Genetic Technologies as Tools for Geographically Isolated Shellfish Production Systems

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Overview

- Breeding programmes in aquaculture
- Current breeding methods
- Biotech tools as a ‘low-tech’ alternative
- Summary
Why Breed?

- Aquaculture production
- Fisheries restocking
- Conservation
Production System Benefits

- Improved yield
- Product quality/value
- Disease resistance
Aquaculture Breeding Gains

<table>
<thead>
<tr>
<th>Species</th>
<th>Genetic Gain in Growth Rate per Generation</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oysters</td>
<td>14.3%</td>
<td>4</td>
</tr>
<tr>
<td>Clams</td>
<td>9.0%</td>
<td>1</td>
</tr>
<tr>
<td>Scallops</td>
<td>17.0%</td>
<td>2</td>
</tr>
<tr>
<td>Coho Salmon</td>
<td>10.1%</td>
<td>1</td>
</tr>
<tr>
<td>Rainbow Trout</td>
<td>11.5%</td>
<td>2</td>
</tr>
<tr>
<td>Atlantic Salmon</td>
<td>13.6%</td>
<td>3</td>
</tr>
<tr>
<td>Channel Catfish</td>
<td>17.5%</td>
<td>2</td>
</tr>
<tr>
<td>Tilapia</td>
<td>13.5%</td>
<td>2</td>
</tr>
<tr>
<td>Rohu Carp</td>
<td>17.0%</td>
<td>1</td>
</tr>
<tr>
<td>Shrimp</td>
<td>9.7%</td>
<td>2</td>
</tr>
</tbody>
</table>
Breeding Strategy

- Gain driven by:
  - Genetic variation
  - Heritability
  - Selection intensity
  - Selection accuracy

- Gain has to be balanced against increased relatedness
Practicalities

- Shellfish reproductive biology similar to plant biology
  - Many offspring per family
  - Not very mobile as adults but...
  - Larval ‘seed’ phase
- Between family selection for accurate breeding value estimation
- Within family ‘mass’ selection for high selection intensity
Mixed Family Rearing Strategies
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Current Shellfish Breeding Methods

- Larval bottleneck
  - Difficult
  - Requires sophisticated hatchery technology
Current Shellfish Breeding Methods

- Nursery phase
  - Tank effects
  - Resources
Current Shellfish Breeding Methods

- Identification
  - Tagging
  - Engraving
Pacific Oyster Weights at Harvest

Weight (kg ± 95% CI)

- Wild crosses
- Wild spat
- Top 50% select
- Best families

Family
Pacific Challenges

- Low population density
- Infrastructure reliability
- Infrastructure vulnerability
- Reluctance to invest capital
Reducing Reliance on Hatchery Sophistication

- Microsatellites: a ‘genetic signature’

  Individual 1: ATGCAGCTACACACACACATGACGT
  Individual 2: ATGCAGCTACACACACACACACACATGACGT
  Individual 3: ATGCAGCTACACATGACGT

- Enables determination of parentage and therefore relatedness
- Testing carried out in mainland labs
Mixed Family Rearing Strategies
Genetic Marker Application

- Juveniles can be mixed from the larval stage
  - Less sophisticated systems required
  - Reduced tank effects
- Reduced risk of inbreeding
- Less risk of mislabelling errors
No selection (e.g. conservation restocking)

Mass selection

Family selection with individual ID (e.g. tagged)
Expected genetic improvement

Loss ———> Gain

- No selection (e.g. conservation restocking)
- No selection with controlled mating
- Mass selection
- Mass selection with genetic marker ID: reduces risk
- Family selection with genetic marker ID: reduces hatchery sophistication
- Family selection with individual ID (e.g. tagged)
Summary

- Genetic markers can potentially:
  - reduce risk of inbreeding
  - reduce reliance on hatchery technology
  - less chance of mislabelling errors

- Application:
  - selective breeding programmes
  - fisheries restocking
  - conservation
Summary

- Implications for smaller Pacific nations
  - reduces reliance on investment and hatchery rearing resources
  - enables regions with only basic hatchery facilities to enjoy breeding programme benefits