Genetic effect of domestication selective pressures on Pacific oyster at larval stage

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Crassostrea gigas life cycle

The “elm-oyster model”

Williams 1975

<table>
<thead>
<tr>
<th>Stages</th>
<th>Survival</th>
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<td><img src="image1.png" alt="Stage 1" /></td>
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<td><img src="image2.png" alt="Stage 2" /></td>
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<td><img src="image4.png" alt="Stage 4" /></td>
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<td><img src="image5.png" alt="Stage 5" /></td>
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High fecundity and high mortality at early stages
Can specific rearing practices (culling) and/or environmental conditions (high temperature) lead to a specific genetic adaptation in *C. gigas* larvae?

😊 Few genitors needed for mass production of juveniles
😊 Culling (size selection)

😊 Low effective population size (Hedgecock *et al.*, 1992)
😊 Risks of rapid loss of genetic variability and inbreeding in closed populations

Which consequences of such a life history strategy for hatchery production?
Genetic variability of early life traits in \textit{C. gigas}?

Ernande \textit{et al.}, 2003

- limited number of families
- no family replicates
- a single environment
Mixed-family approach

One set of 3 PCR-multiplexed markers allowing efficient parental assignment of larvae (Taris et al., 2005)

- More families
- Homogeneous rearing conditions
- G x E ?
1. Effect of culling

Crossing of 3 females x 10 males with equal gametic contribution within each sex

Progressive culling from day 4 to day 15

- 50%

Control
1.1 Phenotypic effect of culling 50% of the smallest larvae

**Limited effect on yield:**
- 30% of ready-to-settle larvae (higher survival of fast growing larvae)
- 15% of spat (higher settlement success of fast growing larvae)
1.2 Genetic effect of culling

The effect of culling on genetic diversity is mediated through its effects on the timing of settlement.

\[ Ne = \begin{array}{c} 8.2 \\ 6.3 \end{array} \]

12.3

15.2

15.9

D20

D25

D28
2. Effect of temperature

Crossing of 4 females x 12 males with equal gametic contribution within each sex

Individual measurements of larvae prior to genotyping

Estimation of hatching rate at day 1
2.1. Phenotypic effect & sampling

Larval stage

Time after fertilization (days)

length (µm) larval shell

Spat

cohorts

early
late

settlement

early
late

20°C 26°C
2.2. Variance of female reproductive success

Observed maternal contributions relative to mean hatching rate at Day 1
2.2. Variance of parental reproductive success

Observed paternal contributions relative to mean hatching rate at Day 1
2.2. Variance of parental reproductive success

- Male: **
- Female: ***

Temperature conditions:
- 20°C
- 26°C
2.3. Paternal contributions at day 80 (spat)

Significantly different contributions between early and late cohorts at 20°C (same result at 26°C)

Significantly different contributions between early cohorts at 20°C and 26°C (same result for the late cohort)
2.2. «G x E» interaction on larval size

Reaction norm larval diameter/temperature per family

Male

 ns

 p<0.05

Female

 ns

 p<0.05
2.4. Effect of temperature during larval rearing on spat growth
3. Selection for fast growing larvae in hatcheries?

Hatchery broodstock

Wild broodstock

7 generations of breeding
Loss in allele diversity $\approx 70\%$
Loss in heterozygosity $\approx 20\%$

Rearing conditions:
- $24^\circ C$
- no culling
3.1. Larval growth
3.2. Larval survival

![Graph showing larval survival over time](image)

- **Hatchery**
- **H x W**
- **W x H**
- **Wild**

Days after fertilization:
- 3
- 6
- 8
- 10
- 13
- 15
- 17
- 20

Survival: 100, 90, 80, 70, 60, 50, 40, 30
3.3. Timing to reach the pediveligere stage and settlement success

Settlement success (%):

Hatchery 90.7 > HxW 78.1 > Wild 72.3 > WxH 68.7
3.4. Within progeny variation for larval size

C.V. of larval length

Wild progeny
Hatchery progeny

Distribution of larval length at Day 15

Hatchery
H x W
W x H
Wild

Coefficient of variation

Days after fertilization

Wild larvae
Hatchery larvae

205 μm
225 μm **

Inbred larvae?
Conclusions

Methodology
- As individual tagging is impossible at early life stages, marker-based parentage analysis of mixed families represents an efficient tool to study genetic variability of larval traits.

Selection at larval stage
- Significant differences are observed between progenies, confirming the existence of genetic variation for several traits.
- Temperature influences the expression of genetic variability for growth and survival and therefore is likely to increases the genetic effect of culling.
- Intensive rearing practices can lead to the selection of faster growing / higher settlement larvae, despite inbreed depression.
Thanks