Investigation of Ark Clam Culture and Marketability

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FUNDED BY:
USDA CSREES and Florida Sea Grant
Rationale

- Clam farming in Florida supports small businesses
  - Over 350 growers in 10 coastal counties
  - 1800 acres in leases
  - $13M in sales value
  - 92 shellfish wholesalers

- However, it is a monoculture industry

- Need for diversification from a single species
  - Augment profit potential
  - Spread production risks
Rationale

- Alternative species for aquaculture consideration
  - Native molluscan species
  - Cultured and marketed similar to hard clam, *Mercenaria mercenaria*

- Sea Grant-funded research has evaluated the suitability of several mollusk species
  - Angel wing, 1990-2
  - Bay scallop, 1997-9
  - Sunray venus, 2006-8
Rationale

- Ark clams harvested in mid-Atlantic states (VA, NC) in limited quantities
- Development of a major fishery for these species restricted by
  - Dispersed wild populations
  - Minimum understanding of reproduction
  - Small, isolated ethnic markets
- Research efforts in Virginia during 1990s concluded slow growth of arks limit aquaculture potential
- Natural recruitment of arks into newly-planted clam bags supported hypothesis that arks may have potential for commercial development in Florida
Reproductive Patterns

- Determine gametogenic cycles of blood ark off Florida’s east coast (2002-3) and ponderous ark off Florida’s west coast (2001-3)
  - Histologic analysis of gonadal tissue
  - Monthly gonadal index values
  - Peak spawning periods
  - Sex ratios

- Findings published
Reproductive Patterns

- Dribble spawning reproductive strategy for both ark clams
- Prolonged spawning over most of year with bimodal peaks
- Sexes separate, females and males represented in similar ratios

<table>
<thead>
<tr>
<th>Ark</th>
<th>Sexes</th>
<th>Sex Ratio (M/F)</th>
<th>Reproductive Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td>Dioecious, 2% hermaphrodites</td>
<td>2.68 / 1</td>
<td>Major peak during late spring-early summer months (45% ripe in May). No activity in summer. Minor peak during winter (21% ripe in December). Spawning seen in all months.</td>
</tr>
<tr>
<td>Ponderous</td>
<td>Dioecious, no hermaphrodites</td>
<td>1.19 / 1</td>
<td>Ripens rapidly during the spring, peaks in summer and fall months. However, spawning noted year round.</td>
</tr>
</tbody>
</table>
Seed Production

- Set-up experimental molluscan shellfish hatchery and nursery at UF Whitney Lab near Saint Augustine

- Conduct spawning, larval rearing and setting trials
- Develop ark seed production techniques
- Compare with standard hard clam protocols
Spawning

- Wild ark clams were sourced from different sites
- Broodstock were conditioned at lab
- Spawning induced by temperature cycling from 20 to 30°C
- Spawning behavior like hard clam
- Serotonin injection not successful
# Spawning Trials, 2002-5

<table>
<thead>
<tr>
<th>Ark</th>
<th># Trials</th>
<th>% Spawns</th>
<th>Spawns per month (%)</th>
<th>Fecundity (# eggs / )</th>
<th>Fertilization Rates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td>29</td>
<td>38</td>
<td>March -- 10</td>
<td>0.7 – 3.9 million</td>
<td>low – 55%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>April --- 36</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>May --- 10</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>June --- 19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>July --- 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ponderous</td>
<td>51</td>
<td>20</td>
<td>August ----- 10</td>
<td>1.5 – 3.5 million</td>
<td>low – 79%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>September - 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>October ----- 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>November -- 10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Fertilized eggs
  - Color: orange to reddish
  - Size:
    - Blood: 55 μm
    - Ponderous: 65 μm
    - Hard clam: 70 μm
Embryonic Development

Blood Ark
- Fertilization: 0 minutes
- First cleavage: 1 hour
- Blastula: 4-5 hours
- Gastrula: 7-8 hours

Ponderous Ark
- Fertilization: 0 minutes
- First cleavage: 1 hour
- Blastula: 5 hours
- Gastrula: 8-9 hours

- Documented using light and fluorescence microscopy
Embryonic Development

- Differences in timing of development between ark clams were negligible
- Behavior and developmental timeline of ark clams similar to hard clam
- Documentation of protocol and reference for commercial hatchery development
# Larval Rearing

<table>
<thead>
<tr>
<th>Species</th>
<th>Day</th>
<th>Stage</th>
<th>Larval Size (μm)</th>
<th>Screen size (μm)</th>
<th># per ml</th>
<th>Survival %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Clam</td>
<td>1</td>
<td>D-shape</td>
<td>105 x 90</td>
<td>34</td>
<td>6.9</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Setting</td>
<td>225 x 215</td>
<td>100</td>
<td>2.7</td>
<td>39</td>
</tr>
<tr>
<td>Blood Ark</td>
<td>1</td>
<td>D-shape</td>
<td>80 x 65</td>
<td>34</td>
<td>4.3</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Veliger</td>
<td>115 x 110</td>
<td>54</td>
<td>0.5</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Setting</td>
<td>275 x 200</td>
<td>110</td>
<td>0.2</td>
<td>5</td>
</tr>
<tr>
<td>Ponderous Ark</td>
<td>1</td>
<td>D-shape</td>
<td>90 x 70</td>
<td>34</td>
<td>2.4</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Veliger</td>
<td>130 x 100</td>
<td>54</td>
<td>1.7</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Setting</td>
<td>211 x 155</td>
<td>110</td>
<td>0.6</td>
<td>25</td>
</tr>
</tbody>
</table>
Setting and Post-set

- Setting was problematic
- No distinct pediveliger stage
- Setting based on behavior (probing the tank bottom) and size (>200 μm)
- Experiments conducted to evaluate cues on settlement
  - Physical (substrates - sand, mud; poly strands) cues – 0% set
  - Chemical (H₂O₂, KCl, exudate, norepinepherin) cues – 0% set
  - Biological (algal species) cues –
    - T-Iso, Pav, Ch, BG, no food – 0% set
    - Benthic algae (<35 μm) – 74% set within 7 days
Land-based Rearing

- Post-set rearing in downwellers
  - Tendency to crawl out of tanks
  - Attach to tanks and other arks with byssal threads
  - Growth rates
    - Blood: 6-12 days to 1 mm
    - Ponderous: 49-56 days to 1 mm

- Land-based nursing in downwellers
  - Sieving difficult
  - Growth rates
    - Blood: 3-4 months to 14-15 mm SL (3.5-4.3 mm/mo)
    - Ponderous: 6 months to 19 mm SL (3.2 mm/mo)
Blood Ark Culture

- Conduct field nursery and growout rearing trials in St. Augustine (east coast of Florida), 2003-4
- Document growth and survival in soft (polyester) bags and hard (polyethylene) culture bags
From 14 mm to 34-35 mm (1.4”) SL in 11 months (1.9 mm/mo)

No differences in bag types
Blood Ark Shell Width

- From 7 mm to 22-23 mm (0.9”) SW in 11 months (1.4 mm/mo)
- No differences in bag type
Blood Ark Survival

- 66% survival in nursery (2 months), 80-93% survival in growout (9 months)
- Overall survival of 61% in hard bag and 53% in soft bag (11 months)
Ponderous Ark Culture

- Conduct field nursery and growout trials in Cedar Key (west coast of Florida), 2004-6
- Document growth and survival in hard (polyethylene) culture bags
From 19 mm to 44 mm (1 ¾”) SL in 24 months (1 mm/mo)
From 11 mm to 30 mm (1 ¼”) SW in 24 months (0.8 mm/mo)
From 2 grams to 31 grams whole weight (14 per pound) in 24 months
76% survival in nursery (6 months), 72% survival in growout (18 months)

Overall survival of 62% through Dec 05, or 55% through Jun 06
Ark versus Hard Clam Growth

- Shell Length to Width Ratio: 1.5-Blood Ark, 1.4-Ponderous Ark, 1.9-Hard Clam
Ark Clam Marketability

- Assess magnitude of potential domestic market for ark clams, 2003
  - Over 2,100 shellfish wholesalers surveyed nationwide
  - 309 respondents, or 15%
- Survey results revealed limited trade awareness
  - Over 90% wholesalers unfamiliar with them
  - Only 1% reported selling ark clams in previous year
- Nearly one-third were willing to evaluate product samples of both species
Ark Clam Marketability

- Determine desired product attributes and evaluate sensory attributes, 2003-4
  - 82 interested dealers received live samples and questionnaire
- Evaluate a number of basic product characteristics – appearance, taste, aroma, and textural properties
  - 52 provided useful evaluations, or 63%
- Estimate potential sales through respective firms
Marketability

- **Appearance** evaluations were mediocre
  - Rating of 5 on 0 to 10 scale
  - Negative comments on black color, “fuzzy and “furry” shell
- **Meat Color** evaluations fared worse
  - 4.2 rating for blood
  - 3.6 rating for ponderous
  - Negative comments on bloody appearance
- **Texture** was “slightly” to “much too tough”
- Taste ratings were under 5 if eaten raw and about 5 is eaten cooked
Ark Clam Marketability

- Sales projections for arks
  - 50-60% of respondents could not sell
  - 20% did not know if they could
  - 11 firms, or 21%, estimated sales of 30 to 170,000 blood arks per week
  - 8 firms, or 14%, estimated sales of 30 to 120,000 ponderous arks per week

- Wholesale prices ranged from $0.18-0.25 per ark clam

- Preferable sizes ranged from 1-1.25” shell width

- Current sellers noted inadequate supplies appear to limit market growth

- Current market is limited

- Widespread lack of familiarity
- Blood Ark – 99% survival in refrigerated storage after 9 days, 88% after 15 days
- Ponderous Ark – 99% survival in refrigerated storage after 23 days
Ark Clam Nutritional Composition

- Nutritional facts and labeling for cultured ark clams were determined for serving size of 100 grams of edible portion
  - Low in calories, fat, cholesterol
  - No carbohydrate
  - High in protein
  - High in sodium
  - High in iron (50-70% of daily value)

- In comparison, hard clams
  - Higher in calories
  - Similar in fats, cholesterol, and carbohydrate
  - Less sodium
  - 1/2 to 1/3 daily values for iron

<table>
<thead>
<tr>
<th>Blood Ark</th>
<th>Ponderous Ark</th>
</tr>
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<tbody>
<tr>
<td><strong>Nutrition Facts</strong></td>
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</tr>
<tr>
<td>Serving Size (100g)</td>
<td>Serving Size (100g)</td>
</tr>
<tr>
<td><strong>Amount Per Serving</strong></td>
<td><strong>Amount Per Serving</strong></td>
</tr>
<tr>
<td>Calories</td>
<td>36</td>
</tr>
<tr>
<td>Calories from Fat</td>
<td>6</td>
</tr>
<tr>
<td>% Daily Value^</td>
<td>1</td>
</tr>
<tr>
<td>Total Fat</td>
<td>0.5g</td>
</tr>
<tr>
<td>Saturated Fat</td>
<td>0g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>35mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>740mg</td>
</tr>
<tr>
<td>Dietary Fiber</td>
<td>less than 1 gram</td>
</tr>
<tr>
<td>Sugars</td>
<td>0g</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>1g</td>
</tr>
<tr>
<td>Vitamin A R%</td>
<td>•</td>
</tr>
<tr>
<td>Vitamin C %</td>
<td>•</td>
</tr>
<tr>
<td>Calcium %</td>
<td>•</td>
</tr>
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<td>Iron %</td>
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^Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

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<tr>
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<th>2,500</th>
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<tbody>
<tr>
<td>Total Fat</td>
<td>Less than 65g</td>
<td>80g</td>
</tr>
<tr>
<td>Saturated Fat</td>
<td>Less than 20g</td>
<td>25g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>Less than 300mg</td>
<td>300mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>Less than 2,400mg</td>
<td>2,400mg</td>
</tr>
<tr>
<td>Dietary Fiber</td>
<td>28g</td>
<td>30g</td>
</tr>
<tr>
<td>Calorie per gram:</td>
<td>Fat 9 • Carbohydrate 4 • Protein 4</td>
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<tr>
<td>Cholesterol</td>
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Ark Clam Market Information

Complete Market Report can be found on the UF/IFAS Florida Agricultural Market Research Center’s website: [http://www.agmarketing.ifas.ufl.edu](http://www.agmarketing.ifas.ufl.edu), first click on “Publications,” then click on “Marketing Research Publications 2000+”

Summaries of Phase I, II, III of the marketing assessment can be found at the UF/IFAS Electronic Data Information Source (EDIS) website: [http://edis.ifas.ufl.edu](http://edis.ifas.ufl.edu), click on EDIS pub FE478 and FE568.
Ark Clam Summary

- Seed can be produced using standard hard clam techniques
- Most likely higher seed costs
  - Lower larval survival
  - Longer larval period
    - Blood – 17 days
    - Ponderous – 21 days
    - Hard clam – 9 to 12 days
- Need to optimize survival at settlement
Ark Clam Summary

- Land-based nursing, field nursing and growout can be conducted using equipment and methods for hard clams
  - Survival commercially acceptable in field
    - Blood – 57%
    - Ponderous – 62%
    - Hard Clam – 56 to 64%

- Crop period from 1 mm SL to 25 mm SW (“littleneck”-size)
  - Blood – 16 mo
  - Ponderous – 24 mo
  - Hard Clam – 18 to 24 mo
Ark Clam Summary

- Unlikely to be a widespread, mainstream demand for ark clams
- Market development proponents should recognize importance of ethnic markets in target locations on East and West coasts
- Targeting seafood dealers with large Asian (“akagai”) and Hispanic (“pata de mula”) populations could result in profitable niche markets