Trojan Sex Chromosomes
Can Biased Sex Ratios Drive A Population To Extinction?
Chris Jeszke – Ashton Hatchery
Trojan Sex Chromosomes

Collaborative Fisheries Bureau Investigation:
– Schill, Frew, Horton, Grunder, Heindel – IDFG Fisheries Bureau
– Matt Campbell – IDFG Eagle Genetics Lab
– Phil Mamer – IDFG Eagle Health Lab
– Meyer, Koenig, Dillon – IDFG Nampa Fisheries Research, Region 3
– Doug Engemann, Chris Jeszke, Paul Martin – IDFG Ashton / Springfield Fish Hatchery
Trojan Sex Chromosomes

Exotic Introductions Problematic

• Relatively few practical and effective alternatives exist to deal with non-natives
  – Chemical
  – Removal/depletion
  – Construction of barriers
    Logistically difficult, can be costly, may have collateral damage to non-target organisms
Trojan Sex Chromosomes

Multiple Interpretations in Literature:
Gutierrez and Teem
Cotton and Wedekind

Daughterless Technology
Daughterless Technology

Salmonids share a common trait with most mammals in that they are **MALE HETEROGAMETIC**

Male individual of a given species produces two different “kinds” of gametes with respect to sex chromosomes
Daughterless Technology

MALE HETEROGAMETIC

Either X or Y sex chromosomes
Daughterless Technology

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The table represents different genotypes with X and Y chromosomes, illustrating the concept of daughterless technology in genetics.
Daughterless Technology

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50% XX
**Daughterless Technology**

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50% XX

50% XY
Daughterless Technology

\[ \begin{align*}
\text{♀} & \quad 50\% \ XX & = & \quad Fxx \\
\text{♂} & \quad 50\% \ XY & = & \quad Mxy
\end{align*} \]

\(Fxx\) = phenotypic female (F), genotypic female (xx)

\(Mxy\) = phenotypic male (M), genotypic male (xy)
Daughterless Technology

\[
\begin{align*}
F_{xx} + \text{TESTOSTERONE} &= M_{xx} \\
M_{xy} + \text{ESTROGEN} &= F_{xy}
\end{align*}
\]
**Daughterless Technology**

Why? = trout aquaculture

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<thead>
<tr>
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<th>Mxx</th>
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<tbody>
<tr>
<td>Fxx</td>
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**Daughterless Technology**

Why? = tilapia aquaculture

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*Generation #1*

- **Fxy**
  - 25% XX
  - 50% XY
  - 25% YY

- **Mxy**

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**Image**

- Fish (Fxy)
- Fish (Mxy)
Daughterless Technology

Why? = tilapia aquaculture

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25% XX
50% XY
25% YY
Daughterless Technology

Why?

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100% YY

“supermales”

Generation #2
Daughterless Technology

• Gutierrez and Teem Model:

Repeated introductions of individuals that are phenotypically sex reversed from that of their genotype will provide disproportionate influx of one sex chromosome into subsequent generations, biasing sex ratio, and leading to potential population extinction
Daughterless Technology

• Assumptions:
  – Altered stocks are identical to wild with regards to *mating advantage* (no size, performance, selection differences - current research is lacking)
Daughterless Technology

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Daughterless Technology

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Daughterless Technology

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  – *Offspring viability* identical to wild
  – Model assumes *iteroparity* (unknown ?)
  – All individuals have same *life span* and *mortality rates*

  – No elements in system that can cause *spontaneous masculinization or feminization* (steroids, temperature, social environment, stocking density)
Daughterless Technology

• Rate at which Fxx eliminated relies on:
  – Rate at which Fxx eliminated through mortality
Daughterless Technology

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  – Rate at which Fxx are generated in matings
Daughterless Technology

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- Relative proportion of Fxx to Fyy in population over progressive rounds of mating
Daughterless Technology

• Rate at which Fxx eliminated relies on:
  – Rate at which Fxx eliminated through mortality
  – Rate at which Fxx are generated in matings
  – Relative proportion of Fxx to Fyy in population over progressive rounds of mating
  – Number of Fyy introduced and for how long (model used 3.2% introduction of Fyy in a population of several hundred individuals = extinction after a few decades)
Daughterless Technology

- Reduction in population size dependent on magnitude and frequency of Fyy = can have mild management of a system to complete eradication
- If possible, this technology is non-permanent = sex ratio returns to unity if Fyy ceases before Fxx extinct (example - unexpected and/or unwanted effects detected)
Daughterless Technology

• No (apparent) collateral ecological damage
• Only target species impacted (potential issues with hybridization?)
Daughterless Brook Trout?

Fall 2008

#1

XX Female (Fxx)

XY Male (Mxy)

~50% XX, 50% XY

17 beta-estradiol
20 mg/kg diet, 60 days
Daughterless Brook Trout?

XX Females (Fxx)

XY Neo-Females (Fxy)

Develop Sex Markers?

Retain XY Neo-Females (Fxy)
Daughterless Brook Trout?

Fall 2010

XY Neo-Female (Fxy)

XY Standard Male (Mxy)

~25% XX, 50% XY, 25% YY

Need Sex Markers
Daughterless Brook Trout?

Fall 2010

~25% XX, 50% XY

~1/2 of production

17 beta-estradiol
20 mg/kg diet, 60 days

~25% YY (Myy)

YY Neo-Females? (Fyy)
Daughterless Brook Trout?

Fall 2012

YY Neo-Female (Fyy)

YY "Super male" (Myy)

~100%YY (Myy)

Broodstock Production
What’s Happening Now?

• Need reliable genetic sex markers for Brook trout
• Ability to produce salmonid Fyy with functional gametes is unknown
• Field evaluations (triploidy’s big sister?)
What’s Happening Now?

• 2011 – progeny ponded in one raceway at Ashton:
  
  208 controls + 208 treatments; 4 unique (un-related) family types that can be crossed in 2012 – 2013 release if success. Assume ~ 25% xx, 50% xy, 25% yy in general population

• 2012 – Sex markers have been obtained, can select Fyy’s from population and determine whether or not oocytes are viable
• Spawning took place in ~ Nov 2012
• ~ 25 Myy and ~ 25 Fyy were spawned.
What’s Happening Now?

• If developing oocytes, are they viable? Spawning took place in ~ Nov 2012

• Spawning produced ~ 25 Myy and ~ 25 Fyy that were spawned.

– $25 \times 500$ fecundity = 12,500 green eggs
– 12,500 green eggs @ 70% survival to eye = 8,750 eyed
– ~ 75% eyed to sub-yearling survival = 6,563 fish
– ~ 6,563 sub-yearlings available for release in 2013
– Other crosses were made with know gender control fish to confirm genetic markers
What’s Happening Now?

- Eggs are currently in incubation
- Eggs from first spawning have eyed up
- Gender ratios will be confirmed within the month
- If all offspring are Myy, sex markers are accurate, can move towards production
- Wait and see….update in Boise in 2013