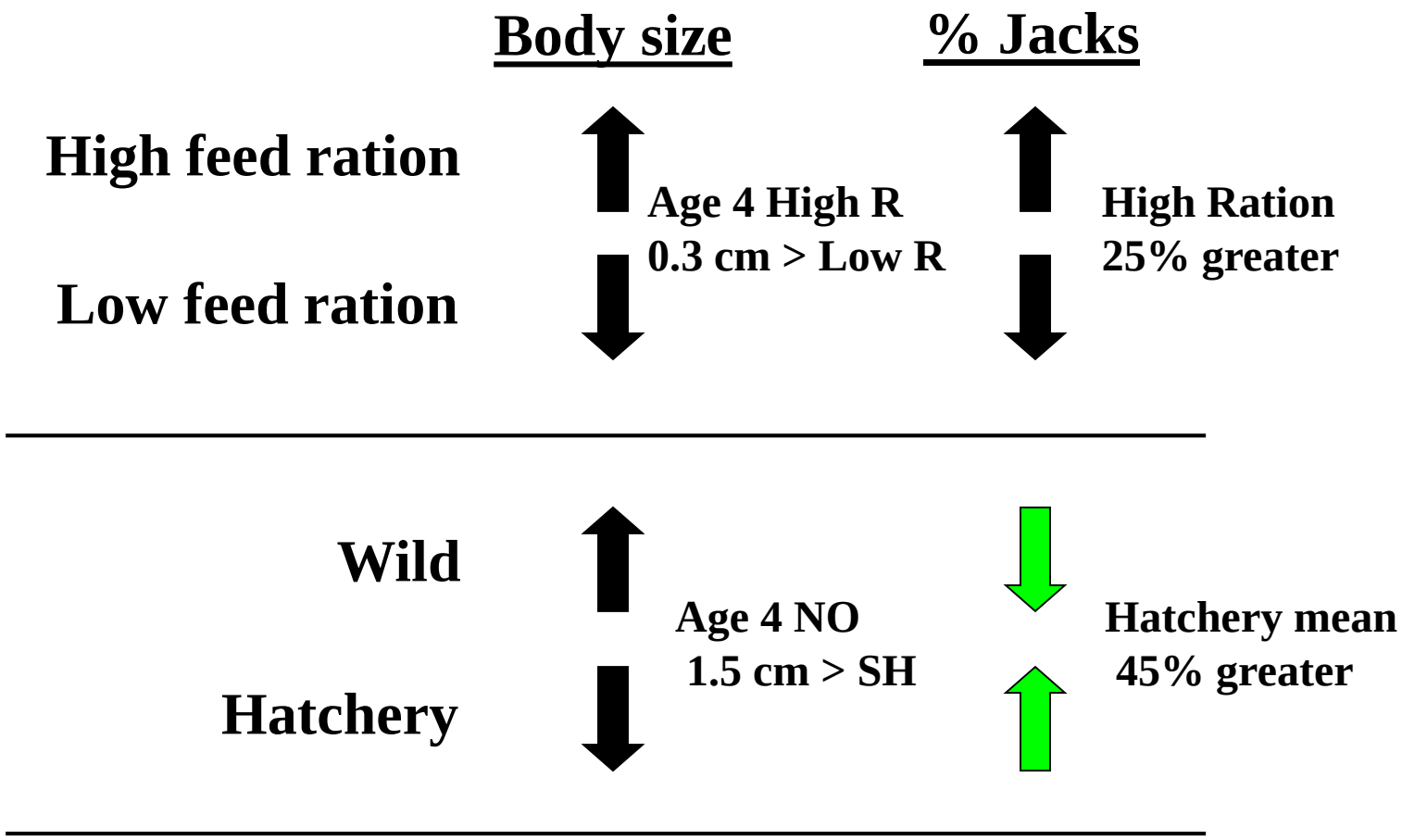

Age 4
Mean difference over years and
acclimations sites 0.3 cm
Treatment effect p=0.023
POHP length (cm)
59.5
59.0
58.5
58.0
57.5
High Ration
Low Ration

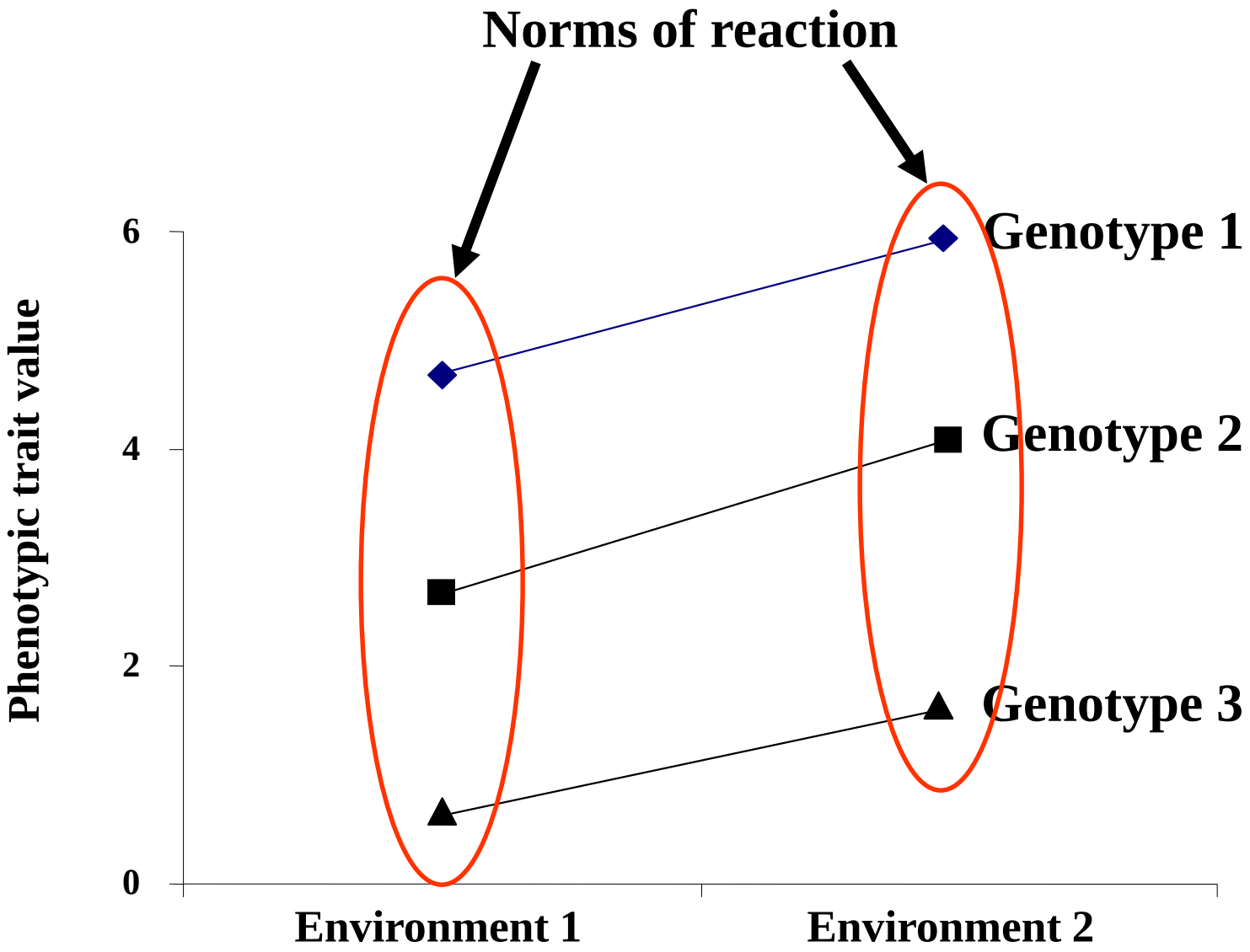

High
Low
Mean % age
100%
80%
60%
40%
20%
0%
HR 25%> LR
3
4
5
Age
Mean Age Composition
(BY02-04)


Body size
% Jacks
Fast growth
Slow growth
Life History Predictions
High Ration
Low Ration
Observed

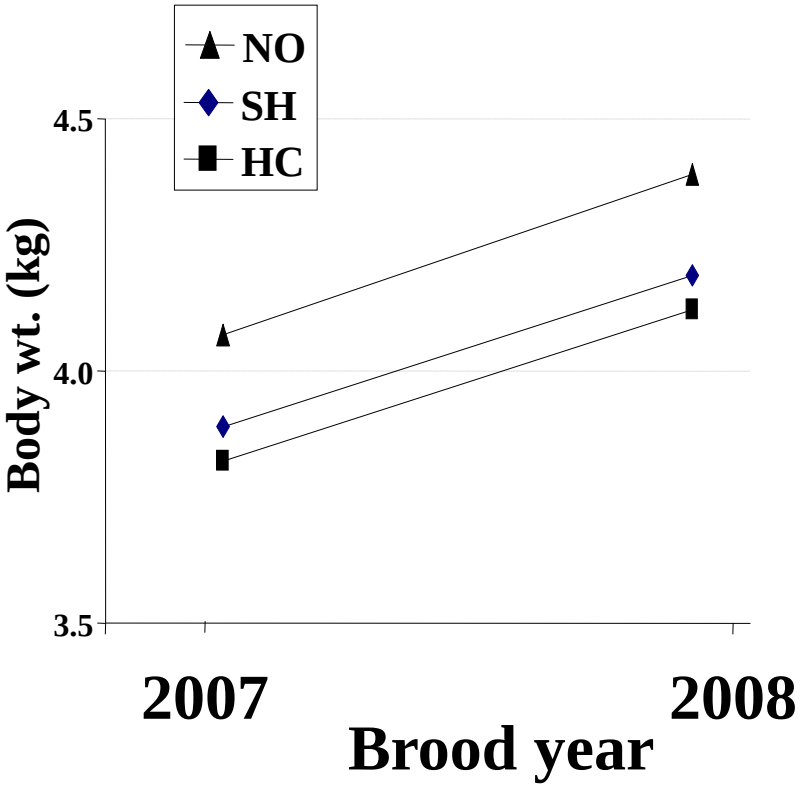
- The Growth/Maturation Paradox:

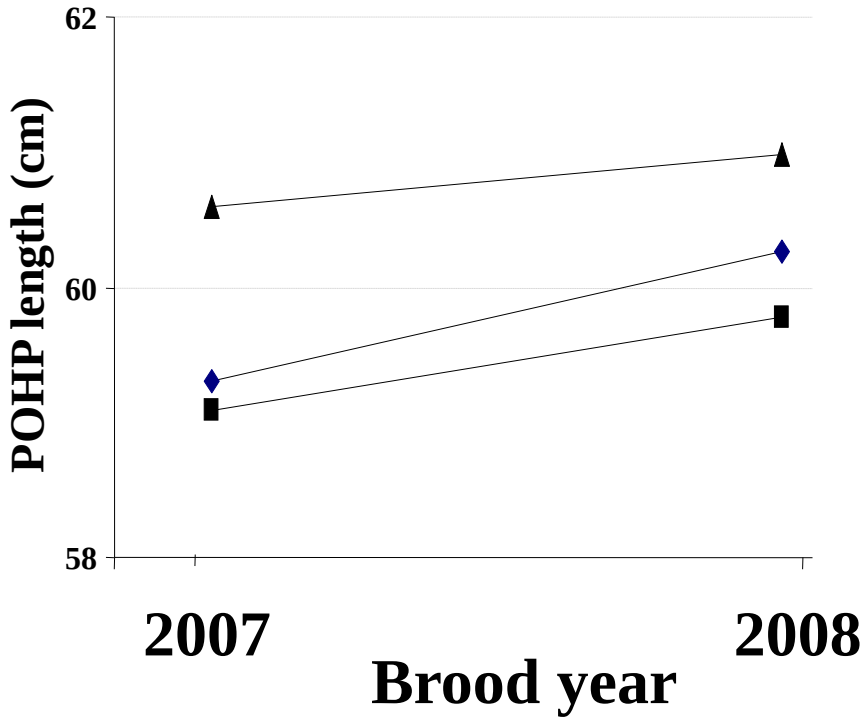
Hatchery origin fish return at a smaller size-at-maturity, but mature at younger mean age


Body size
% Jacks
High feed ration
Low feed ration
Age 4 High R
0.3 cm > Low R
High Ration
25% greater
Wild
Hatchery
Age 4 NO
1.5 cm > SH
Hatchery mean
45% greater


Norms of reaction
Phenotypic trait value
6
4
2
0
Genotype 1
Genotype 2
Genotype 3
Environment 1
Environment 2

Age 4 size-at-age reaction norms for *NO*, *SH* and *HC* fish

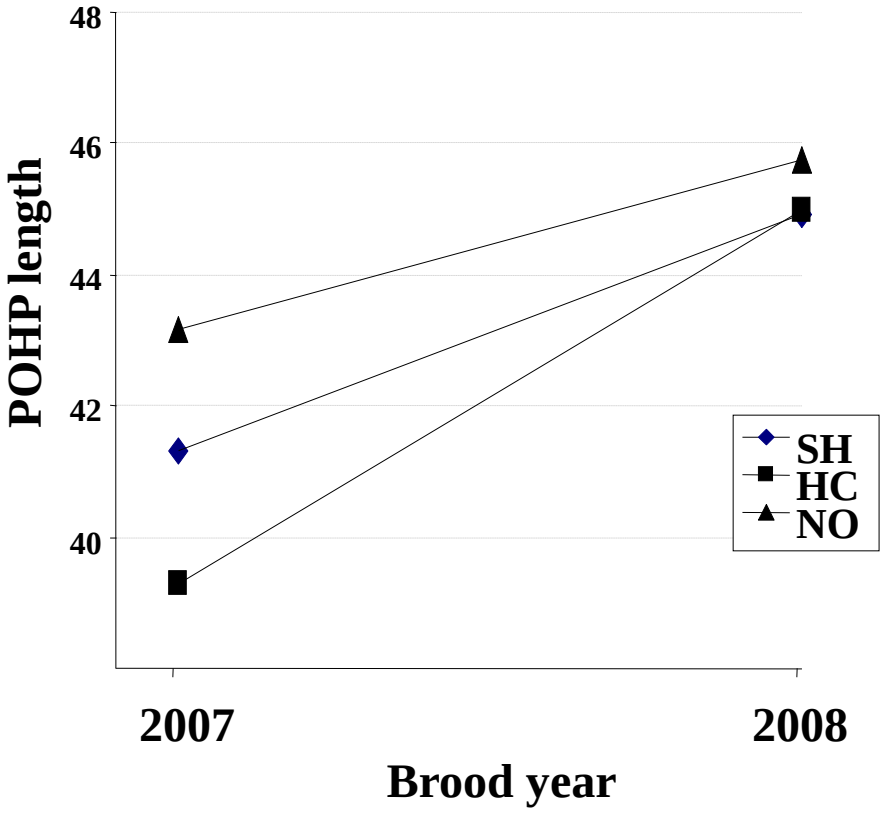


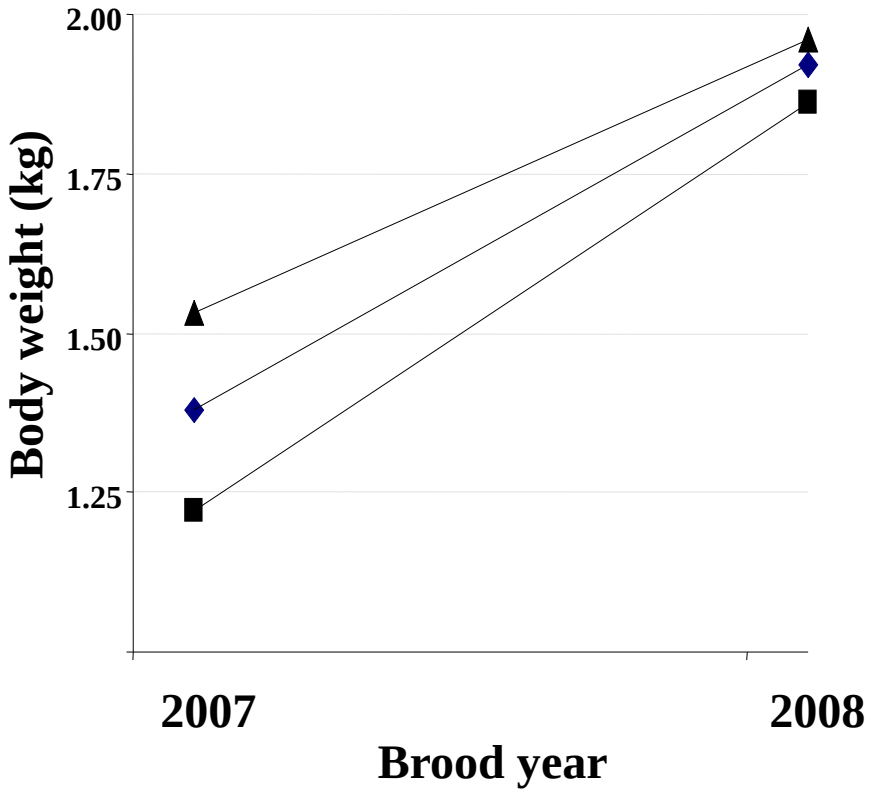


Origin effect p=0.001
Tukey MCT HC < SH < NO

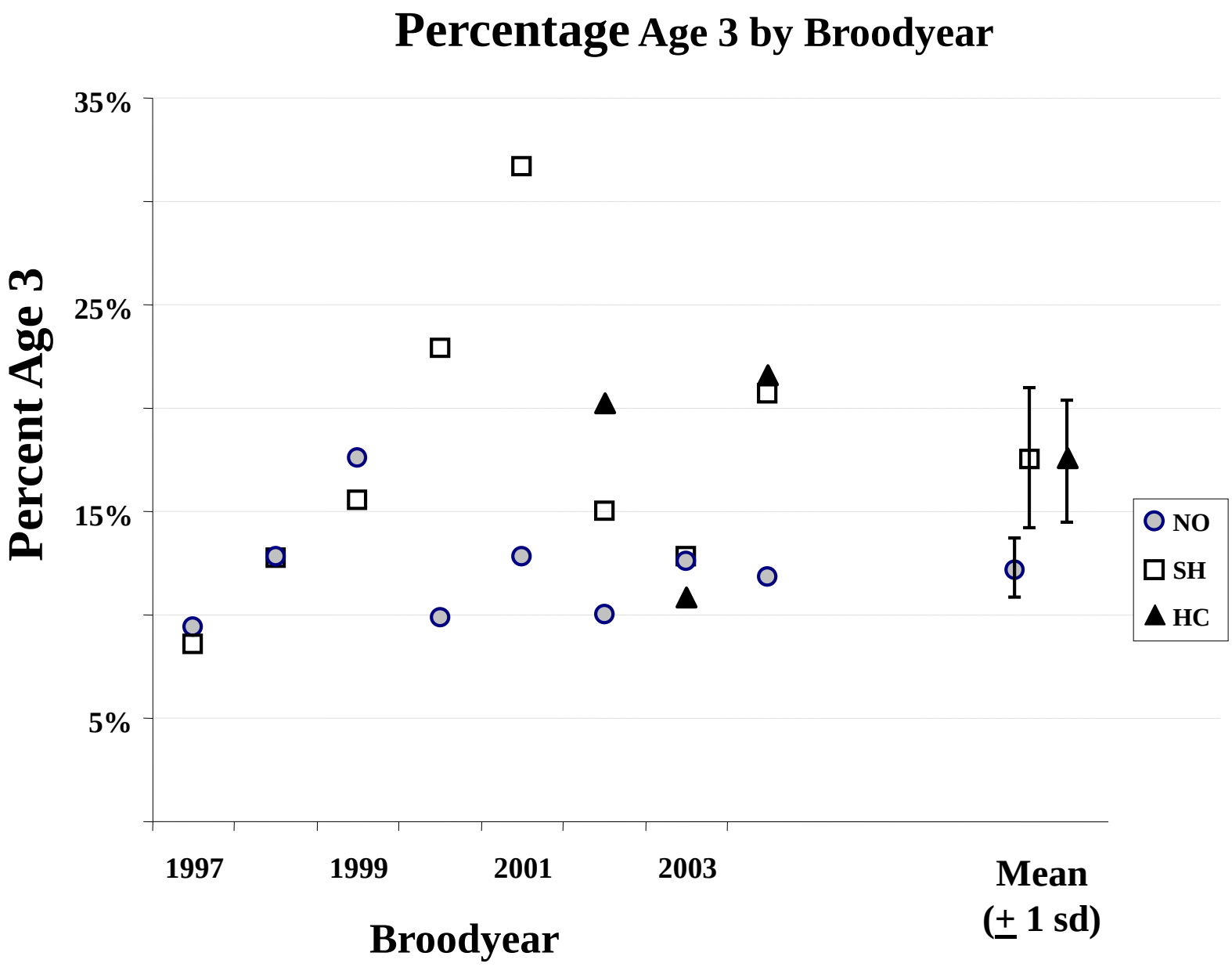
Age 3 size-at-age reaction norms for *SH*, *HC* and *NO* fish

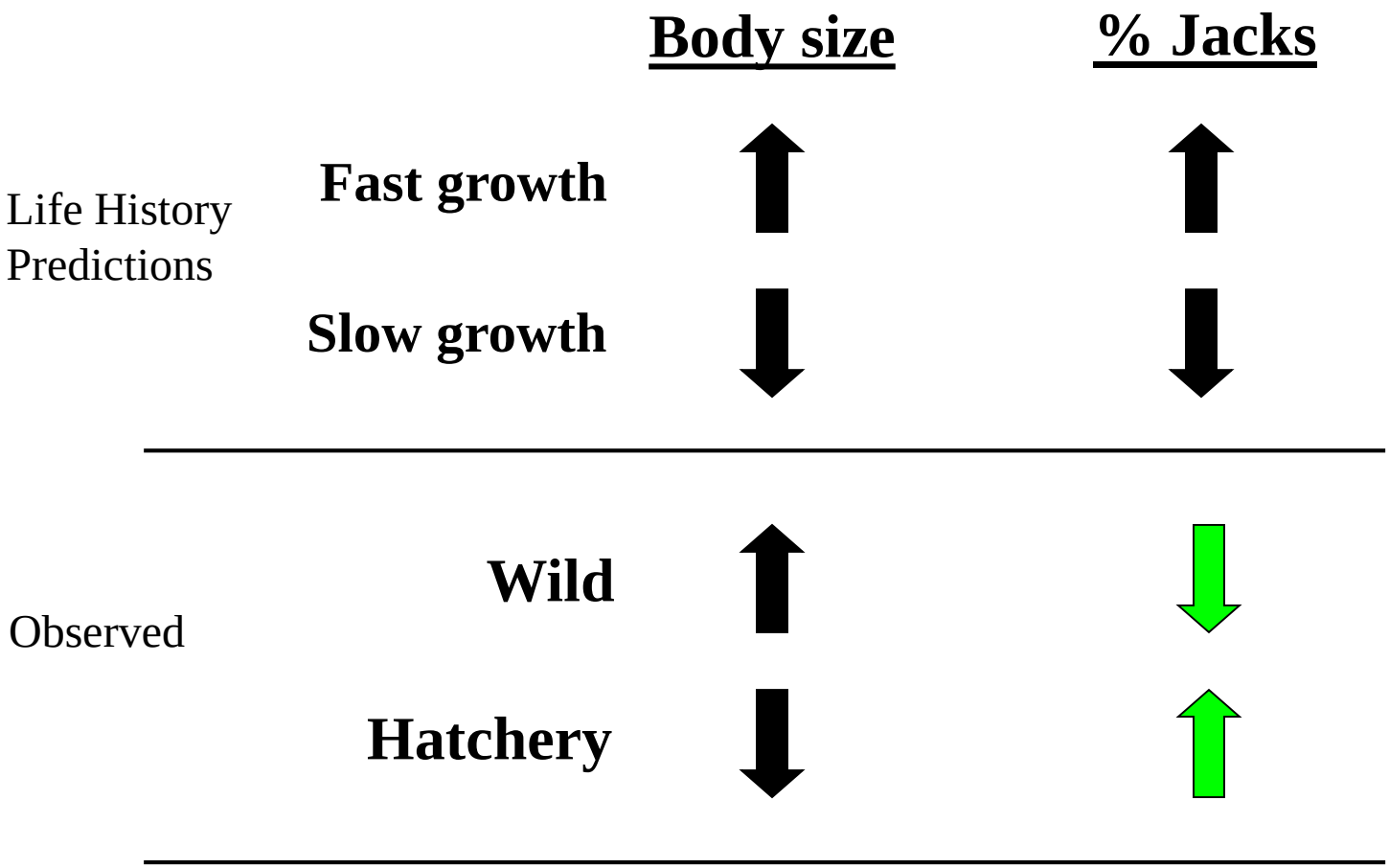
In 2008 fish were 25-58% larger than 2007.
Significant GxE interaction p<0.05.





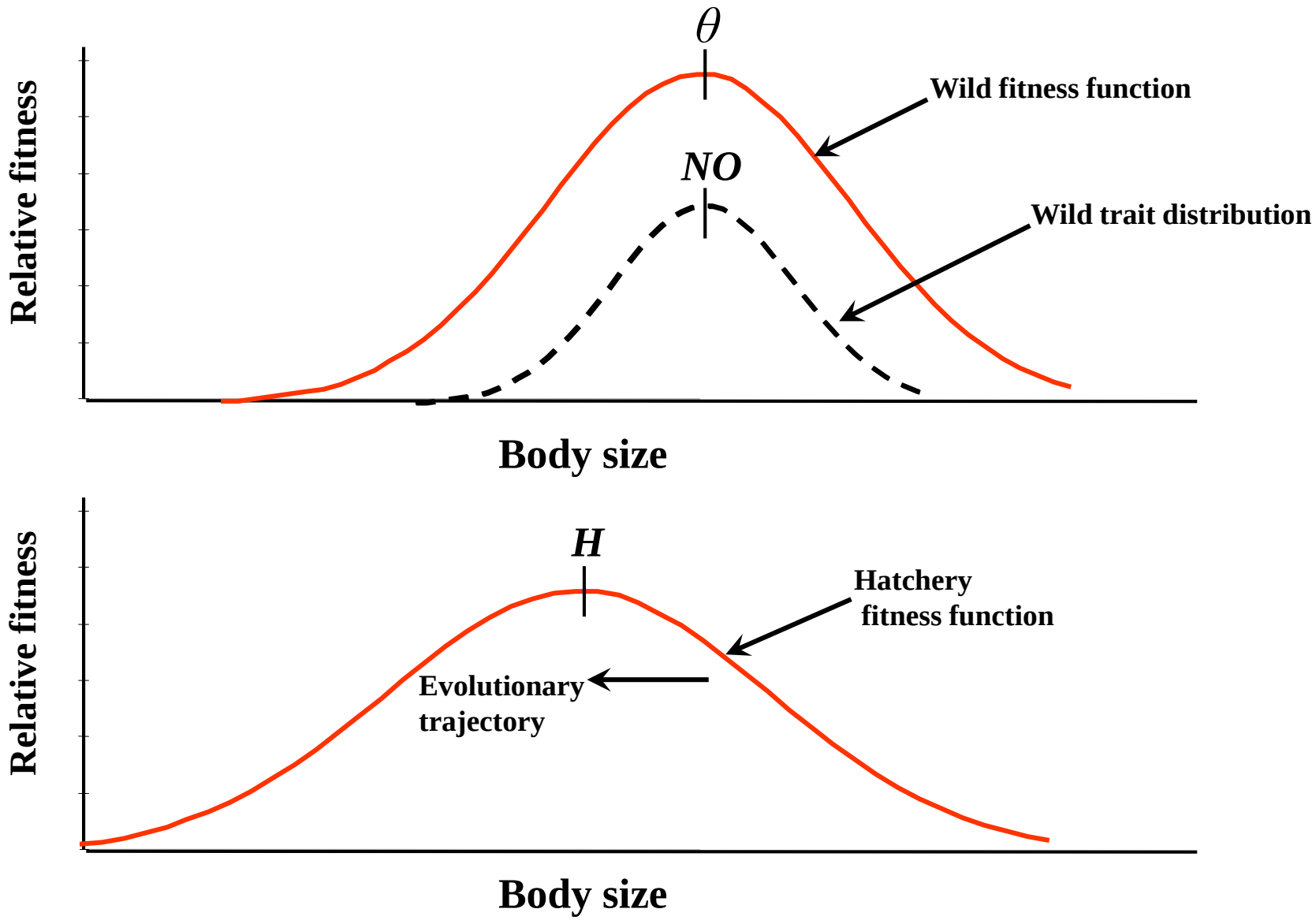
2007 Origin effect p<0.001, Tukey MCT HC < SH < NO
2008 Origin effect p>0.5


Percentage Age 3 by Broodyear
Percent Age 3
35%
25%
15%
5%
1997
1999
2001
2003
Mean
(± 1 sd)
Broodyear
NO
SH
HC

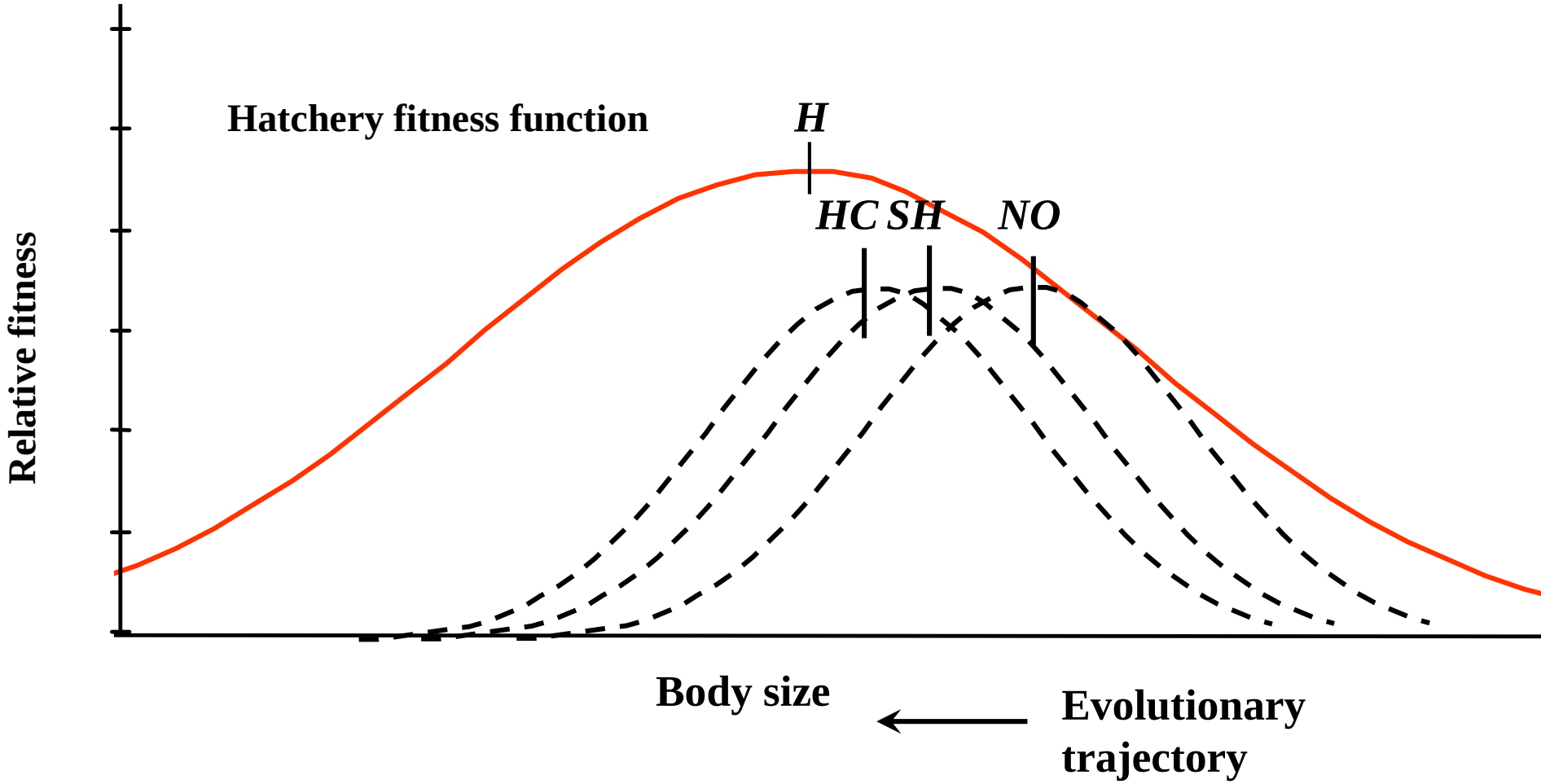


Our results significantly disagree with LHT predictions.
The reason is have three different genotypes: NO, SH and HC.

- What possible processes are in play here that produce results that are contrary to the predictions from LHT?

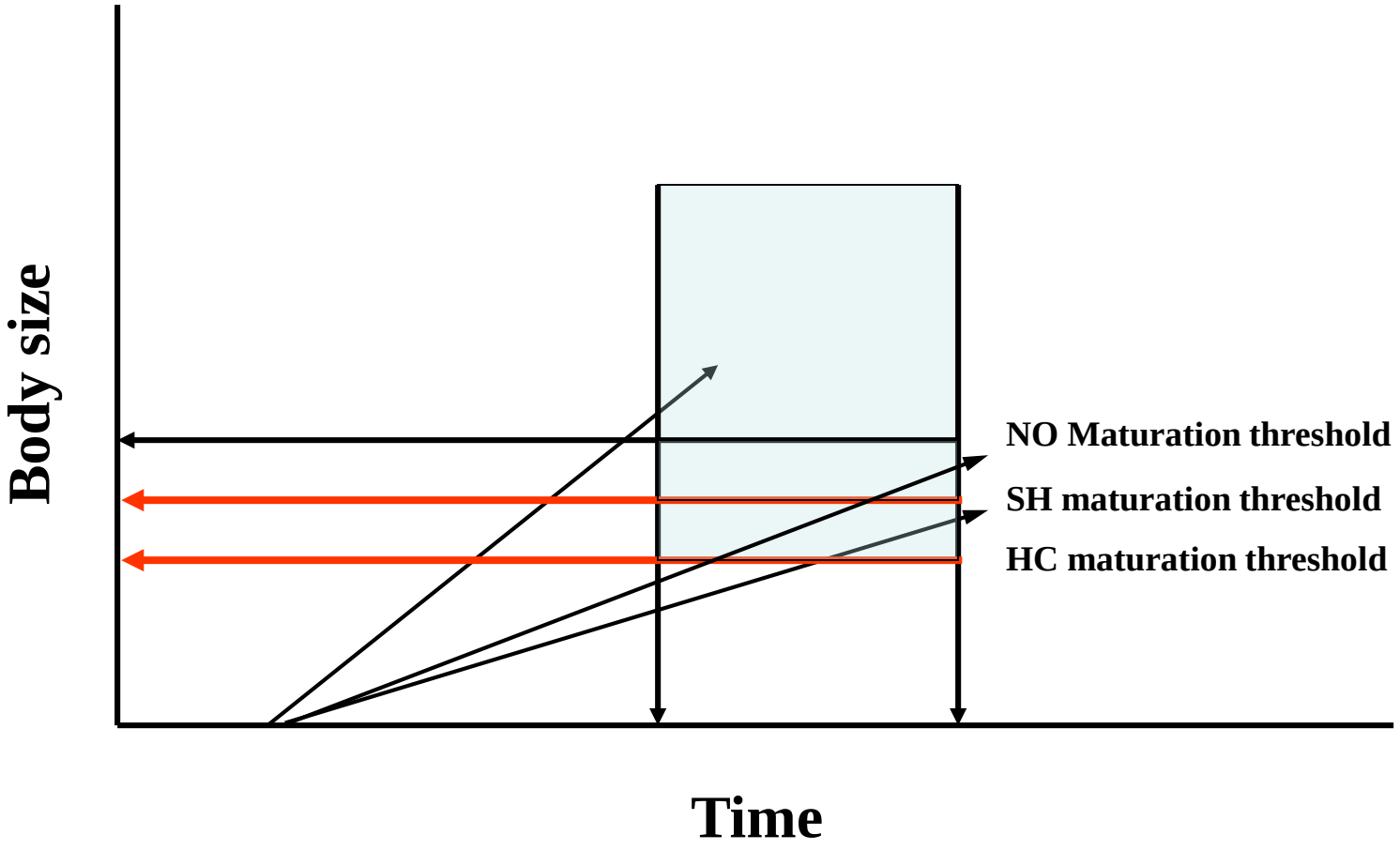

θ
Wild fitness function
NO
Wild trait distribution
Relative fitness
Body size
H
Hatchery
fitness function
Evolutionary
trajectory
Relative fitness
Body size

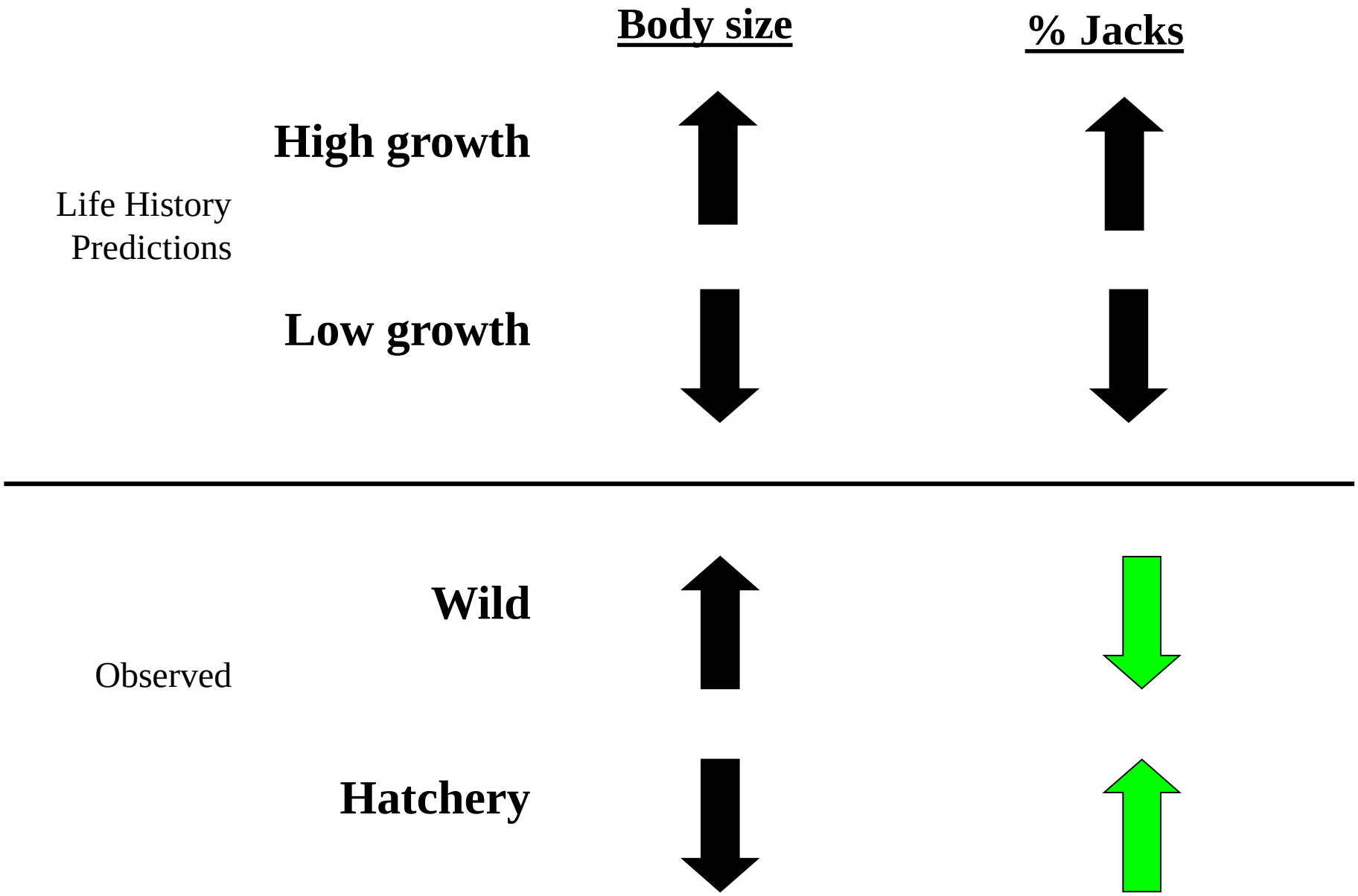
Reaction norms follow this trend:
HC (2 Gen)< SH (1 Gen)< Natural Origin



Given a smaller size-at-age maturation threshold, then:

- **smaller age specific size-at-maturity and**
- **younger age composition.**



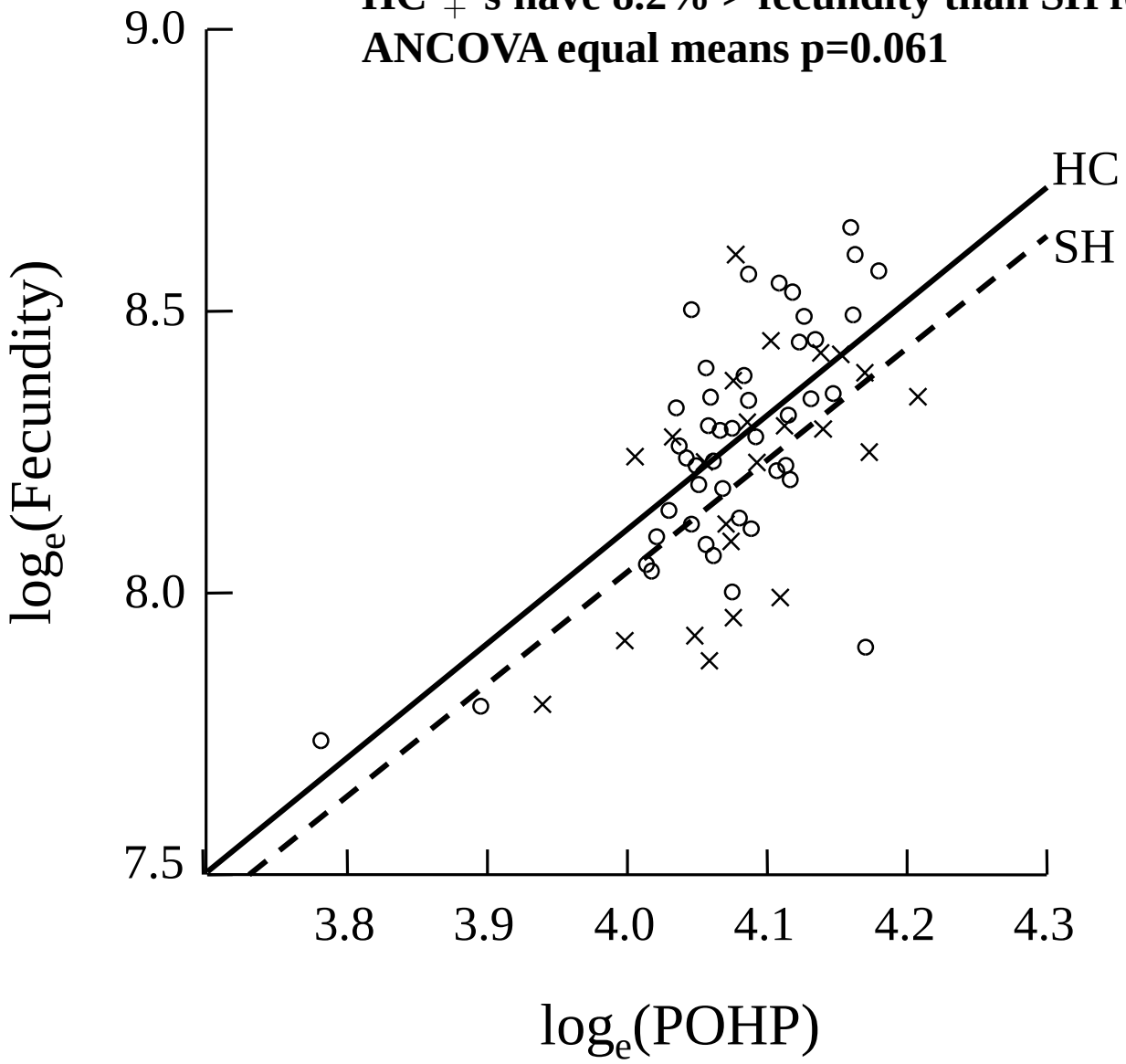

Body size
% Jacks
High growth
Life History Predictions
Low growth
Wild
Observed
Hatchery

- What about other life history or fitness related traits correlated with body size?

2008 Results:

HC ♀'s have 8.2% > fecundity than SH females

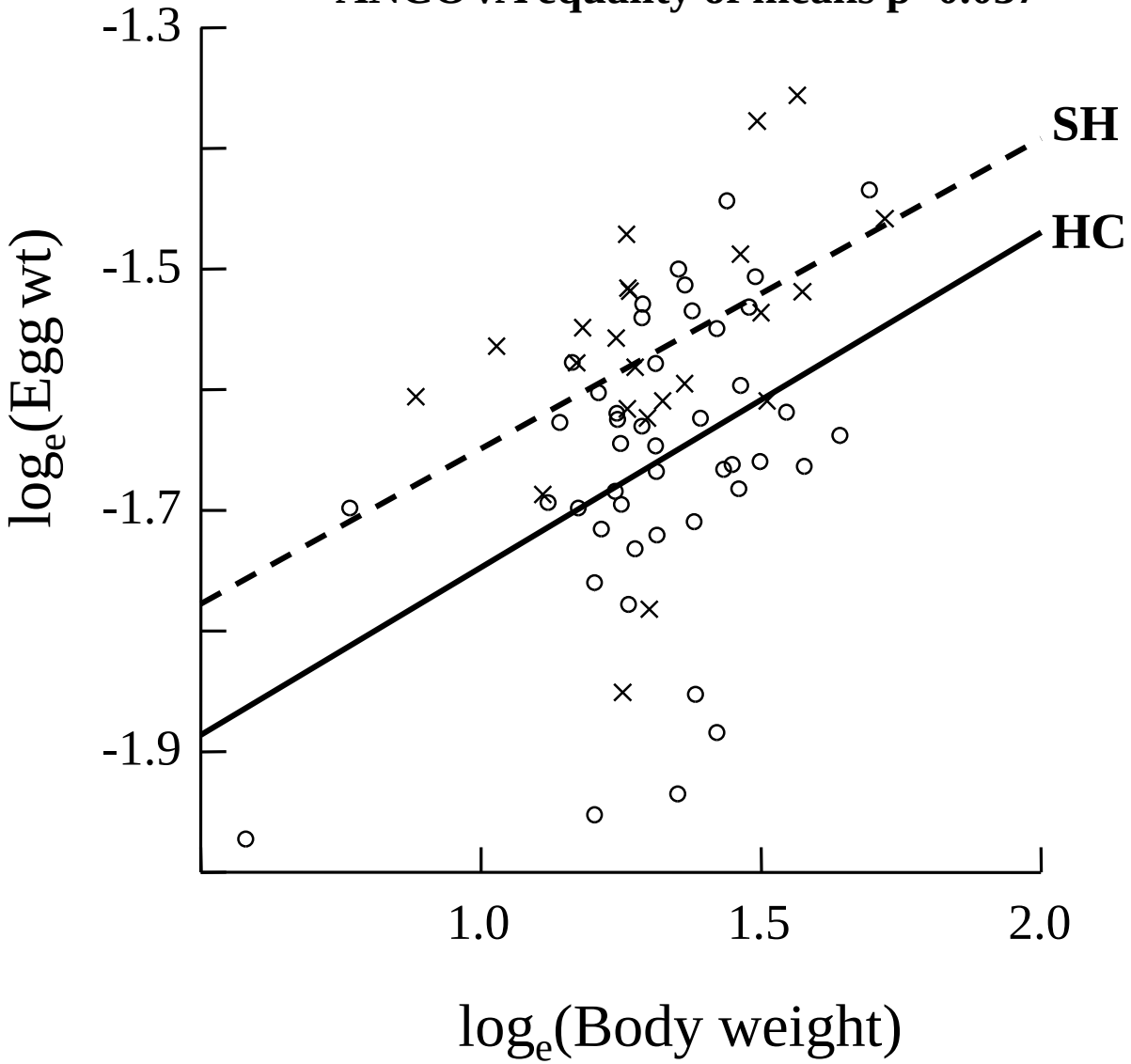
ANCOVA equal means p=0.061



2008 Results:

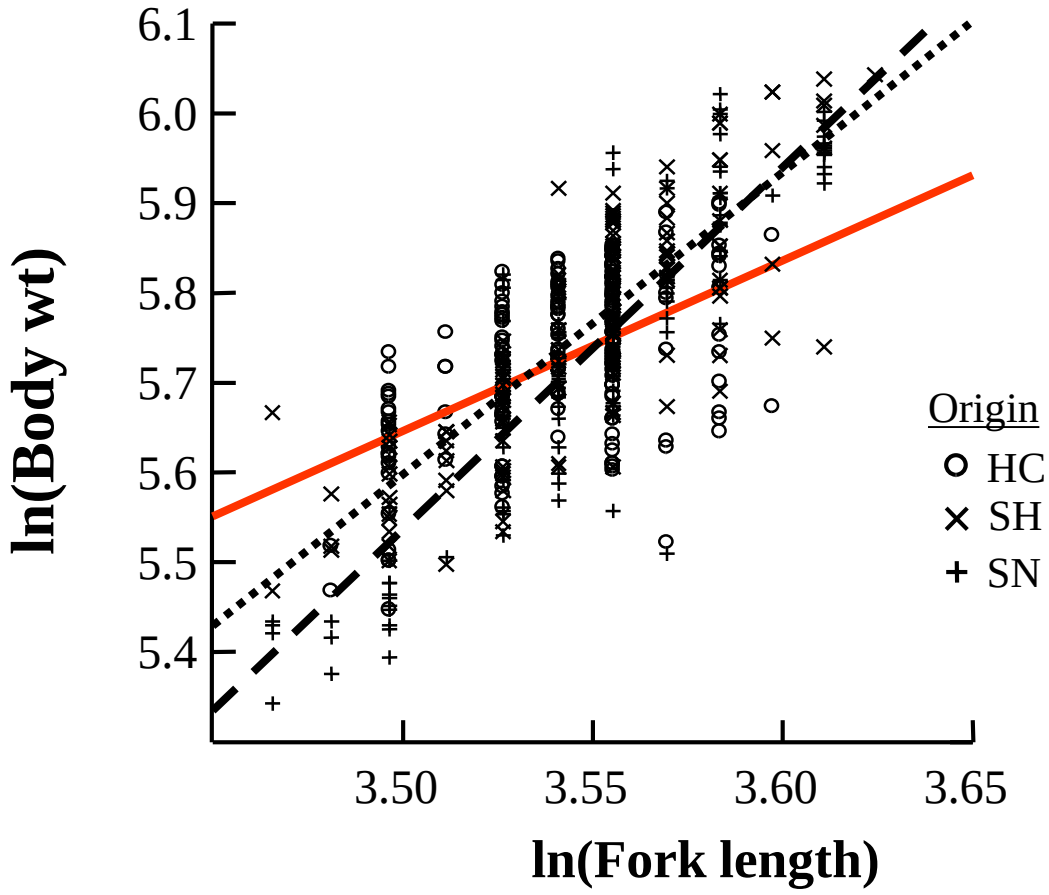
***SH* eggs are 9% larger than *HC* eggs**

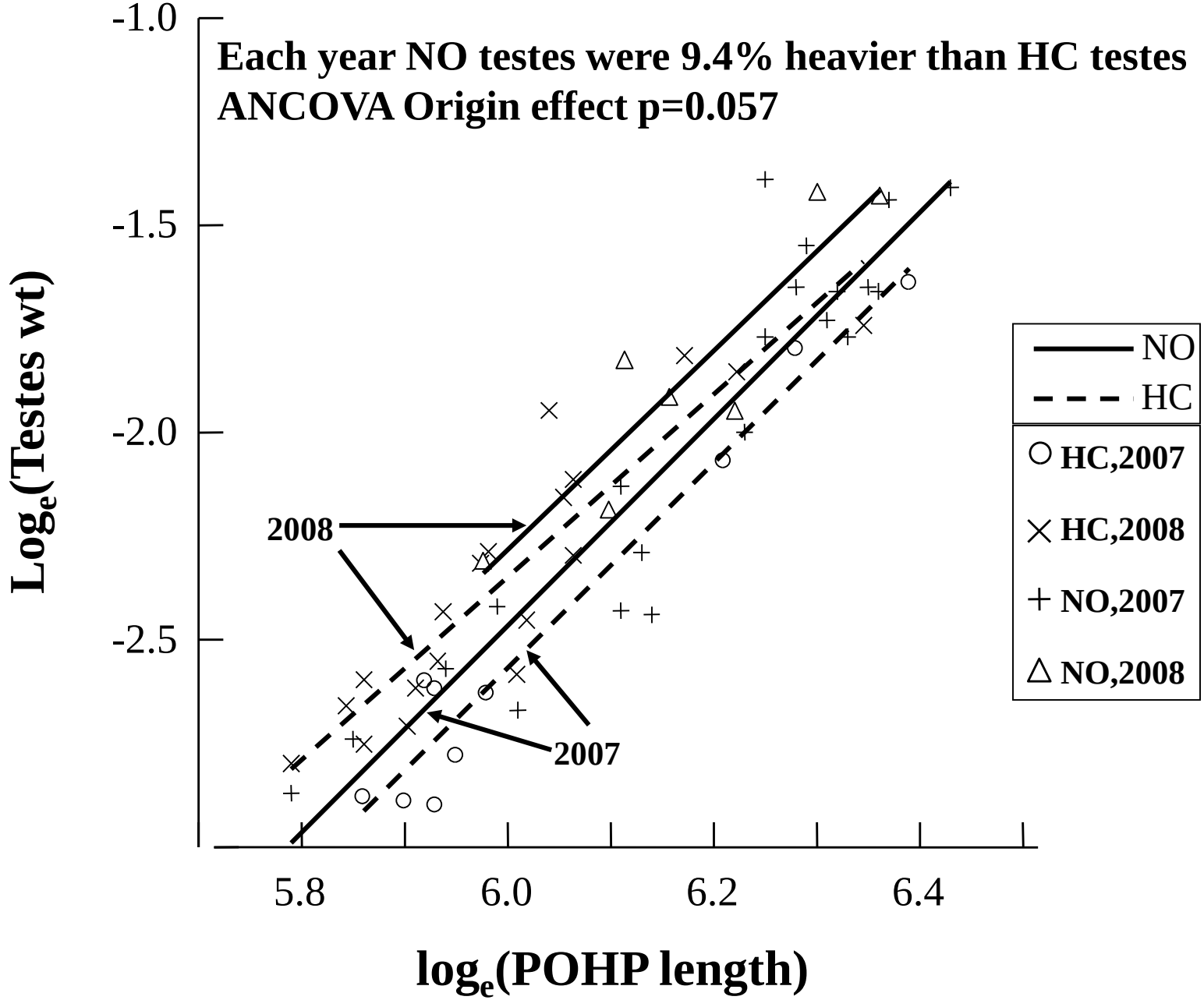
ANCOVA equality of means p=0.037



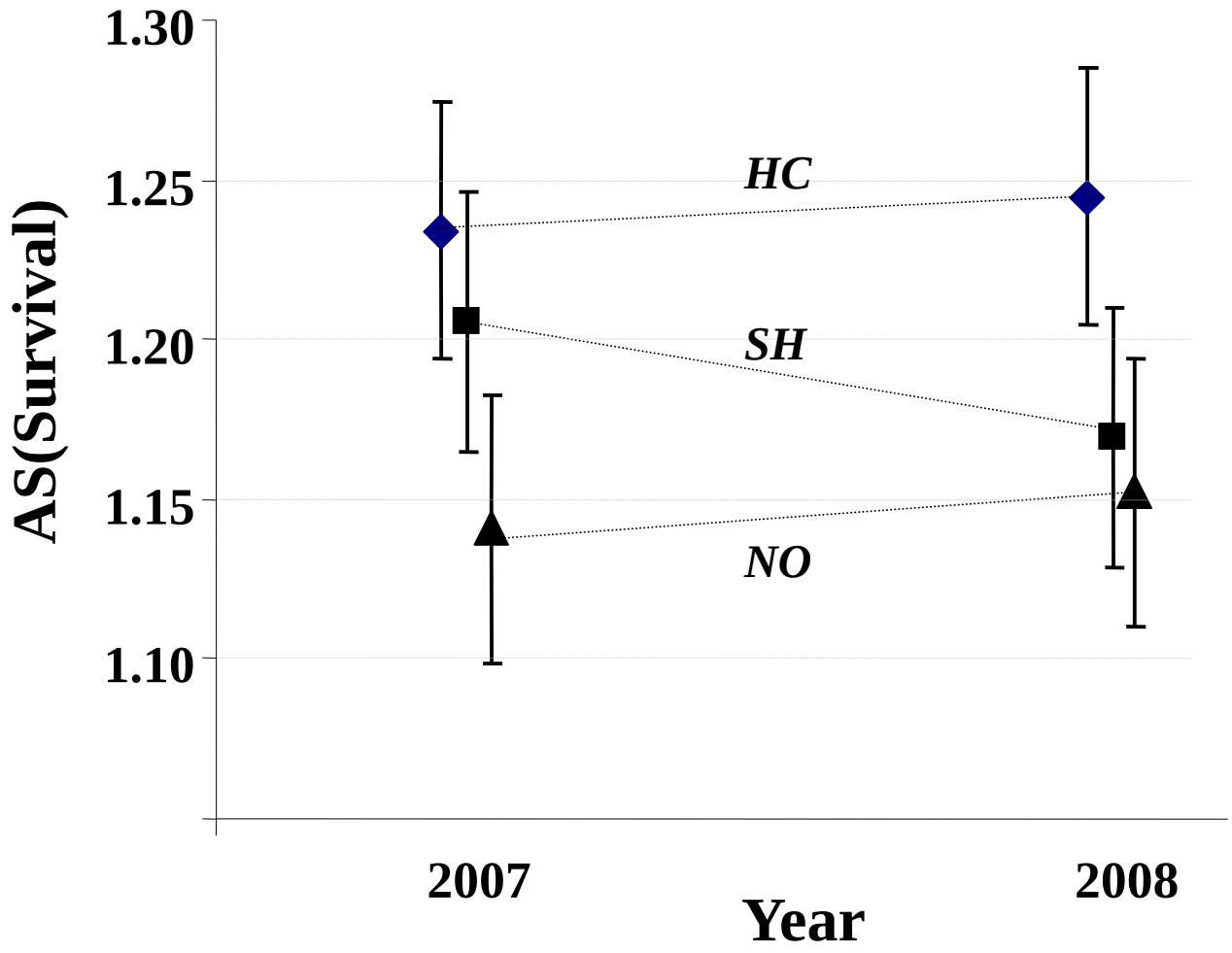
Fry Body Size at ponding BY08

ANCOVA equal slopes p<0.001




Each year NO testes were 9.4% heavier than HC testes
ANCOVA Origin effect p=0.057
-1.0
-1.5
-2.0
-2.5
Log$_e$(Testes wt)
5.8
6.0
6.2
6.4
log$_e$(POHP length)
2008
2007
NO
HC
HC,2007
HC,2008
NO,2007
NO,2008

Mean Eyed-Egg Survival (± 1 SE)

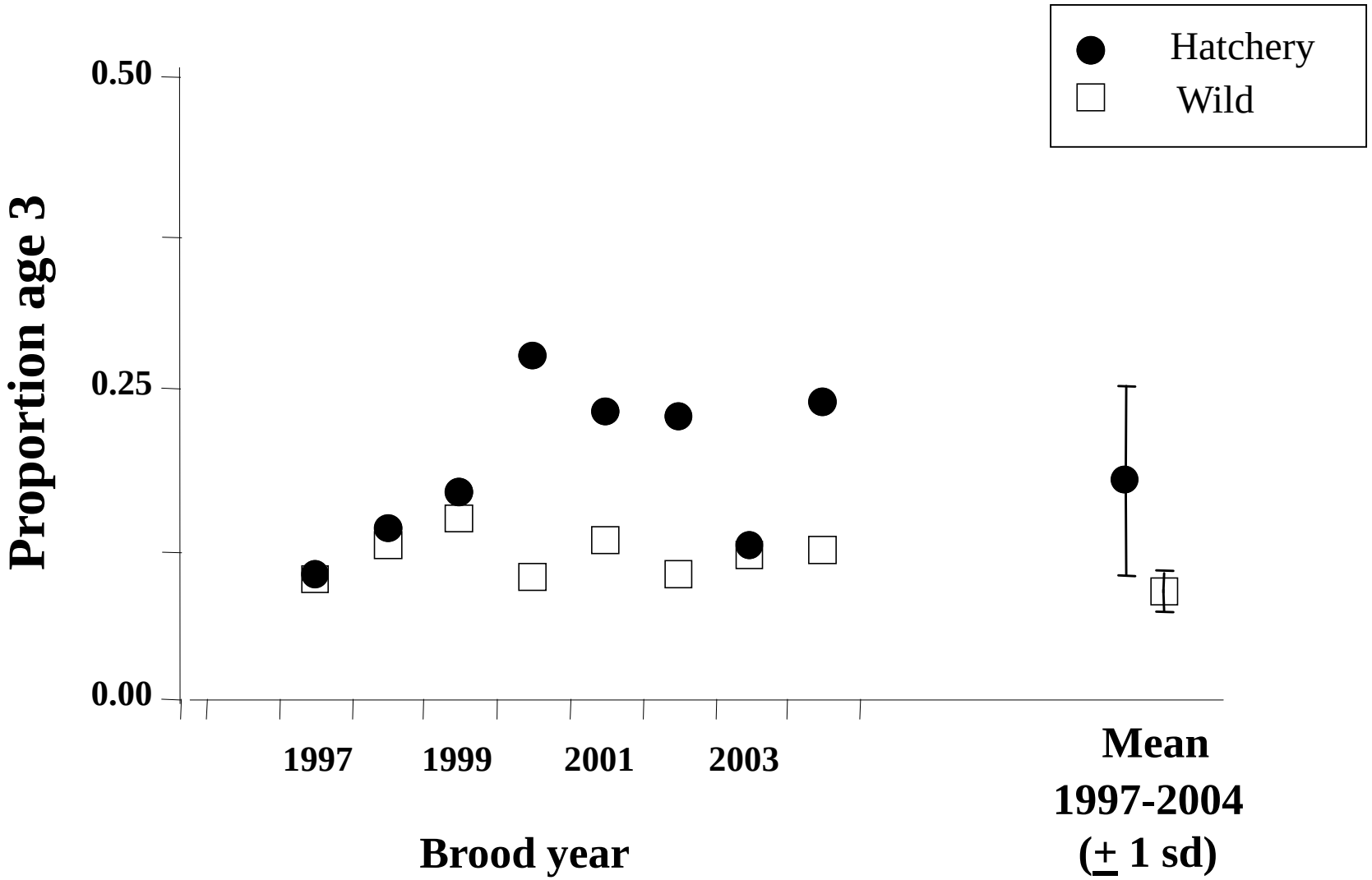


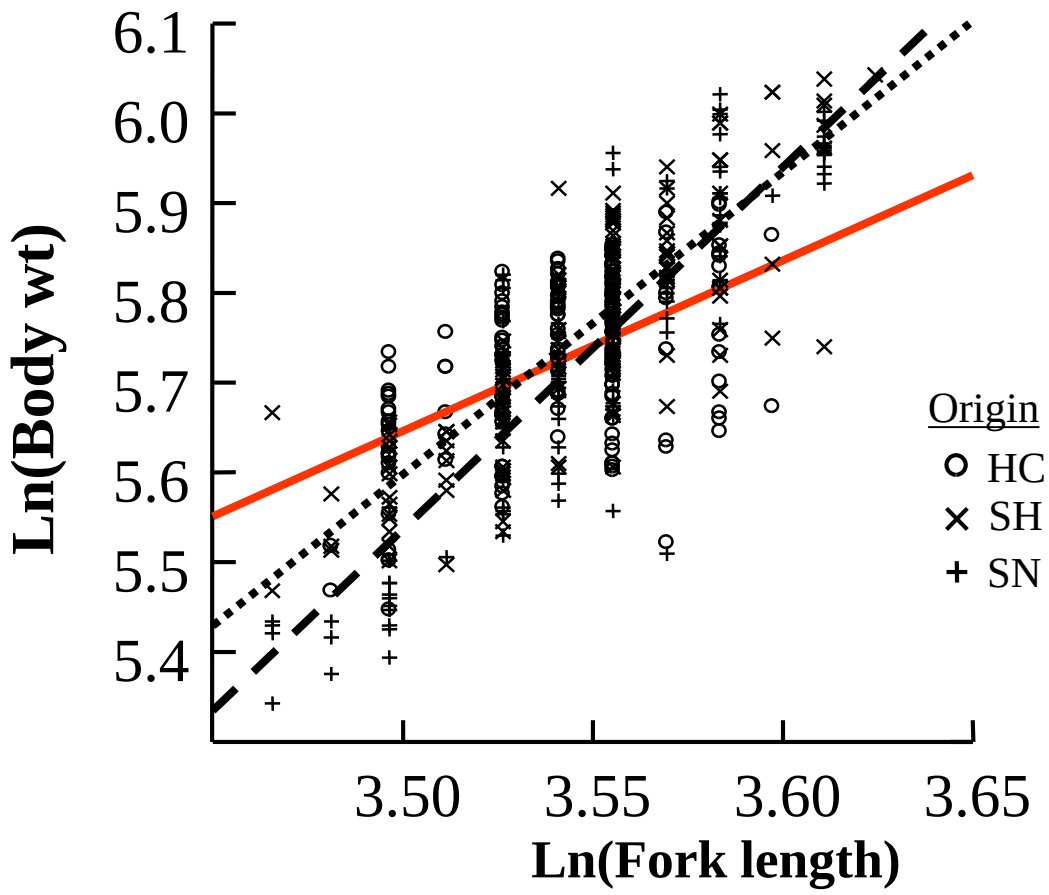
ANOVA Origin effects p=0.080

Summary

- LHT predictions are correct when dealing within a single population or genotype
- NO, SH and HC populations have different reaction norms because they are different genotypes as a result of domestication effects
- Other traits correlated with body size are also showing the effects of domestication
- Evidence of selection for a hatchery type and against NO type within the hatchery

Questions?


Hatchery
Wild
0.50
0.25
0.00
Proportion age 3
1997
1999
2001
2003
Brood year
Mean
1997-2004
(± 1 sd)



Fry Body Size at ponding BY08

ANCOVA equal Slopes p<0.001

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
LN_FL	1.7950	1	1.7950	307.9954	<0.0001
ORIGIN	0.1394	1	0.1394	23.9207	<0.0001
ORIGIN*LN_FL	0.1403	1	0.1403	24.0713	<0.0001
Error	1.9057	327	0.0058		