

Ecological Genomics of the *Climate Cascade*

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Overview

- ① Progress on the *Aphaenogaster* transcriptome

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- ② Identifying genes associated with thermal tolerance

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- ③ Latitudinal variation in gene expression

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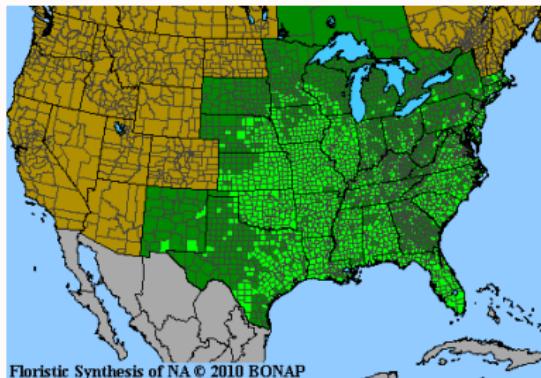
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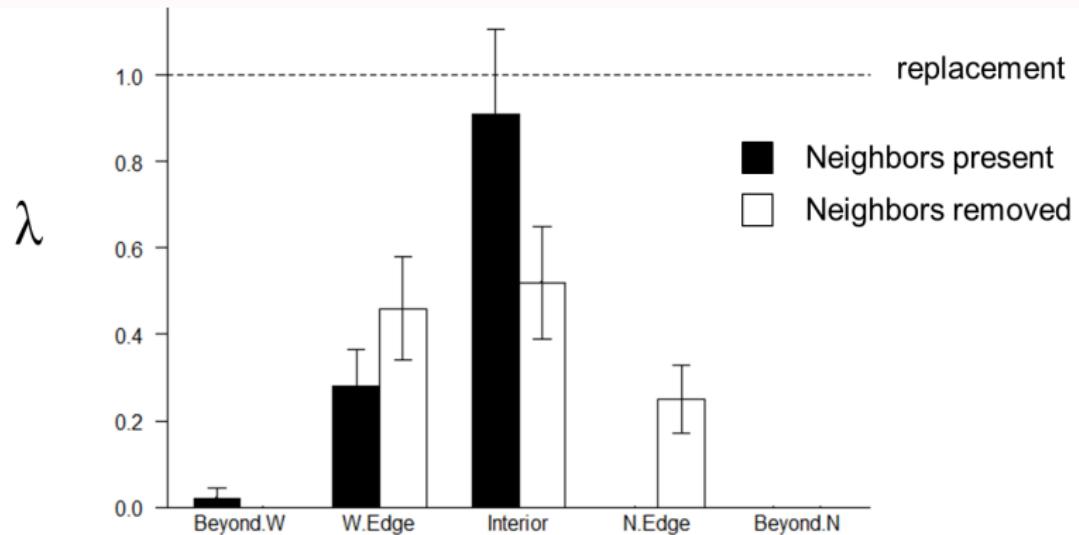
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Why am I here?

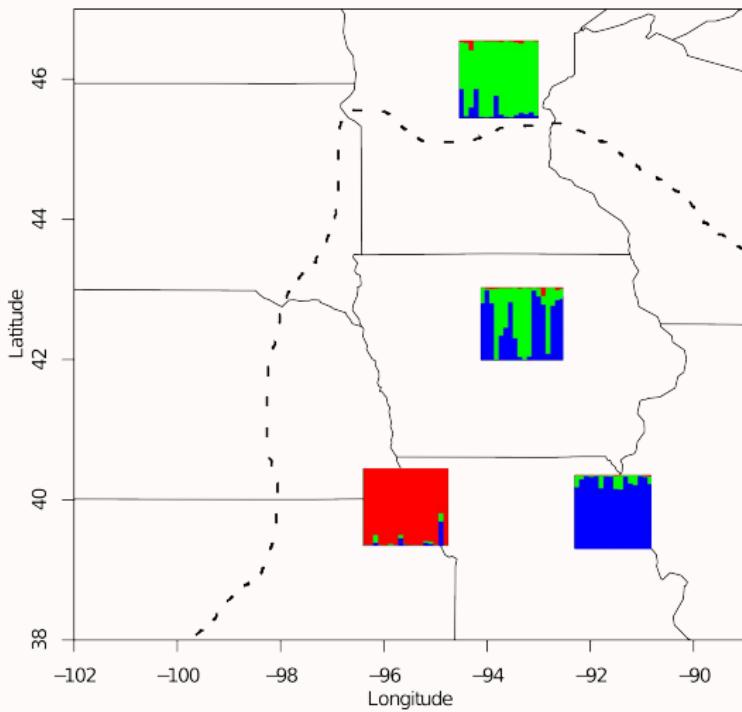
Species range limits



Fitness variation across the range



Population history



Ants

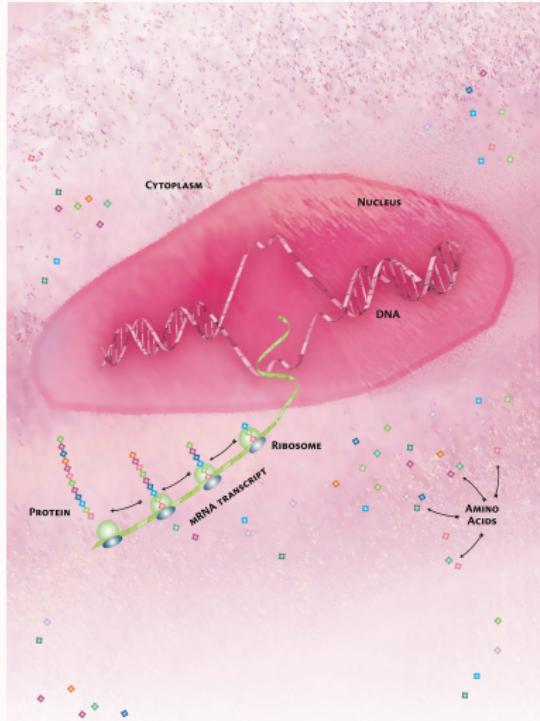


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The *Aphaenogaster* Transcriptome

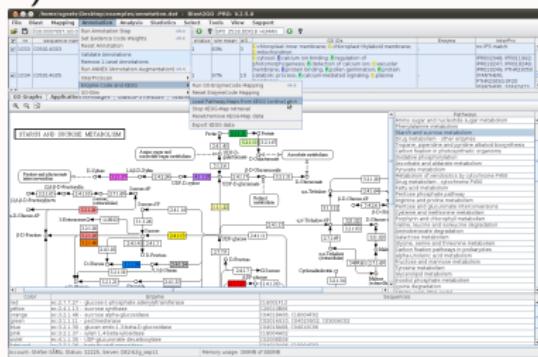
- mRNA transcripts
- all genes expressed in an organism
- about 5% of total genome
- 16-18,000 genes in sequenced ant genomes (Gadau 2012)



Transcripts. To make a protein, a gene's DNA sequence is transcribed into a molecule called messenger mRNA (mRNA). This molecule, referred to as an mRNA transcript, leaves the nucleus and enters the cell's outer region, called the cytoplasm. Molecular machines called ribosomes then read the transcript and use the information to assemble building blocks called amino acids into proteins.

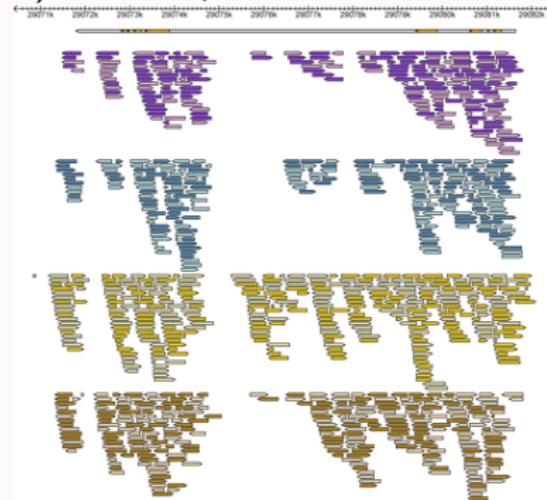
The *Aphaenogaster* Transcriptome

1) Annotation



2) Single nucleotide polymorphisms (SNPs)

3) Gene expression



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Gene Expression

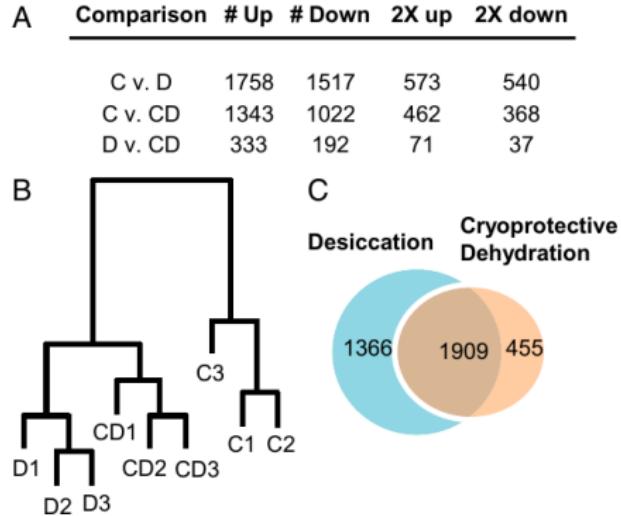


Fig. 1. Expression summary (A), dendrogram (B), and Venn diagram (C) showing degree of similarity between the D and CD groups. In A and B, the criteria for differentially expressed genes was false discovery rate (FDR) < 0.05. In C, the length of each branch indicates the relative distance between two nodes. C, control; D, desiccation; CD, cryoprotective dehydration.

Gene Expression

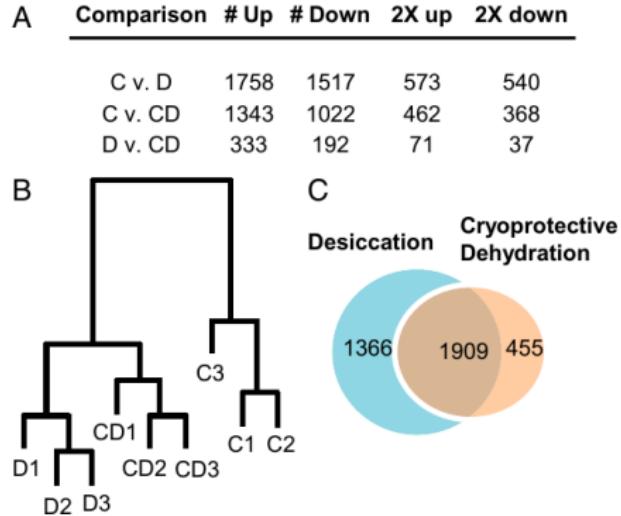
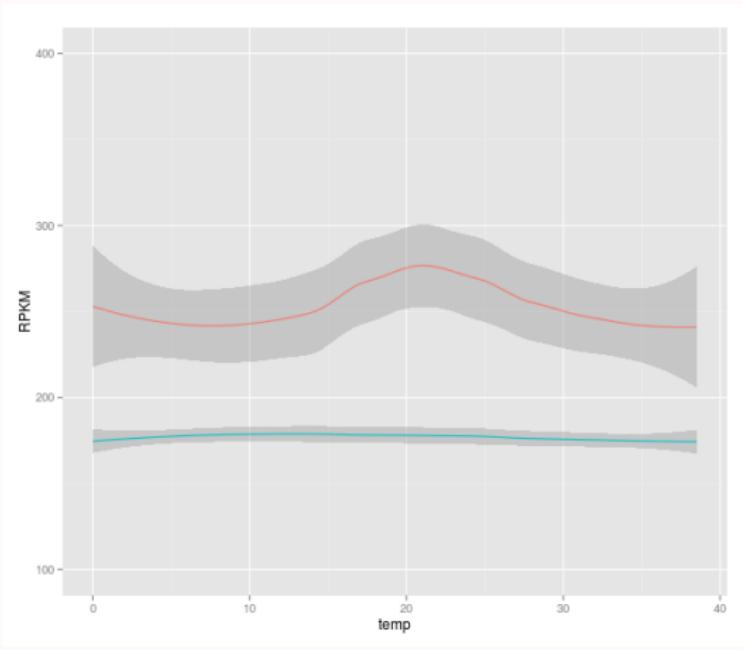


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Gene Expression



- Simulated gene expression patterns for two genes
- Polynomial based on 12 temperature points (0, 3.5, 7, 10.5, 14, 17.5, 21, 24.5, 28, 31.5, 35, 38.5°C)

Gene Expression

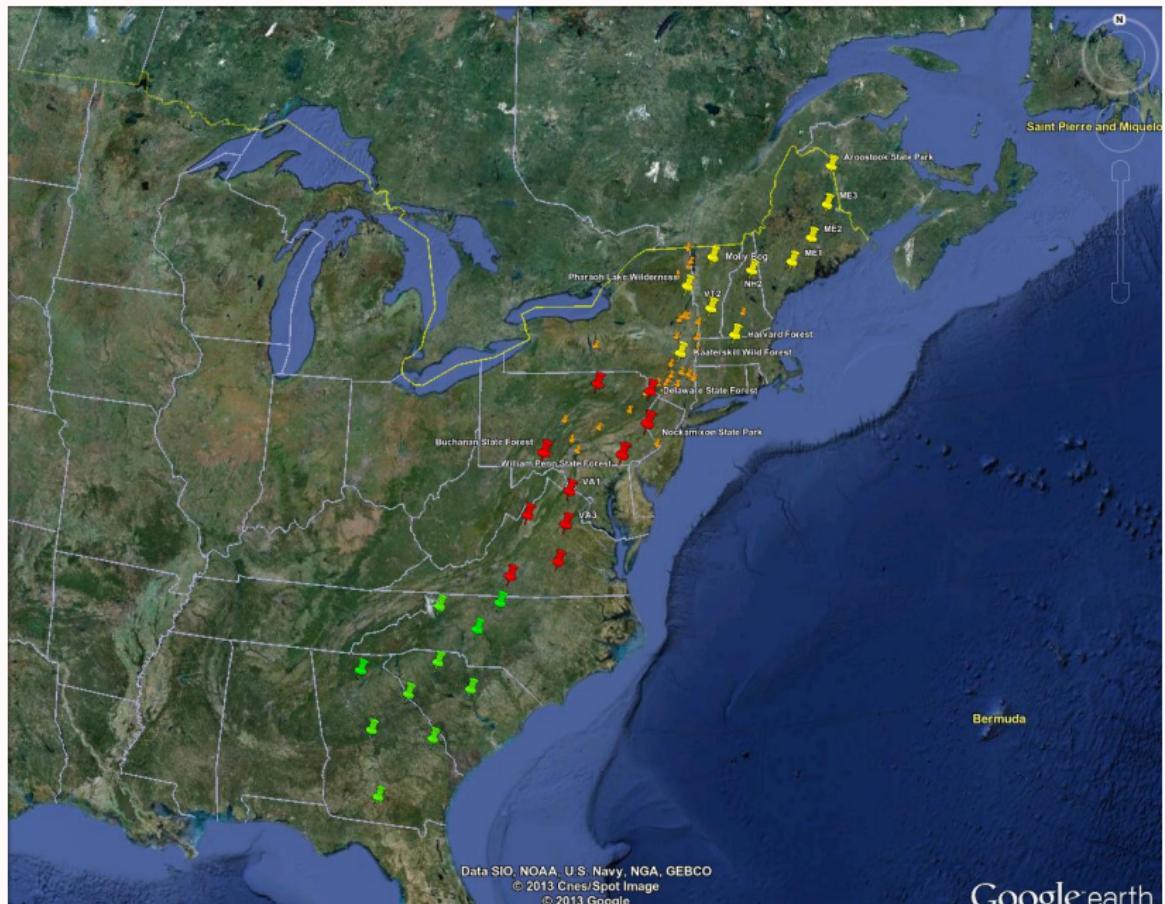
Outcomes

- ① Thermal reaction norms for ALL genes
- ② How many genes change expression with temperature?
- ③ Do *A. picea* and *A. rudis* differ in expression patterns?
- ④ Do genes with significant changes in expression have reduced molecular diversity?

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Latitudinal variation in gene expression



Latitudinal variation in gene expression

- ① What genes show clinal variation in gene expression?
- ② Are changes in gene expression similar along altitudinal and latitudinal gradients?

Population genomics of *Aphaenogaster*

SNPs in 3' tail of gene expression tags



- Do genes with significant changes in expression among sites have reduced molecular diversity? different haplotypes?
- How are populations structured?
- What is the extent of gene flow? Male vs female dispersal?

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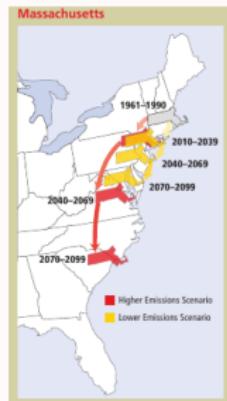
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Adaptive potential of *Aphaenogaster picea* to warming

Past



Future



Adaptive potential of *Aphaenogaster picea* to warming

Given climate predictions, does *Aphaenogaster* have the potential to adapt to climate change *in situ*?

Adaptive potential

The **potential** for species to respond to climate change depends on the **heritability** (proportion of phenotypic variation that is genetic).

$$R = h^2 S$$

where

$$h^2$$

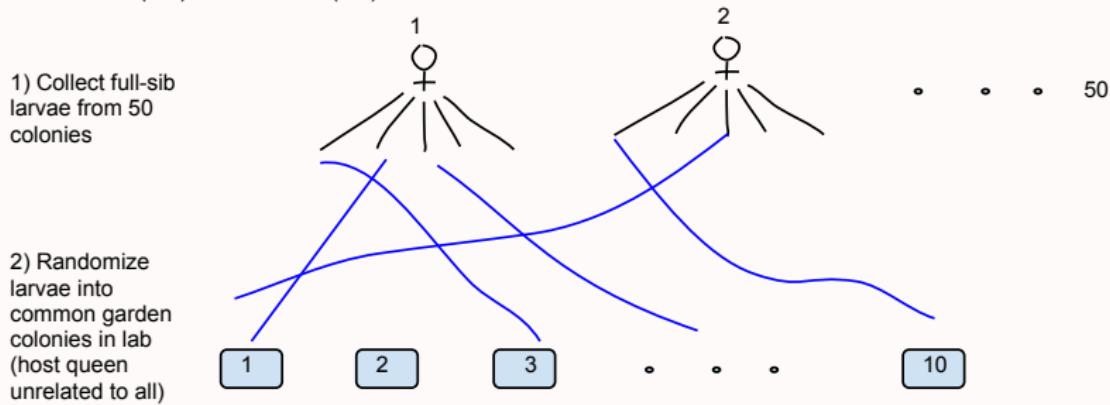
is heritability and S is the strength of selection

Response to selection depends on heritability

$$H^2 = V_g / V_p$$

Adaptive potential of *Aphaenogaster picea* to warming

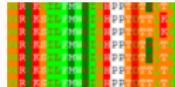
At northern (MA) and southern (NC) sites...



3) Measure thermal tolerance traits



4) Genotype to identify sibs in each common garden colony



5) Estimate heritability of thermal tolerance using standard qgen

$$H^2 = Vg / Vp$$

6) Predict maximum response to climate change

$$R = H^2 \times S$$

Adaptive potential of *Aphaenogaster picea* to warming

Interpretation of results

- Is heritability low or high?
- Does heritability differ for cold and heat tolerance?
- Genetic correlations between heat and cold tolerance?
- Given h^2 can calculate the number of generations required for northern population to match phenotype of southern population...is it adequate to match rate of climate change?

Etterson and Shaw 2000 Science

3) Adaptive potential of *Aphaenogaster picea* to warming

Thanks!

- Sara and Nick

Tomorrow - sampling protocol!