Five Innovations that has changed Shrimp culture

SPF/Nucleus Breeding; Selective genetics, Auto feeders, Toilet, SPR (SPT)
Shrimp Domestication: How it revolutionized the world's shrimp culture industry

Robins McIntosh
Charoen Pokphand Foods, Public Company
Bangkok Thailand
My Voyage to Happiness

Guatemala

Belize

1998

1995

1998
And Then Thailand 2002
Return to “unhappiness”

Declining Harvest Sizes

Low Growth, High size variation
1999: The year where domestication became a dominant theme in Shrimp
Asian Shrimp Production
4 eras and 2 crisis

1. Eras of Growth defined by technical innovation
2. Eras of Stagnation defined by “new disease”

FAO data
SPF vannamei Dominate Asia/
Pond reared APE dominate America
What Type of Program?

SPF

SPF For:
- TSV
- WSSV
- IHHNV
- HPV
- MBV
- BP
- Microsporida

APE

These shrimp look healthy: But are these shrimp "healthy?"

EHP?
BP?
CMNV?
NHP?
LOV?
Running Mortality
Unknown?

Department of Fisheries
Ministry of Agriculture and Cooperatives Thailand
Definition of SPF/SPR/SPT

• **Specific Pathogen Free** Shrimp refers to the health status of a stock and not a genetic characteristic. To be SPF a shrimp should be free of all known shrimp virus (not only OIE listed pathogens).

• **Specific Pathogen Resistant** Shrimp refers to a Genetic characteristic- being resistant to infection of a specific pathogen; a shrimp may be SPF and SPR.

• **Specific Pathogen Tolerant** Shrimp refers to a genetic characteristic where the shrimp can get infected but does not express the disease.
Developing a Breeding Strategy:

Inbreeding Coefficient

Program A

Program B

Generations
Response to introduction of Healthy SPF Domesticated Stocks
Response to introduction of Healthy SPF Domesticated Stocks

Reduction of WSSV in Thai Farms

% Crop Loss to WSSV

Introduction of Virus Free stocks

Interaction with APHNS
Nucleus Breeding is the definition of SPF

KaoKaew Nucleius Breeding Center
Limitation of PCR screening: no substitute for nucleus Breeding

Different but correct results

Sample of 20

10 to lab A

Positive

10 to lab B

Negative

BOTH CORRECT!
Origins of Founders for SPF Programs;

- **Process:**
  1) Screening (pcr + histology)
  2) Quarantine - one generation
  3) Screening (pcr+ histology)

- **Hawaiian SPF** (original concept): from the ocean

- **Reverse SPF** (newer concept): from infected tolerant pond populations
Reverse SPF performance

<table>
<thead>
<tr>
<th></th>
<th>No SPF</th>
<th>SPF</th>
</tr>
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<tbody>
<tr>
<td>Days to PL12</td>
<td>20-21</td>
<td>17-18</td>
</tr>
<tr>
<td>PLs/gr</td>
<td>350</td>
<td>200</td>
</tr>
<tr>
<td>Survival</td>
<td>45-50%</td>
<td>70-75%</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>&gt;15%</td>
<td>10-12%</td>
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Data and Work by Dr. Victoria Alday
Pesca Nova Group; Ecuador/Nicaragua
Does SPF require an Island?

NO,
But it does require nucleus breeding; Most Bio-secure by definition
2. SPF Black Production of Commercial Broodstock
Completely Closed System
Completely Closed Maturation

Broodstock tanks

Recycle
Maturation : Maturation Diet

No live or Fresh Feed: Biosecure
Larval Rearing: Phytoplankton
Larval Rearing: Nursery; Individual Tank
Secure Multiplication of Broodstock Grow out
Continuous Surveillance

Disease Monitoring

1. NBC Lab
2. CP Central Lab
3. Government Lab

Department of Fisheries
Department of Livestock Development

Real Time PCR - highest Sensitivity
What defines a genetics program

Pedigree of CP Monodon
Breeding Strategy: Line Breeding, Cross Breeding, or Breeding to maximize diversity

CP Breeds to Maximize Diversity - requires much larger populations
Other programs use Line Breeding
CPF has changed shrimp farming with fast growing shrimp

Days to reach 30 grams from pl 10

Size of top 5% at mean 30 grams
Disease Resistance: TSV

Year: 2003 to 2013

TSV Survival rate:
- 2003: 60.00
- 2004: 65.00
- 2005: 70.00
- 2006: 75.00
- 2007: 80.00
- 2008: 85.00
- 2009: 90.00
- 2010: 95.00
- 2011: 100.00
- 2012: 100.00
- 2013: 100.00
Maturation without Ablation

30-35 million nauplii/day/1000 females
Use females 6 months
Shrimp Genetic Programs has allowed for a genetic solution to disease

Development of APHNS (EMS tolerance) in shrimp Stocks
Age at MBW 24, 26, 28 and 30 gram
Statistical Analysis showing traits are not negatively correlated
Genetic reduces costs and enhances value through growth

**2012**

- MBW: 14.5 GMS
- YIELD: 10.4 MTONS/HA
- ADG: 0.18 GMS/DAY

**2016**

- MBW: 24.1 GMS
- YIELD: 21,300 KGS/HA
- ADG: 0.31 GMS/DAY
Functional Genetics Programs cost a lot of Money; but very cost effective

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<tr>
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<th>2010</th>
<th>2014</th>
<th>2016</th>
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<tbody>
<tr>
<td>% Culture Pond</td>
<td>77</td>
<td>77</td>
<td>38</td>
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<tr>
<td>DOC</td>
<td>87</td>
<td>59</td>
<td>81</td>
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<tr>
<td>Stock Density /m2</td>
<td>110</td>
<td>79</td>
<td>135</td>
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<tr>
<td>Failure Rate %</td>
<td>0.00</td>
<td>58</td>
<td>0.00</td>
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<tr>
<td>Survival</td>
<td>91</td>
<td>30.5</td>
<td>89</td>
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<tr>
<td>ADG gm/day</td>
<td>0.175</td>
<td>0.28</td>
<td>0.30</td>
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<tr>
<td>MBW</td>
<td>15.5</td>
<td>16.5</td>
<td>25.0</td>
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<tr>
<td>Yield (kg/ha/day)</td>
<td>190</td>
<td>156</td>
<td>333</td>
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<tr>
<td>PI Efficiency tons/mill</td>
<td>13.6</td>
<td>5</td>
<td>21</td>
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<tr>
<td>Total tons</td>
<td>940</td>
<td>108</td>
<td>728</td>
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<tr>
<td>Cost USD/kg (direct)</td>
<td>2.80</td>
<td>13.90</td>
<td>3.25</td>
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<tr>
<td>Farm Profit mill. USD</td>
<td>1.6</td>
<td>-0.80</td>
<td>2.1</td>
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In the future (present) genomics and transcriptomics will reduce the time to respond to new challenges

First assembled P. vannamei shrimp genome
Without Healthy Post Larvae: Genetics don’t mean very much
Domesticating Monodon has presented unique challenges!!!!
Eventually after 7 generations domestication was achieved—“Ease and Predictability of Culture”

<table>
<thead>
<tr>
<th>Year</th>
<th>All Disease</th>
<th>No. of Sample</th>
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<tr>
<td></td>
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<td>WSSV</td>
</tr>
<tr>
<td>2011</td>
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<td>124</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td>286</td>
</tr>
<tr>
<td>2013</td>
<td></td>
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<td>2016</td>
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<td>740</td>
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<tr>
<td>2017</td>
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<td>160</td>
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Before and After Domestication of SPF monodon

Before: 2001

After: 2011
Domestication is Very Difficult with Monodon

In first 5 Generations lost many families; lost many individuals
TODAY
WSSV-APHNS Interaction

29.5°C 7 day challenge
This is not the Future!
This is the Now

6 count P. vannamei
160 gram female
5 tons/hectare in one hectare
160 days post nurse

Jahore, Malaysia
February 2016