Mechanisms of thermal adaptation in Redband Trout (*Oncorhynchus mykiss gairdneri)*

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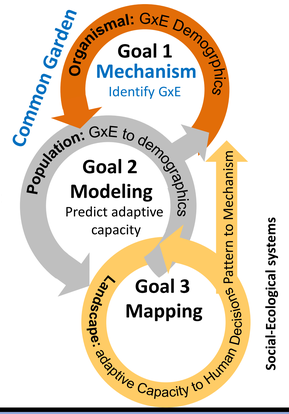
Idaho EPSCoR GEM3

RII Track-1: Linking Genome to Phenome to Predict Adaptive Responses of Organisms to Changing Landscapes

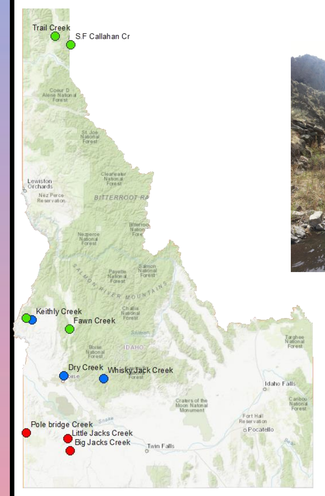
Genes to Environment:
Modeling, Mechanisms, and Mapping (GEM3)

Objectives of GEM3:

1. Identification of **mechanisms** by which fish populations adapt to environmental challenges
2. Identification of **genetic markers** associated with adaptive capacity
3. Estimates of **phenotypic plasticity** of fish populations –ability to cope with environmental conditions –and how it relates to genetic diversity of populations
4. Extensive datasets to use in the **Modelling and Mapping** research thrusts



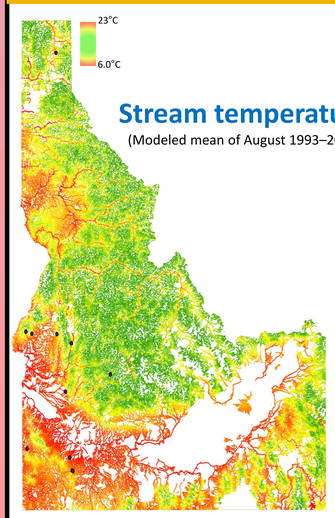
Collections and Study Area[1]



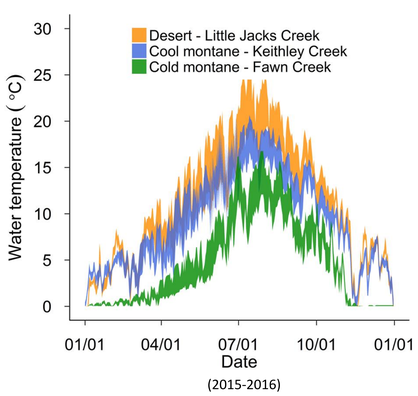
Desert | **Cool Montane** | **Cold Montane**

1) **Desert:**
Little Jacks Creek, Duncan Creek; William Creek
2) **Cool Montane:**
Keithley Creek; Whiskey Jack Creek; Dry Creek
3) **Cold Montane:**
Callahan Creek; Fawn Creek; Upper Mann Creek

Habitat characterization



Stream temperature
(Modeled mean of August 1993–2011)

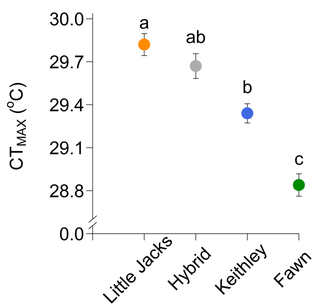


Summary

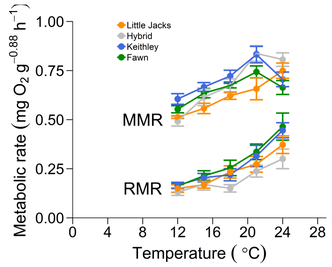
- **Desert redband trout have superior thermal performance.**
  - **Tolerate higher temperatures**
  - **Maintain performance across broader thermal ranges**
  - **Better cardiac performance**
- **"Winners" of future climate change may need a "strong" heart to deliver O_2 for sustained aerobic metabolism.**
- **Putative genomic regions (e.g. CERK gene) for thermal tolerance and adaptation are identified**

Thermal tolerance

Critical thermal maximum (CT_{MAX})

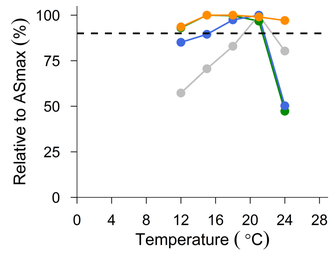


RMR: routine metabolic rate
MMR: maximum metabolic rate



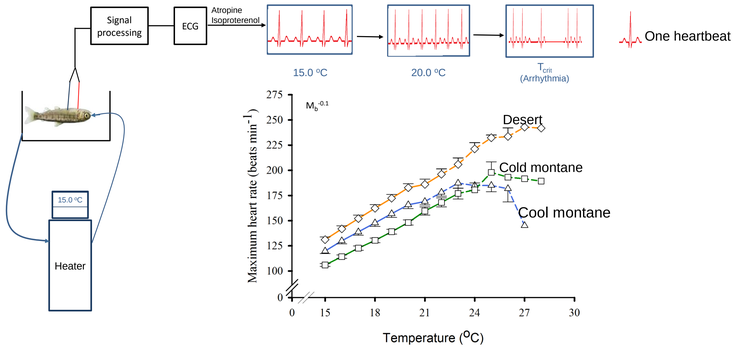
Desert redband trout have superior thermal performance[2]:

1. **Higher critical thermal maximum**
2. **Broader thermal window for optimum aerobic activities.**

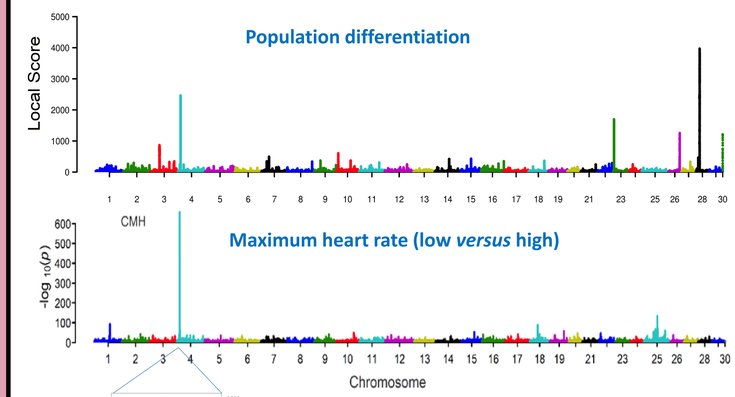


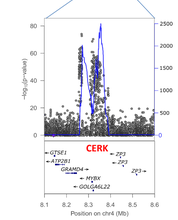
Cardiac function

Desert redband trout have better cardiac performance[2, 3]



Genomic markers of thermal adaptation

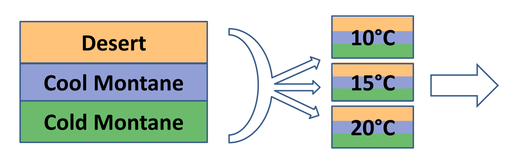




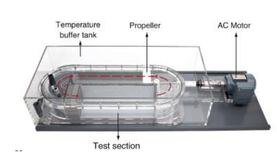
- **Over 5 million SNPs**
- **Over 50% genome coverage**
- **Chromosome4: 8.2M – 8.6M (CERK gene)** is significantly differentiated between desert and montane populations; it is also significantly associated with cardiac function[4].

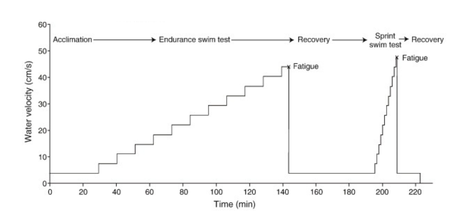
Future Work and Work in Progress

- **Include more acclimation temperatures to study phenotypic plasticity**
- **Examine adaptive traits related to growth and reproduction**



- **Thermal tolerance**
- **Fecundity**
- **Growth**
- **Swimming performance**





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Reference and acknowledgments

1. S. Narum *et al.*, 2010. *Molecular Ecology*, 19, 4622–4637;
2. Z. Chen et al., 2018. *Molecular Ecology*, 19, 4622–4637;
3. Z. Chen et al., 2018. *Evolution Applications*, 11:1686–1699;
4. Z. Chen & S. Narum 2019. *In prep*;

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