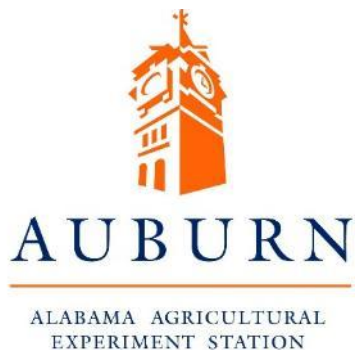


Evaluation of Novel Control Techniques for Invasive Crayfish

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Acknowledgements



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- U.S. EPA Great Lakes Restoration using a Cooperative Agreement between U.S. Geological Survey and Auburn University (Agreement number G19AC00205)
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PEOPLE

- Auburn: H. Abdelrahman, K. Fogelman, G. Elliott, B. Bates, N. Barnes, J. Rodgers, R. Hintz, G. Kor, many others
- USGS: A. Cupp, A. Allert, R. Erickson, D. Schoolmaster
- BGU: A. Sagi, E. Aflalo, M. Kishner, R. Manor, M. Wahl



Procambarus clarkii

Red Swamp Crayfish



Native to S.E USA and N.E Mexico



Highly invasive in U.S. and rest of world



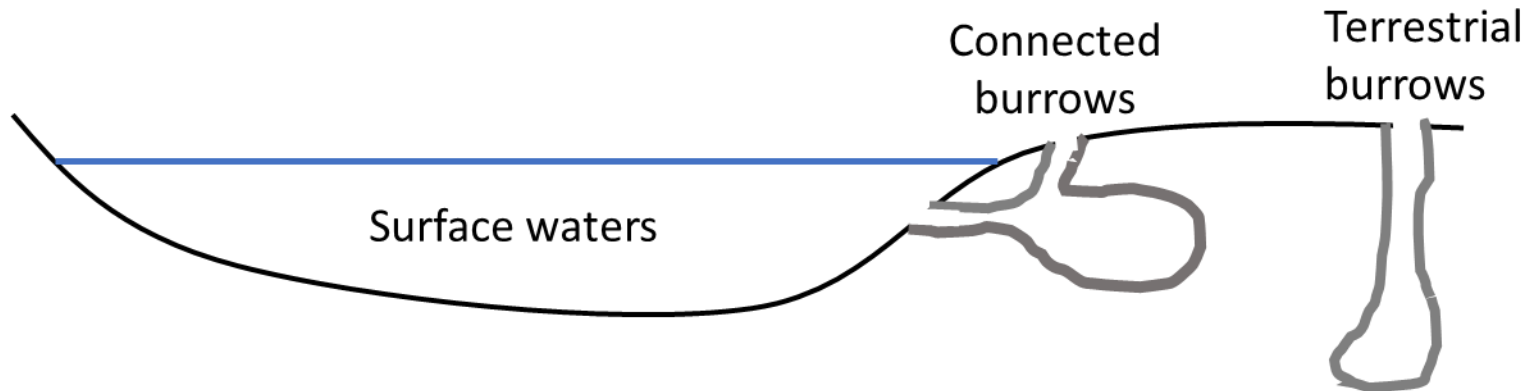
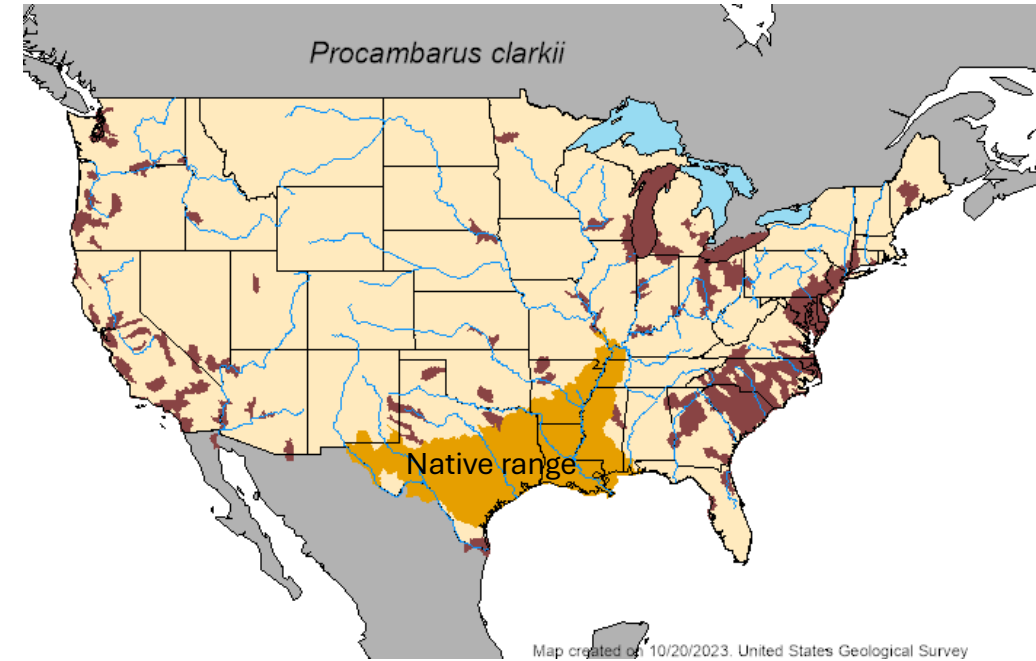
Can adapt to a wide variety of climates



Can adapt to environmental extremes by burrowing

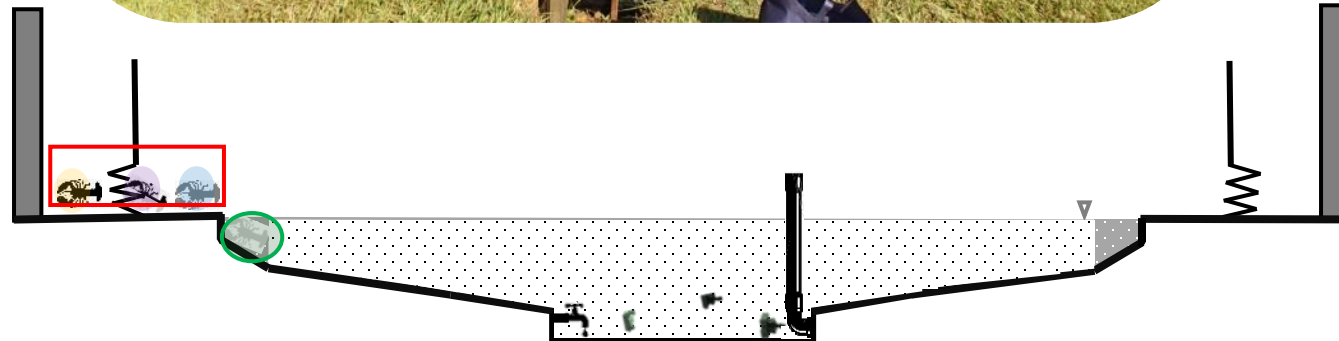
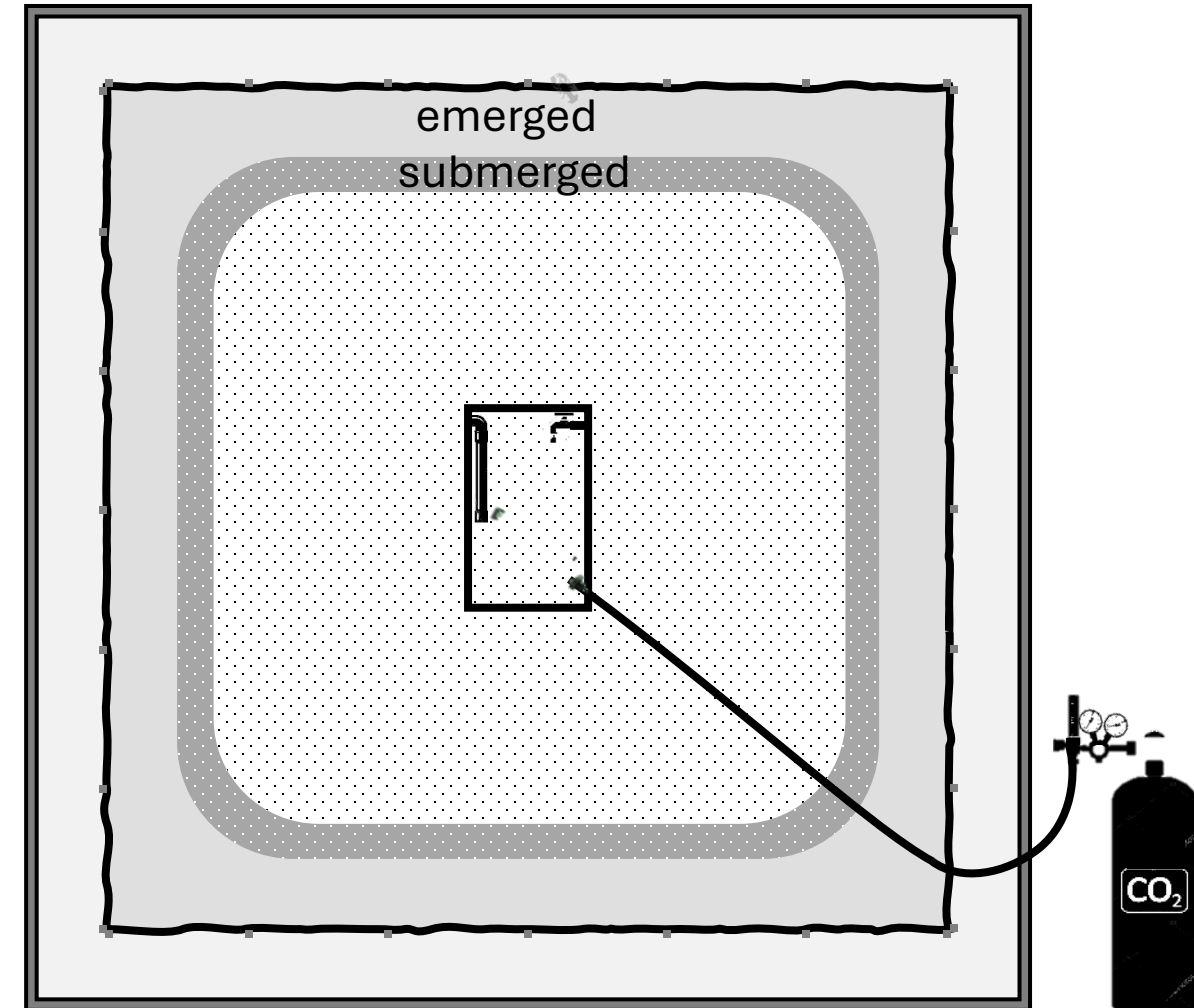
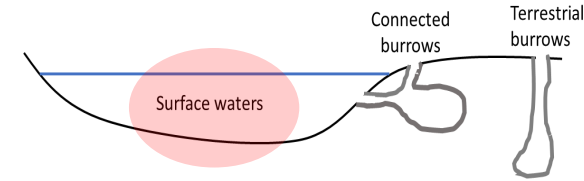
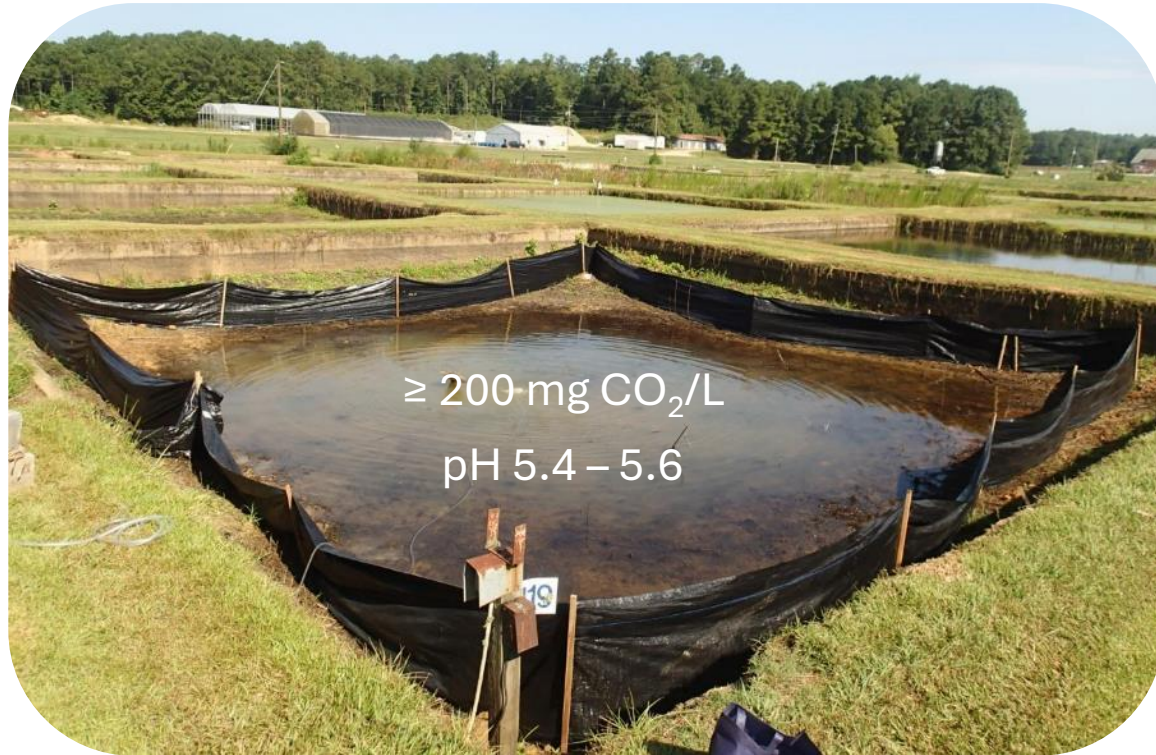


Control methods needed for ponds plus burrows



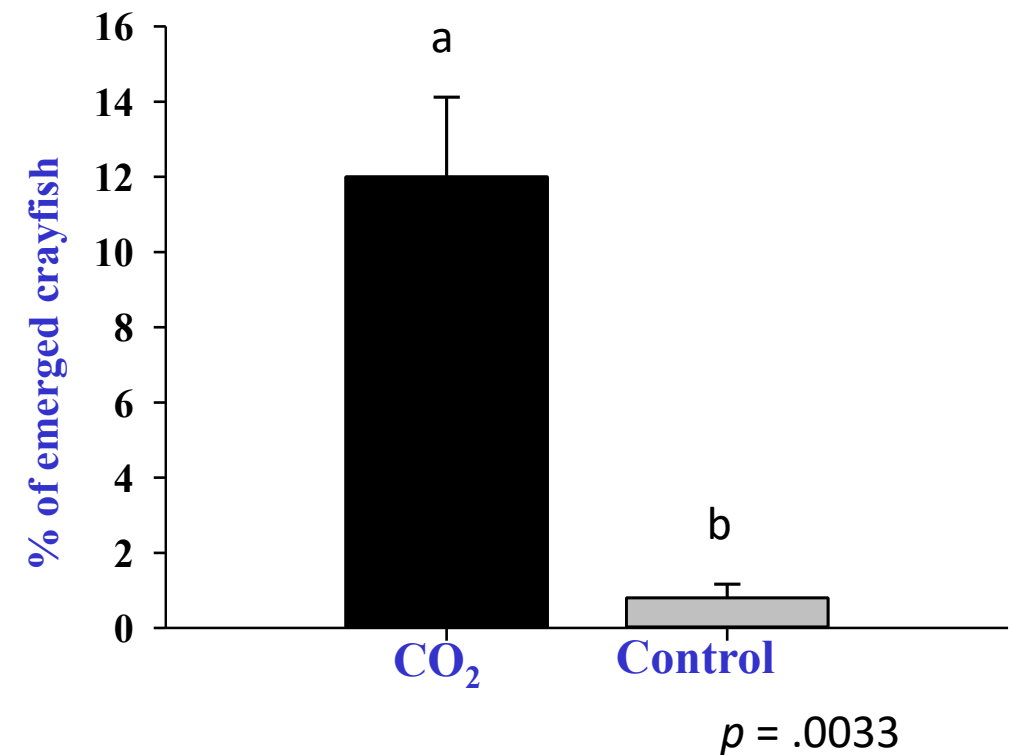
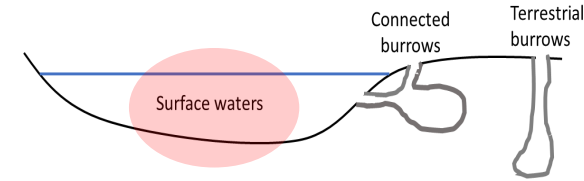
Evaluation of CO₂ as a control tool

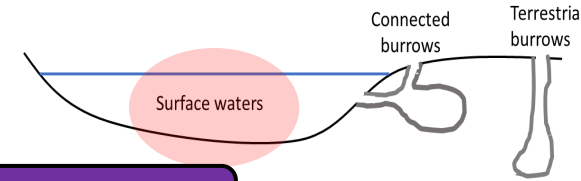
100 crayfish added to each pond



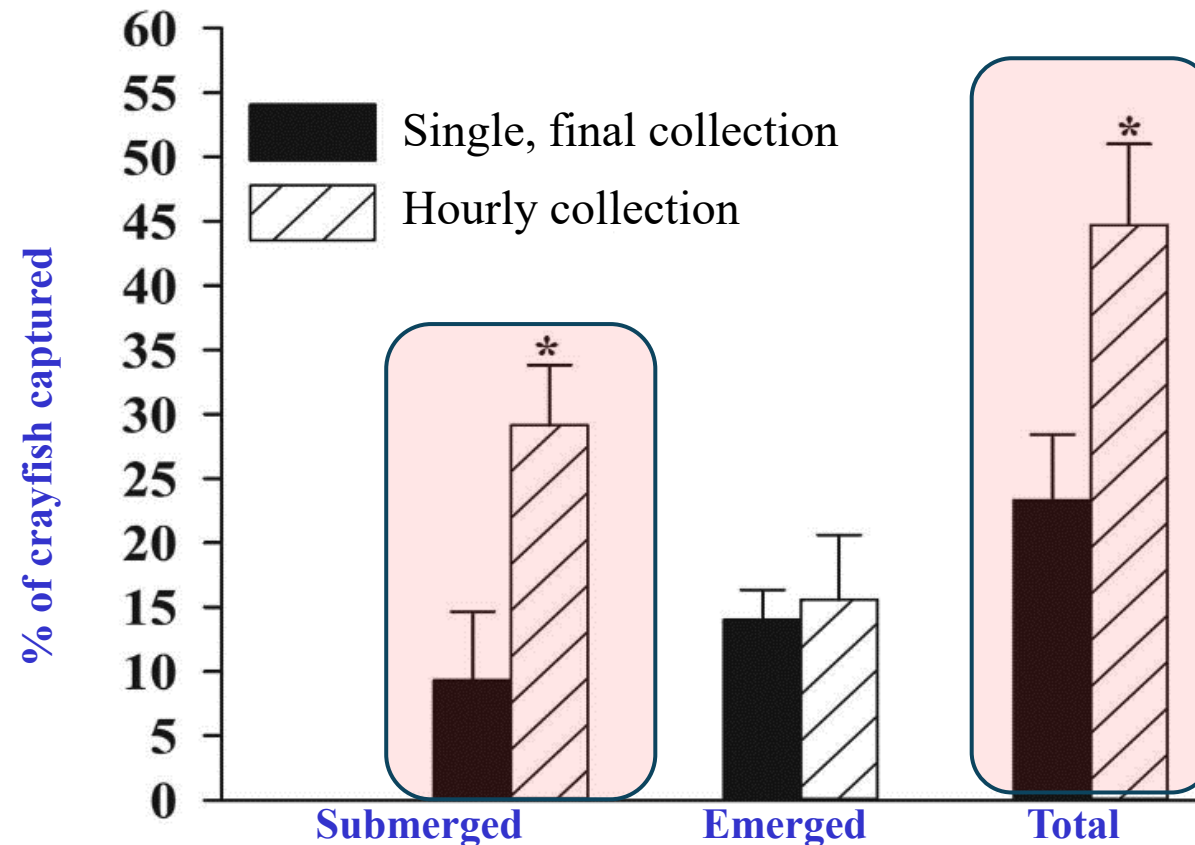
Evaluation of CO₂ as a control tool

1. Can CO₂ be used to induce crayfish emergence from ponds?



I-Pond trials**Evaluation of CO₂ as a control tool**

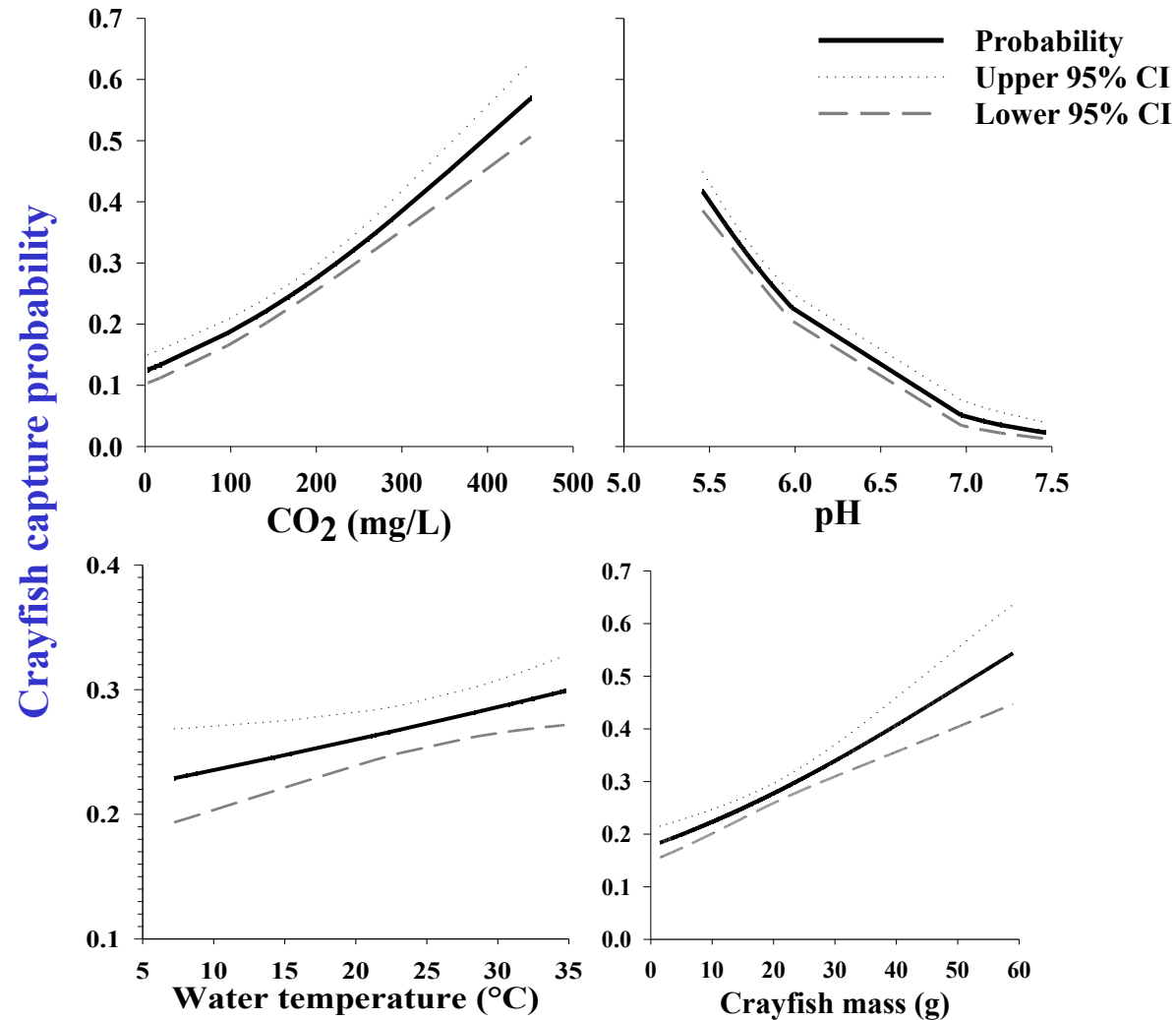
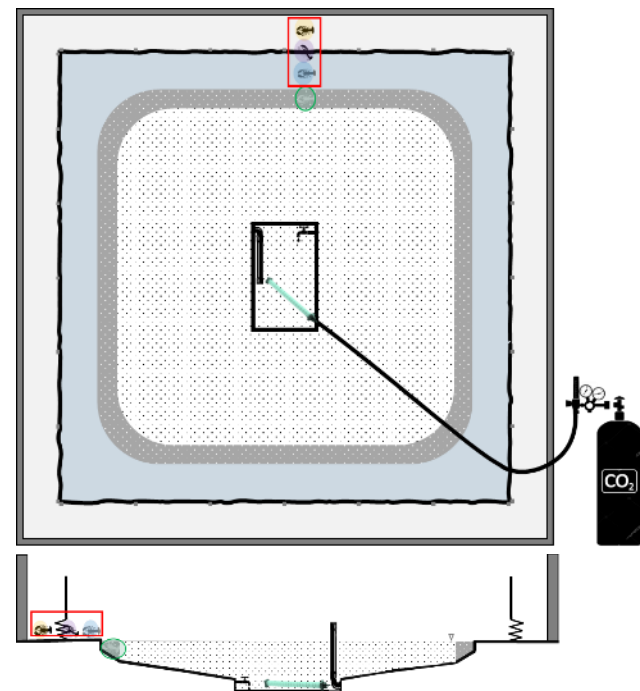
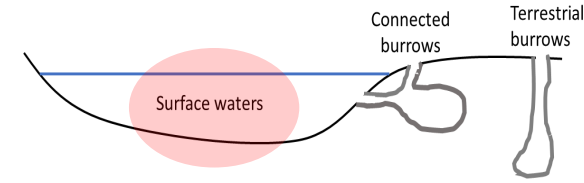
2. Does hourly collections and collection of submerged crayfish increase captures?



- CO₂ Can be fairly effective in small ponds
- Hourly collections more effective than single, final collection
- Due to increased collection of submerged individuals near pond edge
- Substantial effort would be required for larger ponds

Evaluation of CO₂ as a control tool

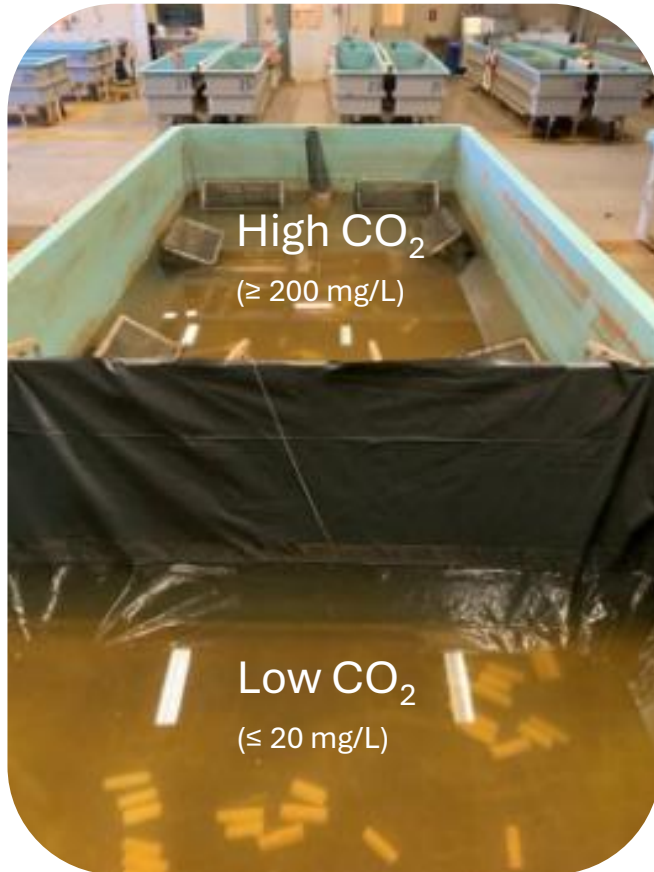
3. Factors affecting probability of crayfish captures?



Does High CO₂ “Push” crayfish to:

Migrate to
water surface

Treatment



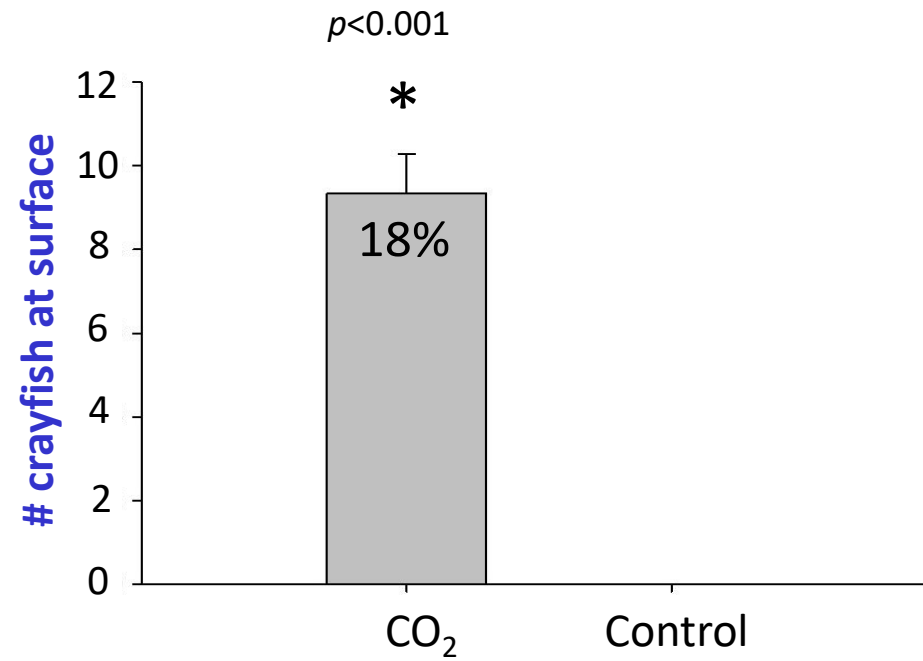
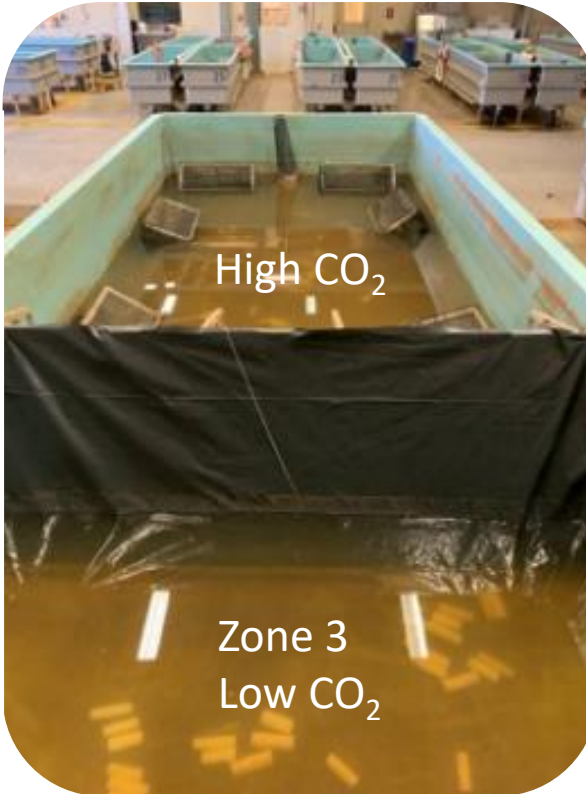
Or

Migrate to low
CO₂ refuge

Control



- 50 labeled crayfish placed in High CO₂ zone
- Crayfish position recorded every 30 min



 **CO₂ pushes crayfish to pond edges/surface but NOT toward low CO₂ refuges**

 **CO₂ Treatment: Hourly collections of crayfish are more effective than single, final collection**

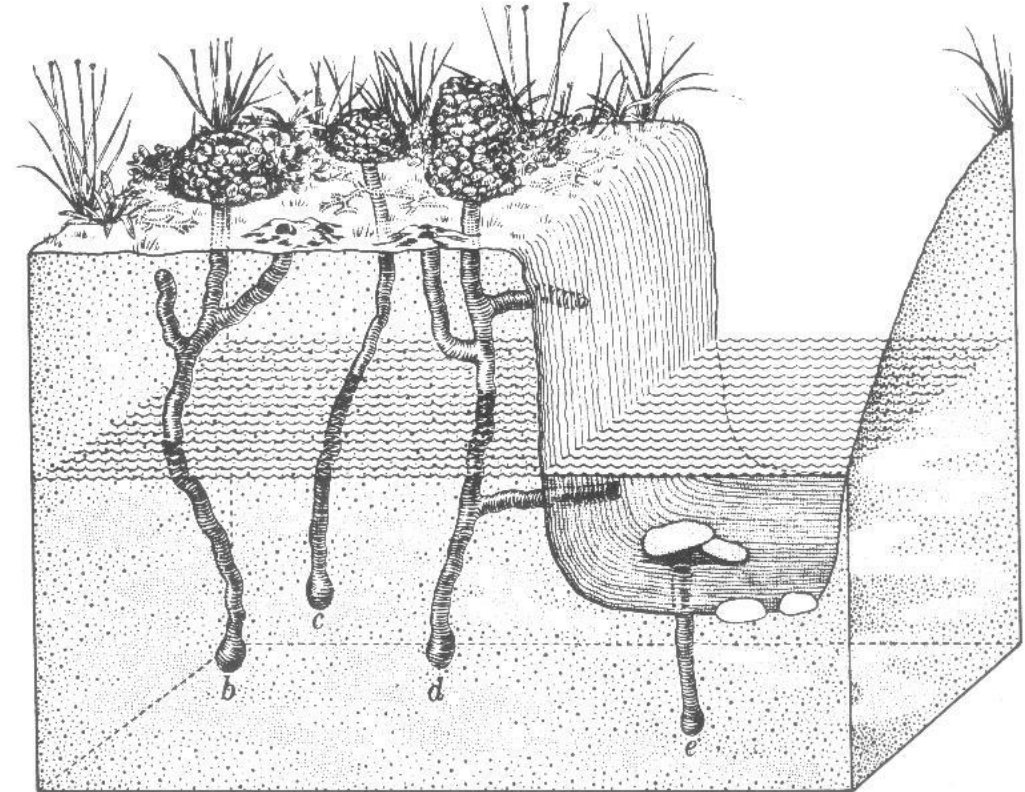
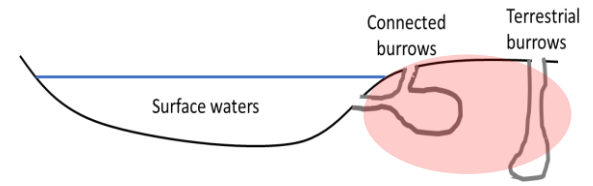
Very labor intensive

 **Develop and test emergence traps as an alternative to hourly collection with dipnets??**



Why do Red Swamp Crayfish burrow?

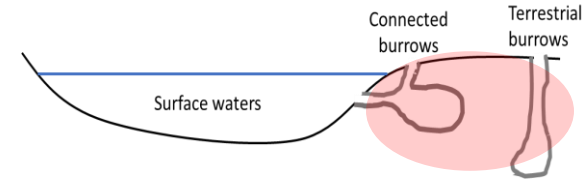
- Predator evasion
- Avoid desiccation
- Reproduction



Hobbs 1981

Can we use physical blockers to control crayfish in burrows?

Can physical blockers effectively control burrowed crayfish?



- 4 replicate ponds (14 x 14 m)
- Raised and lowered pond water levels to induce burrowing
- 3 treatments/pond
- 37 burrows/treatment

Control



Bentonite Clay



Expanding Foam

Insulating foam sealant



Burrows excavated 48 hours after treatment



Uhh...is that a snake?!!

Do I really want to stick my hand in that hole?

Bunch of *#@!! rookies

Am I using the right end of this thing?

Ooh, this is kind of icky!!

...something doesn't smell quite right down here

- 🦏 **Physical blockers (bentonite clay and expanding foam) can be effective for burrows (60-80% mortality)**
- 🦏 **Appeared to be more effective when they reached the groundwater**

More efficient delivery system?

- 🦏 **Effectiveness did not decline in deeper burrows (range ~30 – 70 cm)**
- 🦏 **Bentonite clay recommended over expanding foam**

Natural substance

Fills in burrow and may help reduce damage to shorelines/levees



What about HOT WATER?

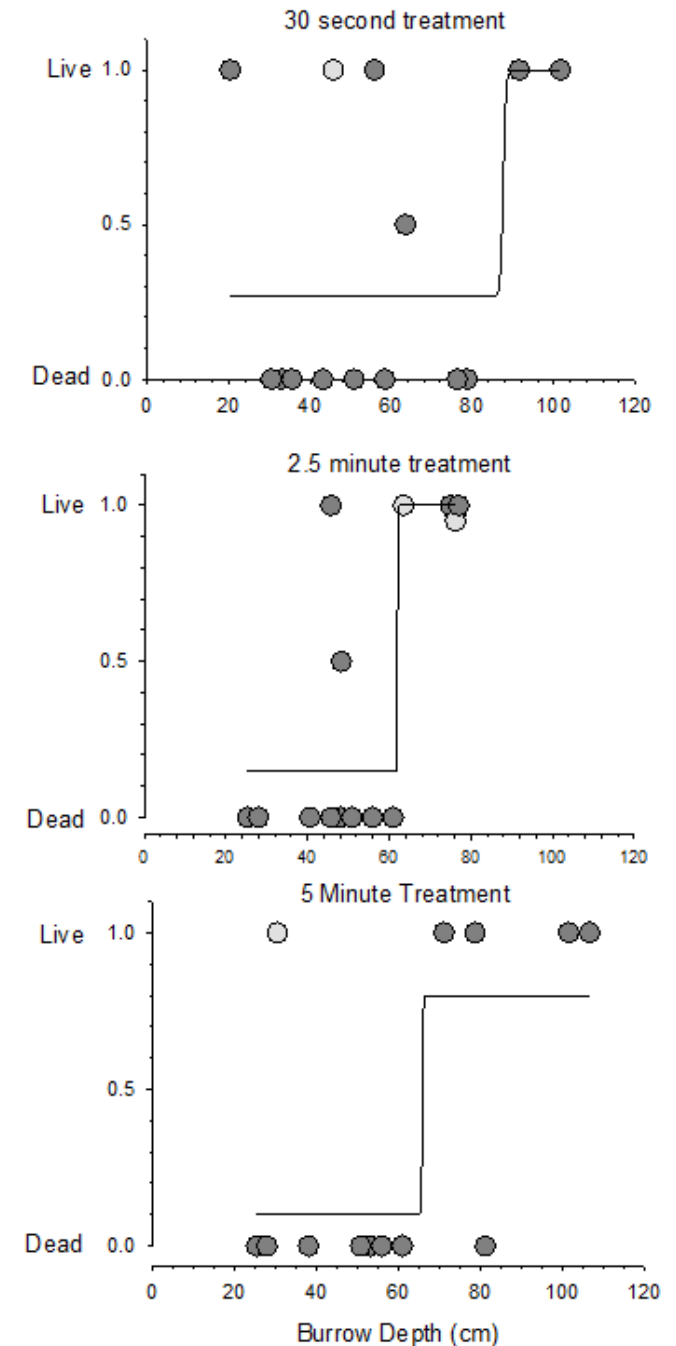
Treatment – Total Time spent spraying **100°C** water into burrow after burrow water reached 70°C

- 30 Seconds
- 2.5 Minutes
- 5 Minutes



Hot Water Treatment Results

- **30 seconds**
 - 10/15 burrows had dead crayfish
 - ~70% probability of death if burrow <80 cm
- **2.5 minutes**
 - 9/15 burrows treated had dead crayfish
 - ~85% probability of death if burrow <60 cm
- **5 minutes**
 - 10/15 burrows treated had dead crayfish
 - ~90% probability of death if burrow <60 cm
- **Additional confounding variables**
 - Amount of water in a burrow
 - Total number of entrances

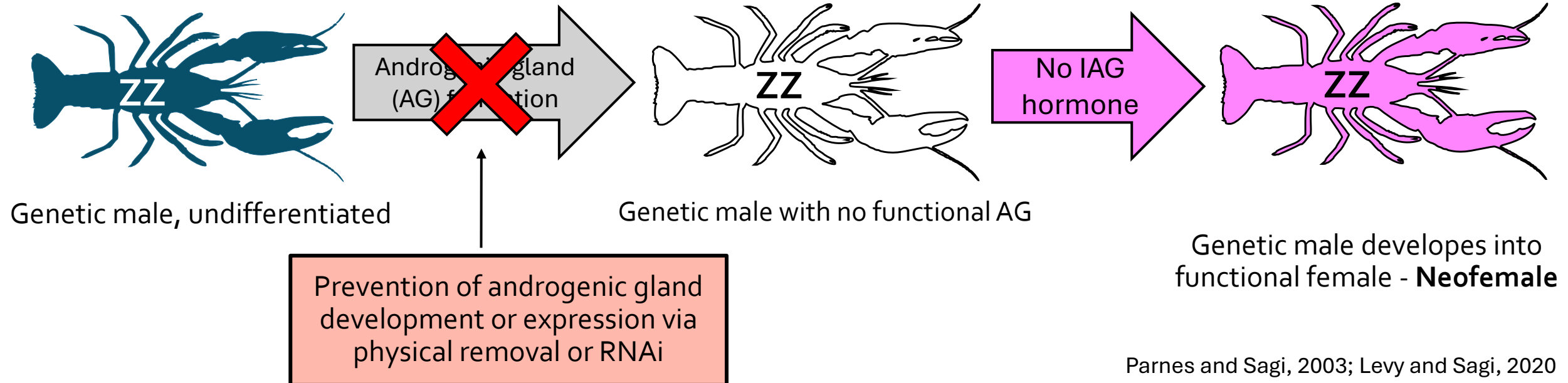
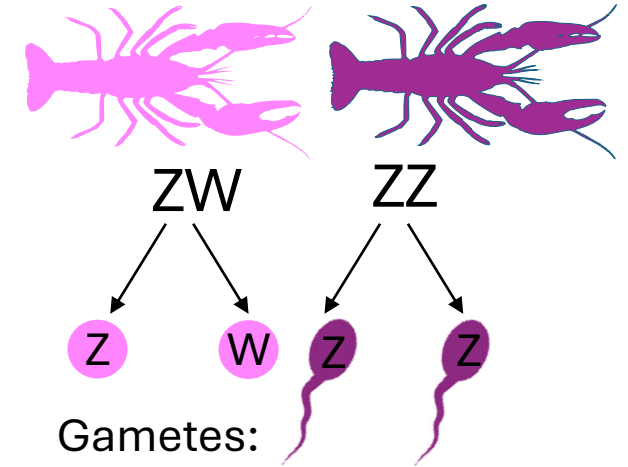


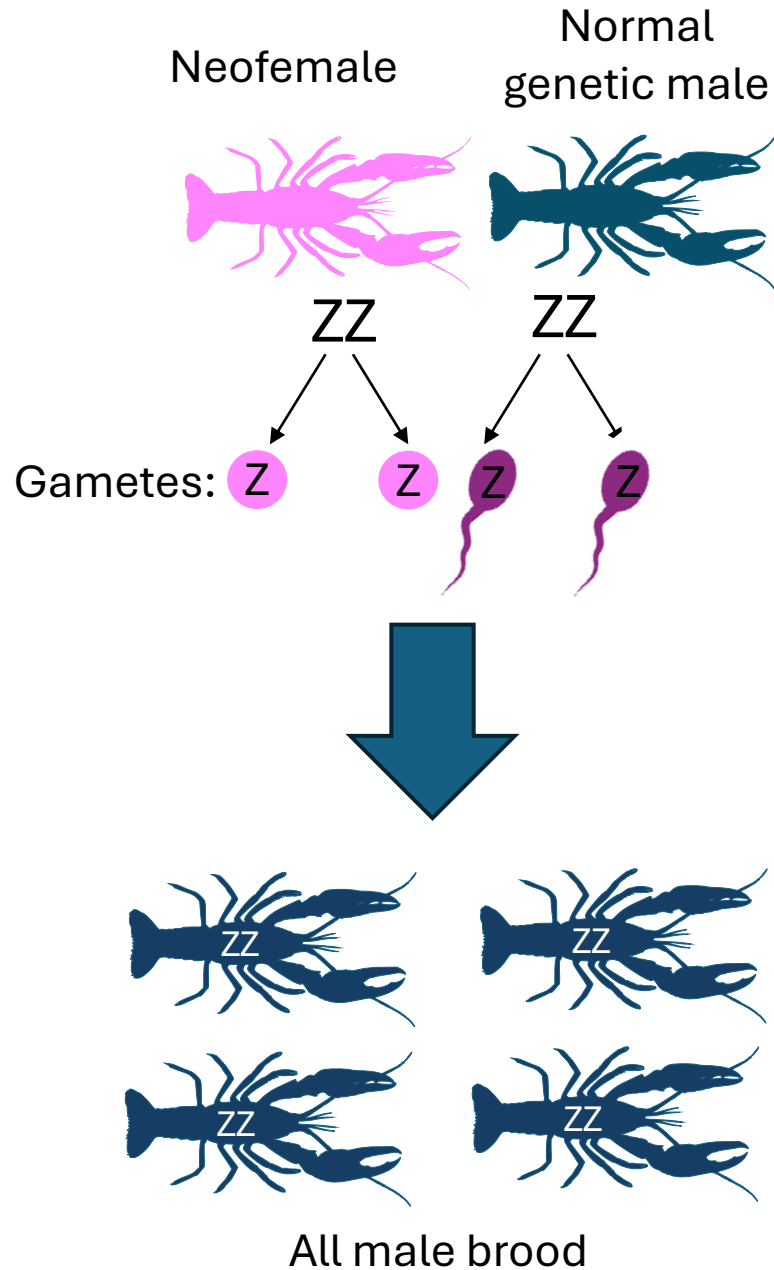
And Now for Something Completely Different



Chromosomal sex determination

- Most crustaceans, including crayfish, assumed to follow ZW female, ZZ male sex determination system
- Hormonal control = androgenic gland, "IAG switch"





Approach currently being used in Freshwater Prawn Aquaculture

Sex-reversal technology does not use hormones or chemicals, does not produce genetically modified prawns



Macrobrachium rosenbergii males (right) grow faster and reach higher weights than females of the species, all-male culture improves harvests.

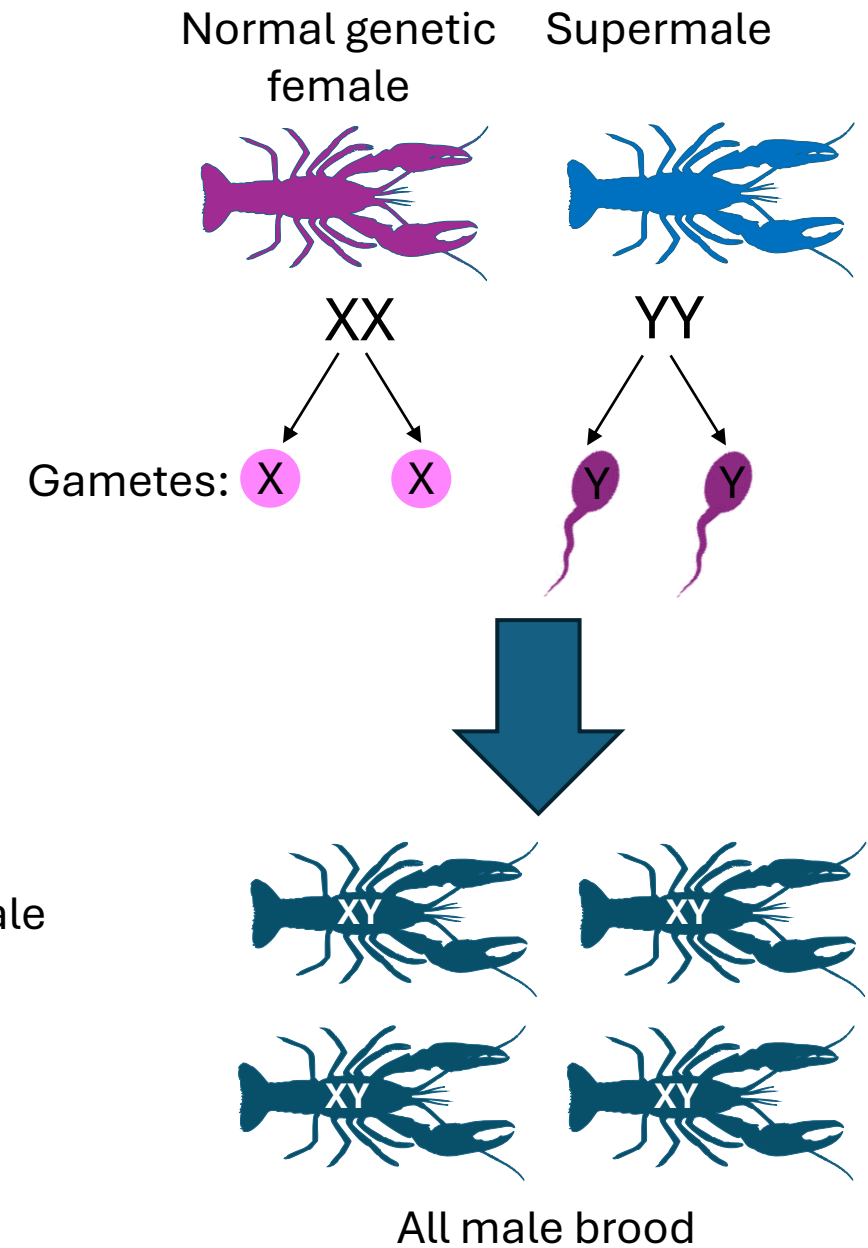
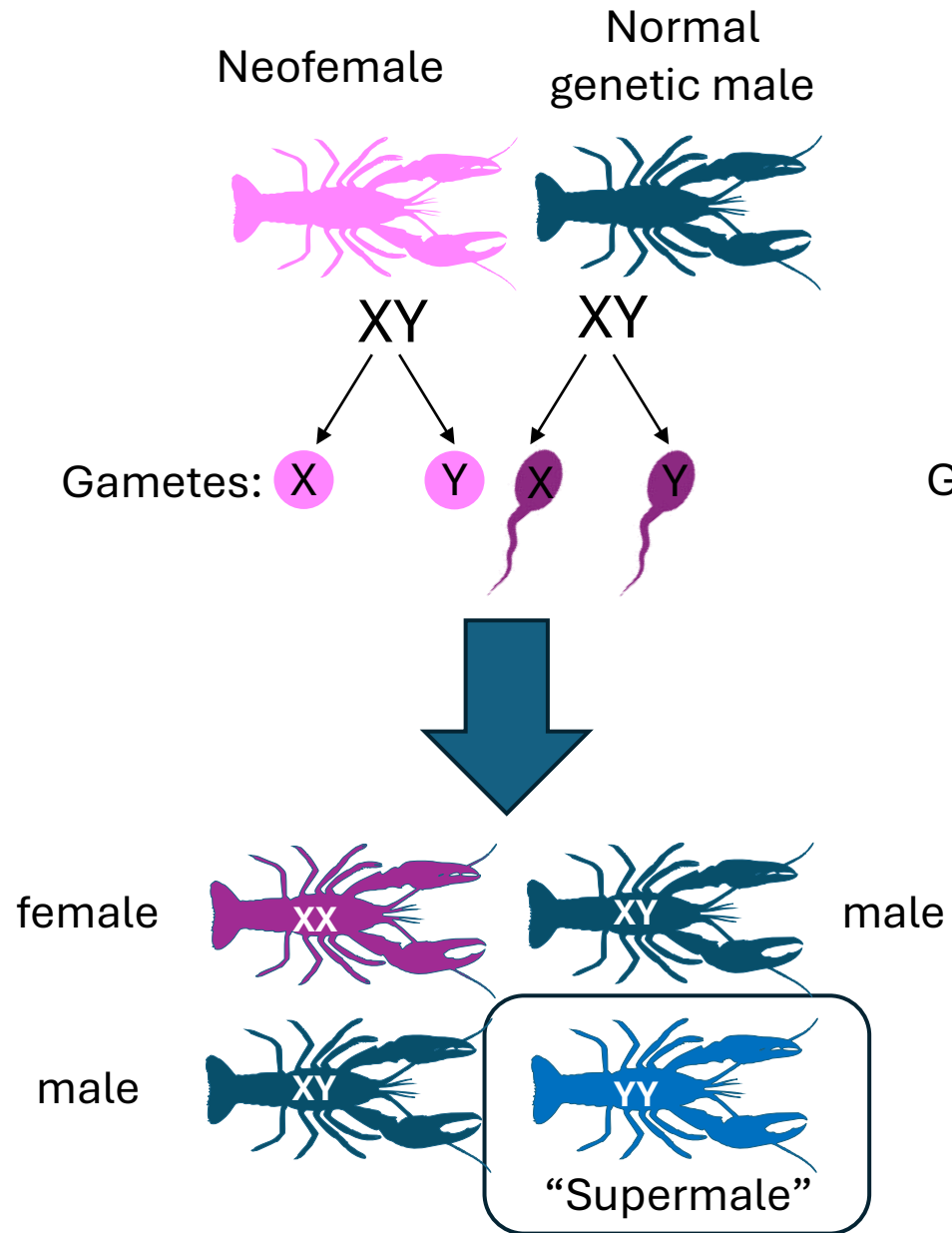
Dr. Amir Sagi – Novus Global Aquaculture Innovation Award

Can it be done for crayfish?

In 2026

P. clarkii shown to be XX, XY

Li et al. (2026)

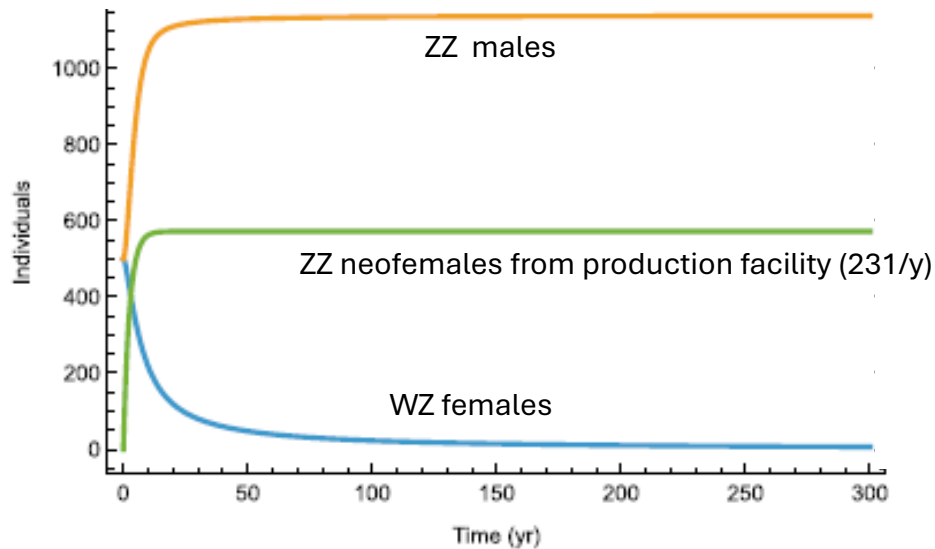


Original Invasive Population Size = 500 males, 500 females

Schoolmaster et al., *in progress*

Originally assumed WZ ZZ system for all crayfish

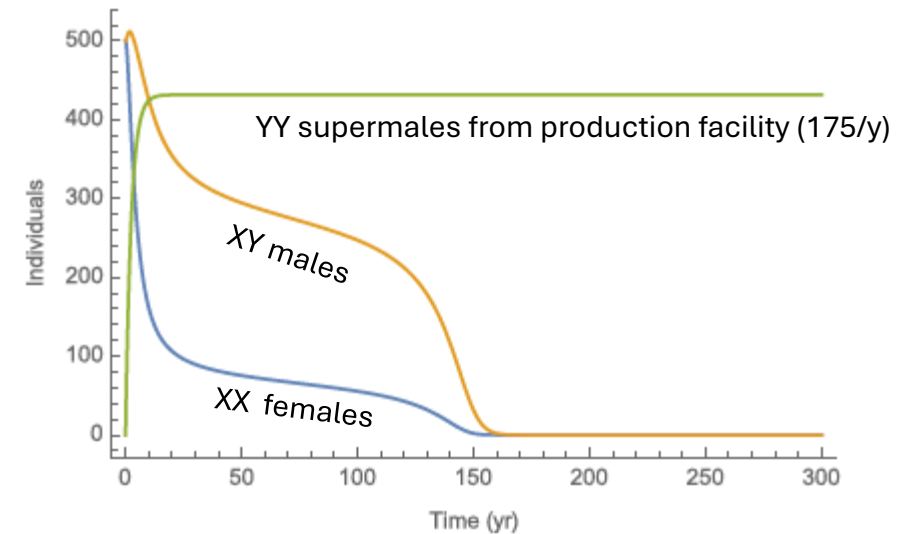
Levy et al. (2020)



- Normal (WZ) females quickly decline within 20 years
- Total population size increases due to:
 - production of all male (ZZ) broods
 - annual addition of neofemales (ZZ)

Recently confirmed WZ ZZ system for *P. clarkii*

Li et al. (2026)



- Normal (XX) females quickly decline within 20 years
- Total population size decreases:
 - Wild males (XY) and females (XX) decline
 - YY supermales dominate

Ongoing Research

BARD Collaborative Research

Sagi Lab, Ben Gurion University, Israel

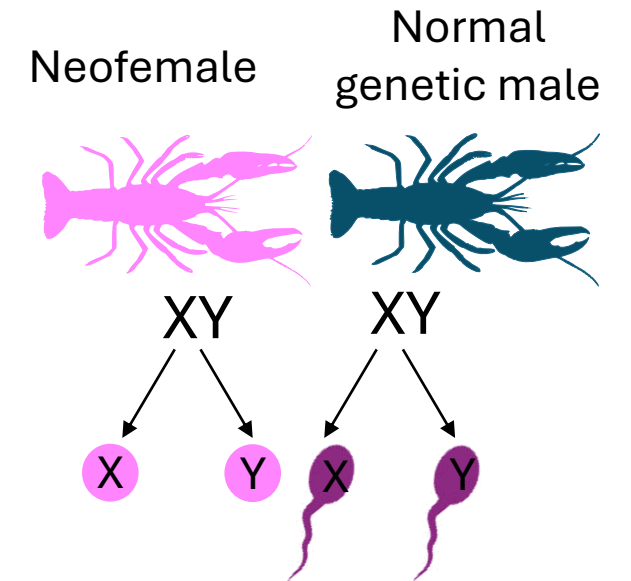
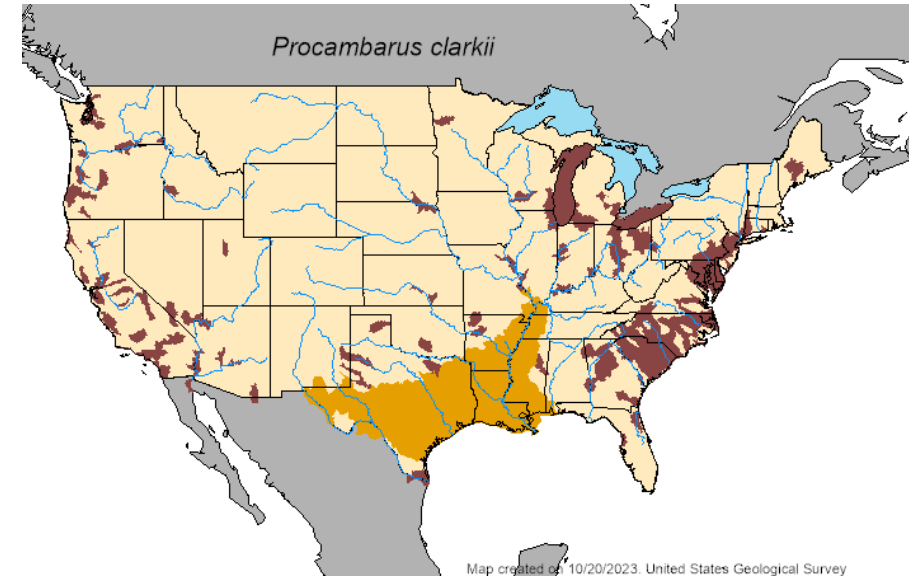
Stoeckel and Butts Labs, Auburn University, US

- Can we produce XY neofemales?
- Will XY neofemales mated with XY males produce YY supermales?
- Are YY males viable and will they produce all-male (XY) broods when mated with normal XX females?
- Can we set up efficient production systems to produce large numbers of neofemales and YY males?
- Will population dynamics follow model predictions



Questions?

jimstoeckel@auburn.edu



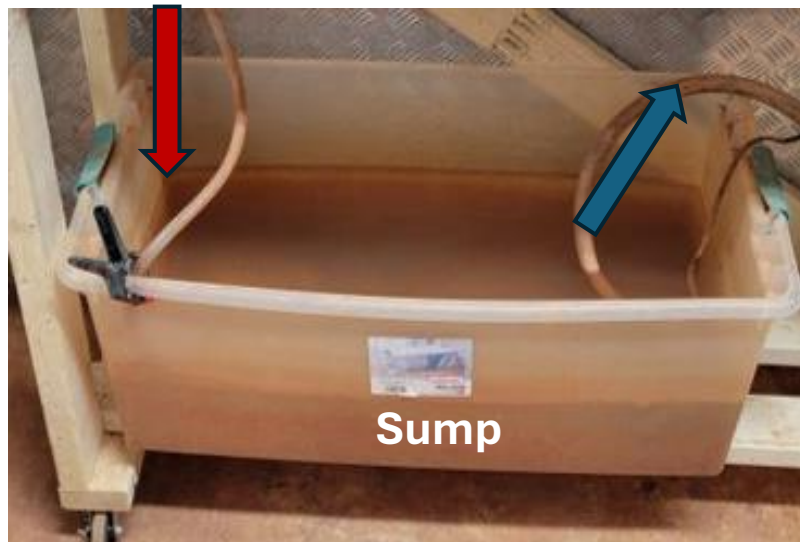
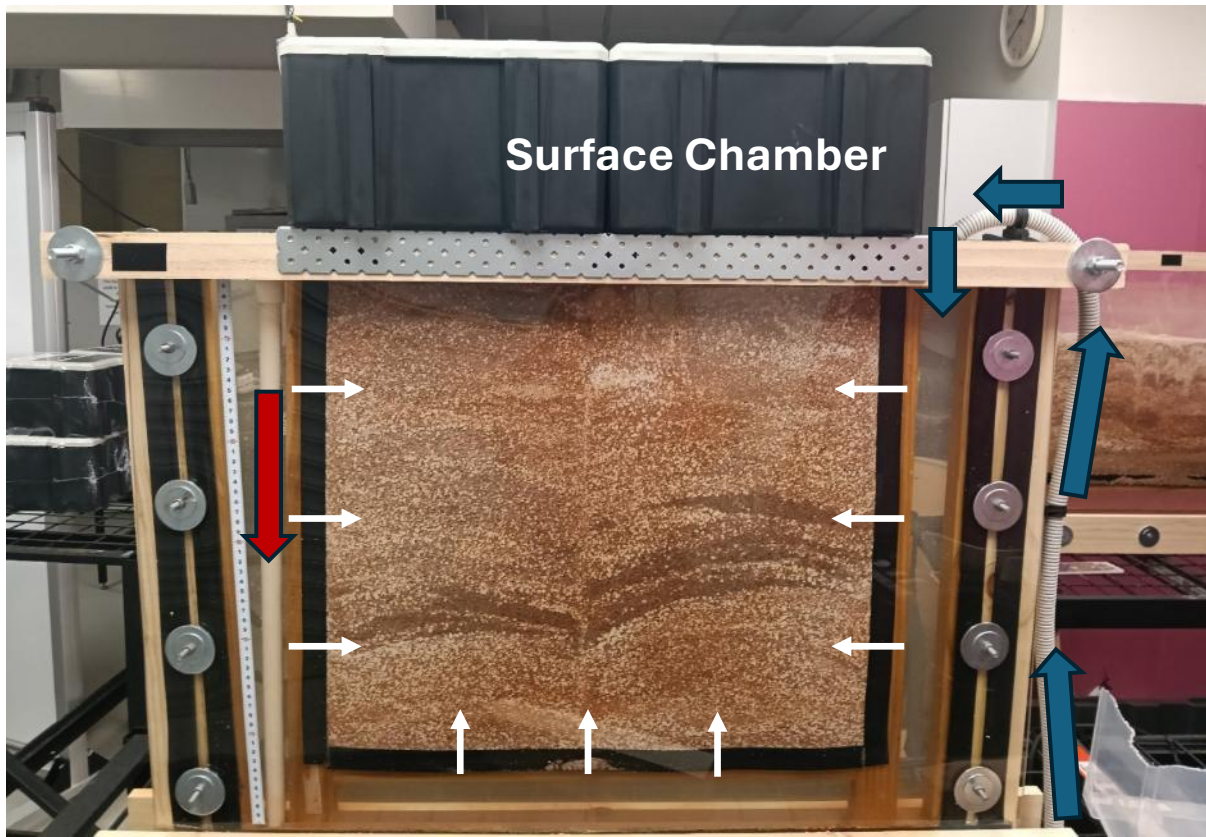
Studying Burrowing

- Research Ponds
- Ant Farms



Basic Principle

- Water is pumped up from a sump beneath the chamber
- Flows through the “outer chamber” and exits through an adjustable standpipe.
- Seeps through the inner frame and into the substrate from three sides





How do different drainage rates affect burrowing behavior?

- 9 burrowing chambers with individual sumps and foraging areas; 4 runs
- Large male Red Swamp Crayfish used
- Soil sieved through 1 cm mesh
- Spring temperatures (24°C) and photoperiod (12 hours on/12 hours off) simulated



Effects of water level drawdown on burrowing (Barnes et al., 2026 accepted)

Treatment	SLOW 4 cm/day(5)days	MEDIUM 8 cm/day(3)days	FAST 24 cm (1) day
Burrowing Crayfish	11/12	7/12 *none of these crayfish burrowed after the first day	0/12 *3 died

