Mechanisms behind the successful invasion of American Bullfrogs (*Rana catesbeiana*) in the Northwest United States

Tiffany Garcia, Rebbecca Hill, Sarah Abdulkarim, and Chris Funk
Department of Fisheries and Wildlife
Invasive Species

Pressing Ecological Question:
What mechanisms allow exotic species to invade and establish in novel environments?

- American Beach Grass
- Himalayan Blackberry
- Nutria
- New Zealand Mudsnaill
- European Starling
- Red Swamp Crayfish
**Invasive Species**

**Pressing Ecological Question:**
What mechanisms allow exotic species to invade and establish in novel environments?
Bullfrog Background Information

Native Range: Eastern North America

Invasive Range: Western North America

Mechanism:
- Frog farms
- Pet release

Rana catesbeiana Distribution

Photo: L. Morrison

http://co.marion.or.us/

Photo: Corel Inc.
Bullfrog Background Information

Invasion Impacts

• Invasive Bullfrogs can negatively impact native species

Joseph M. Kiesecker et al. (2001)
• Adult bullfrogs reduce larval Red-legged growth rates and alter microhabitat choice
• Context dependent: respond only when habitats are disturbed

Red-legged Frogs

Mike Adams et al. (2003)
• Invasion of bullfrogs in the PacNW is facilitated by the presence of non-native fish
• Non-native fish reduce predatory macroinvertebrate densities

Invasive Synergisms
# Bullfrog Background Information

## Comparison of Life History Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Native Bullfrog Populations</th>
<th>Invasive Bullfrog Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Size</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>Hydroperiod</td>
<td>Permanent</td>
<td>Ephemeral + Permanent</td>
</tr>
<tr>
<td>Larval Period</td>
<td>12-36 mos</td>
<td>3-24 mos</td>
</tr>
<tr>
<td>Dispersal Rate</td>
<td>?</td>
<td>&gt;4km/yr</td>
</tr>
</tbody>
</table>

1. Preliminary hydroperiod data
2. Radio tag data
Hypotheses

3 hypotheses for successful establishment

1. Local adaptation to novel environment
   • Phenotypic divergence is genetically based
   • Invasive population has adapted to local conditions

2. Phenotypic plasticity in response to novel environmental conditions
   • Phenotypic divergence is environmentally induced
   • Individuals across populations can plastically adjust phenotype

3. Invasive acts as disease reservoir
   • Invasive species are carriers of a pathogen
   • The introduced disease decreases fitness of natives and facilitates the carrier’s invasion
Why are bullfrogs successful invaders?

**Hypotheses:**

- Local Adaptation
  - Phenotypic differences in Common Garden Exp.
- Phenotypic Plasticity
  - No Phenotypic difference in Common Garden Exp.
- Disease Reservoir
  - Bullfrogs can infect native amphibians with Bd

**Lab Predictions:**

- Time-lag in population establishment in novel habitats

**Model Predictions:**

- Wide distribution despite novel habitats
- Negative interactions of (Bd + BF) on native amphibian distributions

**Ground-truthing:**

- Field Survey
Objective 1: Determine the source population(s) of invasive bullfrogs in the Pacific Northwest

Methods: Use molecular markers to determine the geographic origin of source population(s) within the native range.

- mtDNA markers
- microsatellite markers

Austin et al. 2004
Bullfrog Tissue Collection

Cat tail pond
Turtle Flats
Ankeny NWR
E.E. Wilson Site #4
Results: Objective 1

Source Region: Michigan/Indiana/Ohio Haplotype
- mtDNA analysis points to the Great Lakes bullfrog region
- microsatellite data will increase focus to population level

Novel environmental Factors:
- temperature stability
- altered hydrological regimes
- limited temporal overlap w/natives
- facilitation by other invasives
Research Project

Test Invasion Hypotheses:
1. Local Adaptation
2. Phenotypic Plasticity
3. Disease Reservoir
   - *Batrachochytrium dendrobatidis*

Temperature
Hydroperiod
Objective 2: Determine whether divergence in larval bullfrog phenotypes is genetically based

**Methods:** Large-scale Common Garden Experiment
- Temperature (invasive/source)
- Hydroperiod (ephemeral/permanent)

Quantify Phenotypic Divergence
1. Growth Rate
2. Time till Metamorphosis
3. Morphometrics

OSU’s Center for Disease Research
Research Project

Objective 3: Test whether bullfrogs can infect native amphibians with *Batrachochytrium dendrobatidis* (Bd)

**Methods:** Bd Exposure Experiment

1. Expose native individuals to infected bullfrog individuals
2. Quantify mortality
3. Quantify infection using PCR
Significance

How do you stop bullfrog invasions? Depends….

1. Local adaptation
   • Delayed expansion into novel environments
   • Time to adapt management plans

2. Phenotypic plasticity
   • Expansion only limited by dispersal speed
   • Run for the hills!

3. Disease reservoir
   • Bullfrog invasive range will have little/no overlap with native frogs
   • Target the pathogen
Future Coqui?

- Survey range expansion
- Target adult females
- Seasonally drain ponds

Send me tissue samples!!!
Tiffany Garcia
tiffany.garcia@oregonstate.edu
Dept. of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97333
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Beth Hultman
Becky Hill
Chris Funk
Phil Rossignol
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Scott, Selina & Dylan Heppell
Rob Hultman

Andy Blaustein