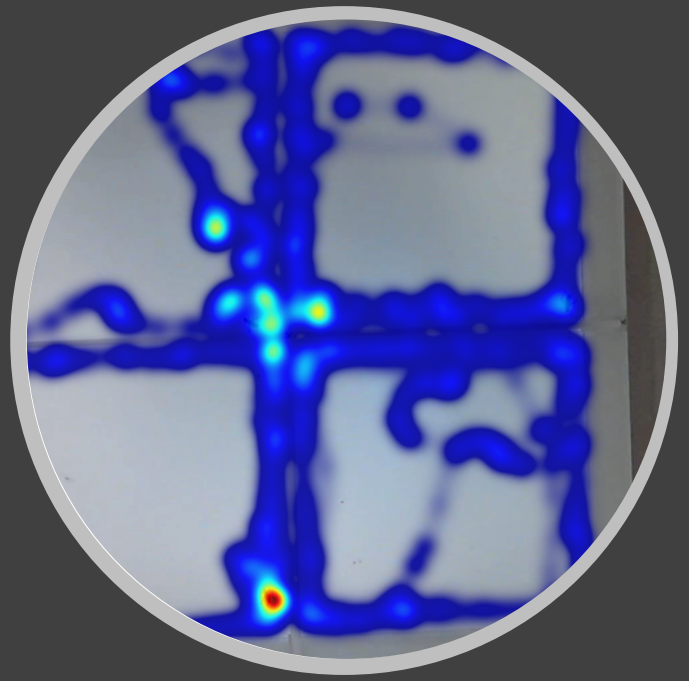
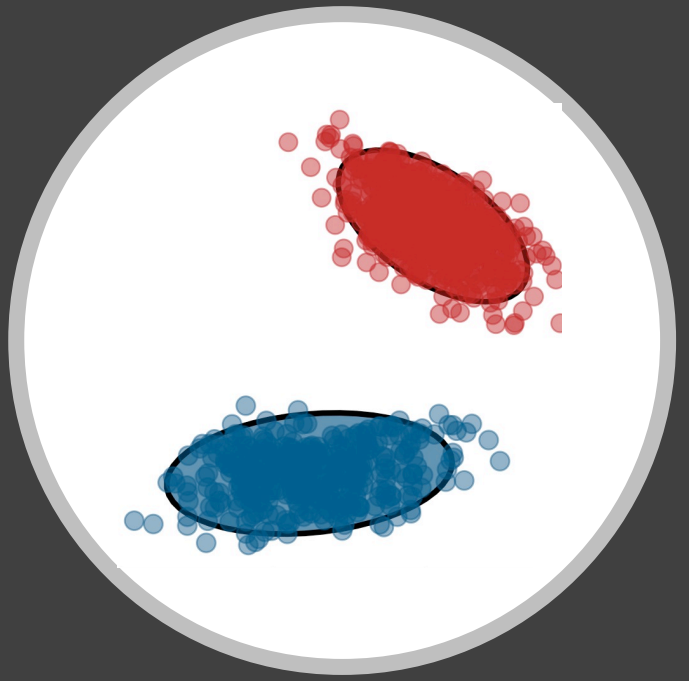
Cross-sex genetic correlations constrain the evolution of a behavioral syndrome





Raphaël Royauté, Ann Hedrick, Ned Dochtermann

25 September 2019

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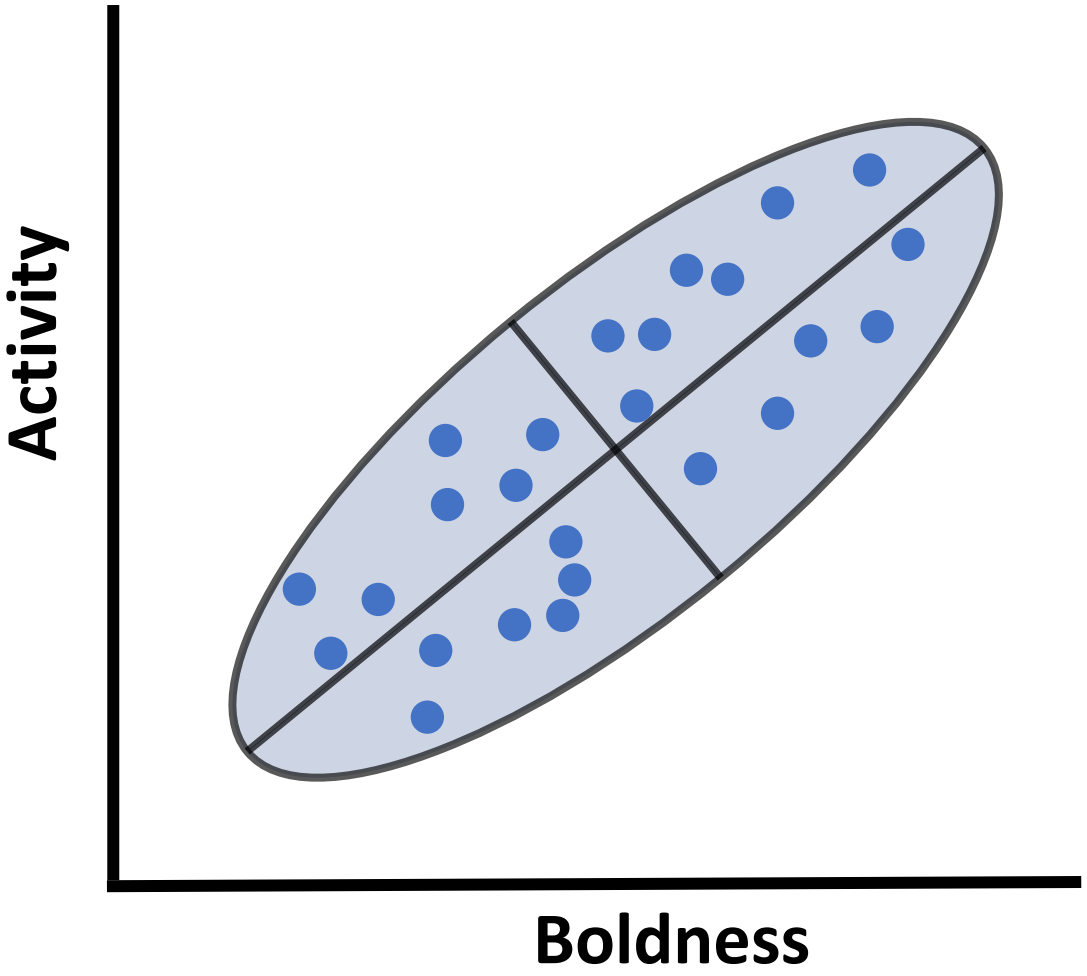
Behavioral Syndromes

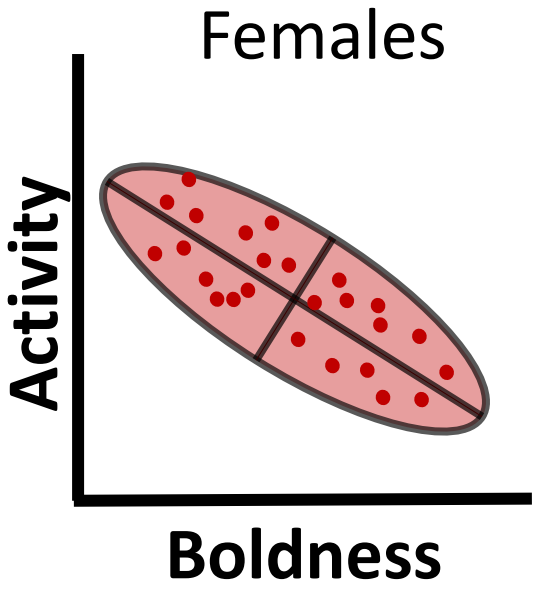


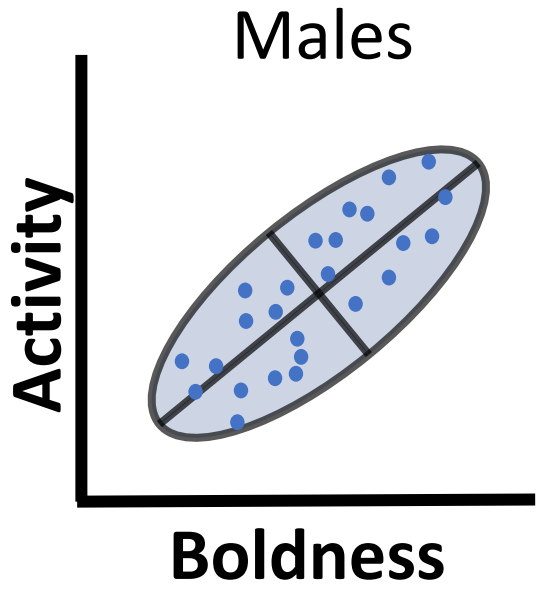
- Among-individual correlations of behavioral traits
- Includes genetic sources of variation
- Little information on sex-specific syndromes

(Sih et al. 2004, Cote et al. 2010, Dochtermann & Dingemanse 2013)

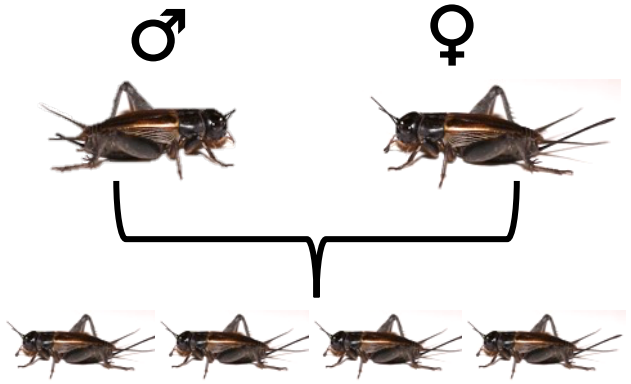
Key Questions

- Do behavioral syndromes vary by sex?
- Does the genetic structure of behavioral syndromes lead to behavioral dimorphism?





Estimating Genetic Contribution to Behavior



Behavioral Trials

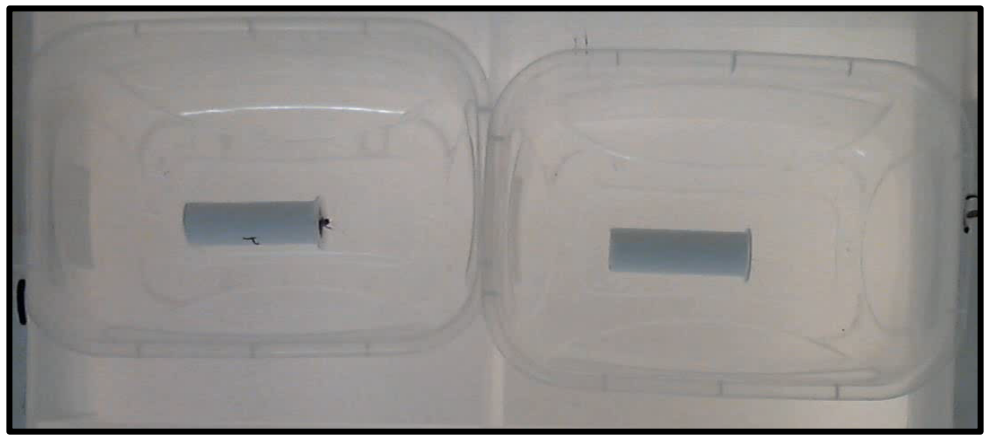
Behavioral Trials

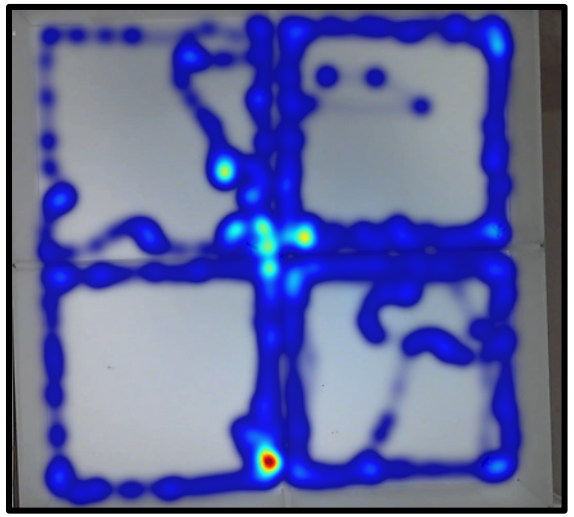
947 Individuals,
3 Behavioral Trials,
2841 Observations

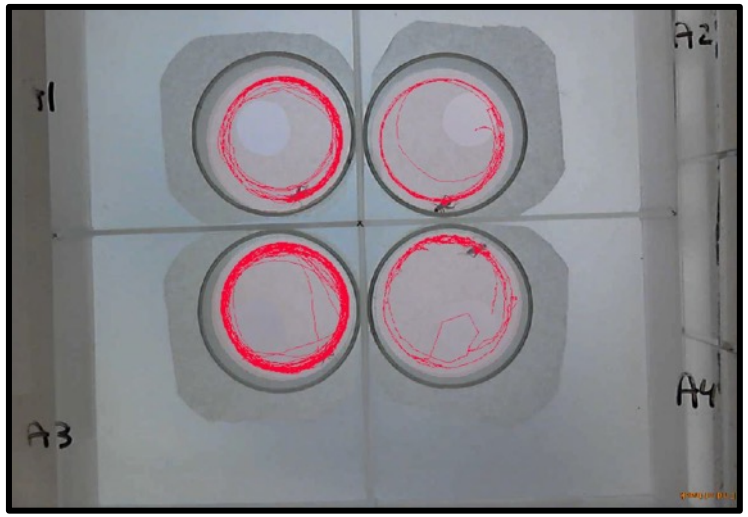
Shelter emergence

Open-field activity

Antipredator response

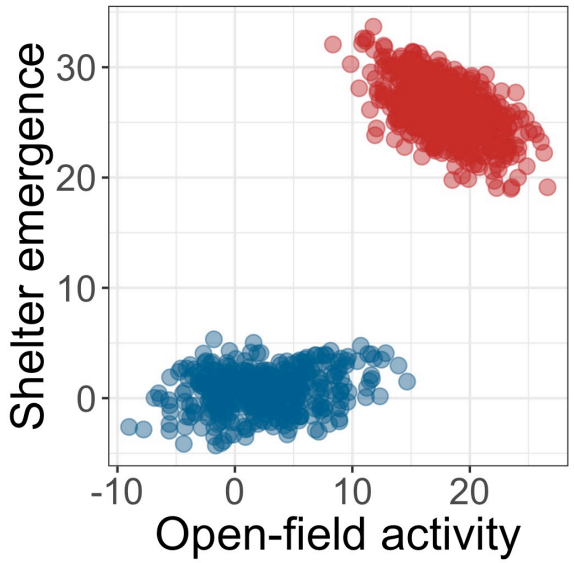




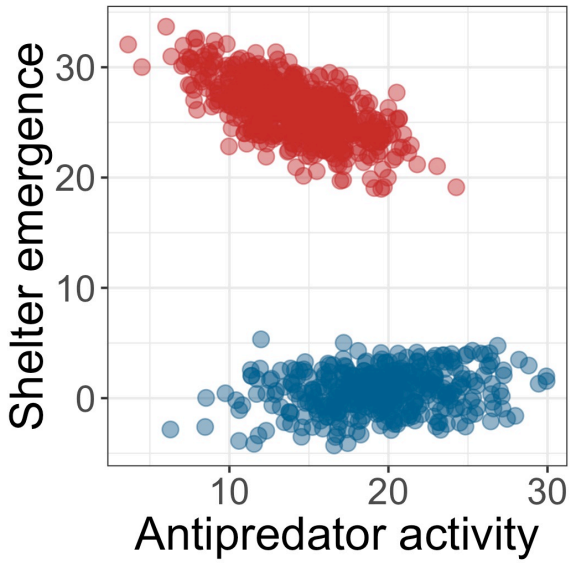


Behavioral Syndromes Differ by Sex

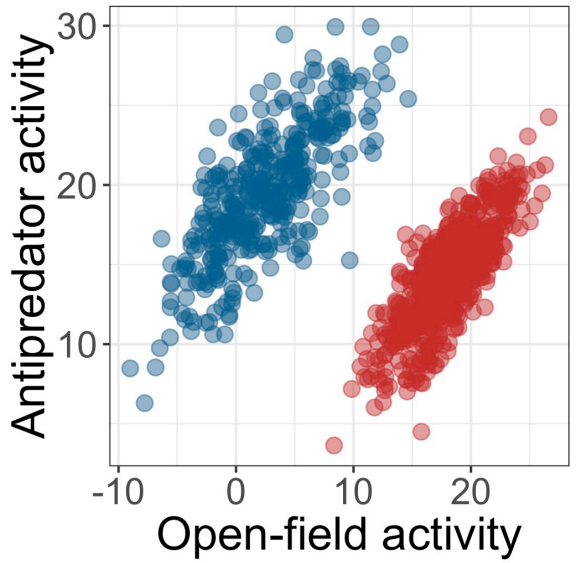
r_F = **-0.36***
r_M = 0.13



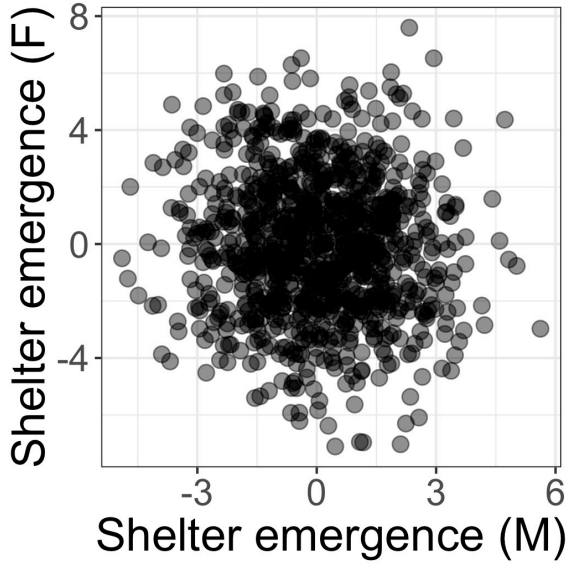
r_F = **-0.46***
r_M = 0.10



r_F = **-0.69***
r_M = **0.69***

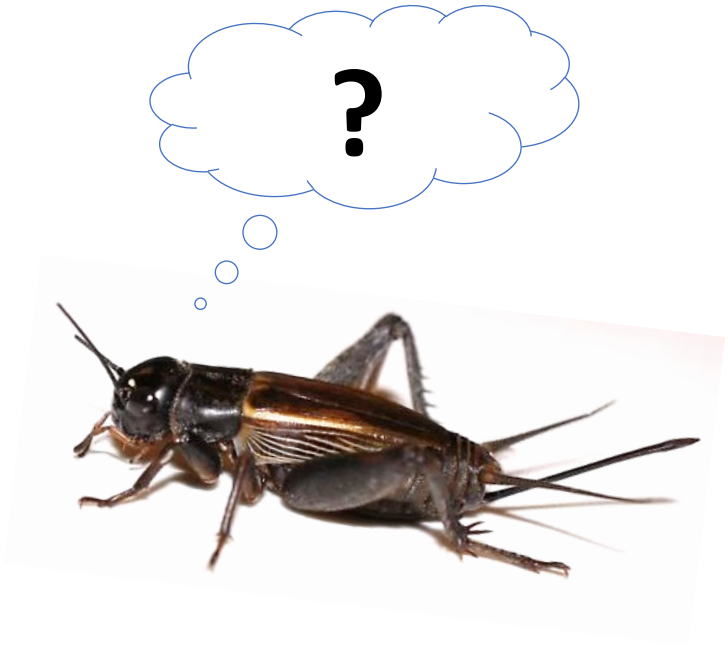


r_{MF} = 0.07



- Activity-boldness syndrome weaker in males
  - Sex-specific syndromes: ✓
- Shelter emergence can evolve independently in males and females
  - Behavioral dimorphism: ✓

Want to Know More?
Meet Me at Poster P11



In field crickets, males and female express **genetically distinct behavioral syndromes,** leading to **diverging evolutionary responses**

Cross-sex genetic correlations constrain the evolution of a behavioral syndrome

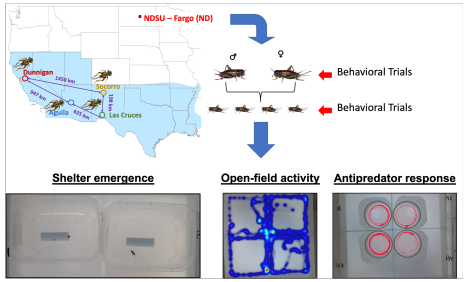
Raphaël Royauté[1], Ann Hedrick[2], Ned Dochtermann[1]

CONTEXT

- Behaviors often integrated into syndromes & have genetic basis
- Sex-specific architecture unknown
- Implications for the evolution of behavioral dimorphism

METHODS

- Field crickets (*Gryllus integer*) collected from 4 populations
- Breeding design over 3 generations and behavioral phenotyping of 965 individuals



PREDICTIONS

Stronger selective pressure for ♀ to be active and for ♂ to guard burrows

→ ♀ quicker to exit shelter and more active ✗✓

→ Less genetic variance in shelter emergence & activity in ♀ ✗✓

→ Stronger activity-antipredator response syndrome in ♀ ✓

RESULTS

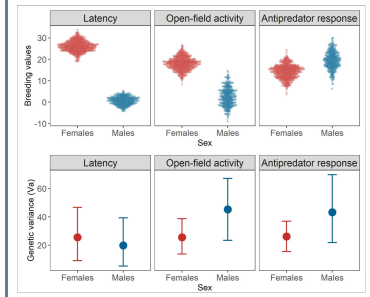


FIGURE 1. Males and females expressed diverging behaviors with females less prone to leave shelter (*Pmcmc* = 0.95) and more active than males (*Pmcmc* = 0.90). Males had more genetic variation in activity (*Pmcmc* = 0.95) and shelter emergence (*Pmcmc* = 0.92). antipredator response had equal variance among sexes (*Pmcmc* = 0.68).

Pmcmc: Bayesian probability for finding a difference among sexes.
Pmcmc < 0.7: Poor evidence of difference
Pmcmc > 0.8 : Moderate evidence
Pmcmc > 0.9 : Strong evidence
Pmcmc > 0.95: Very strong evidence

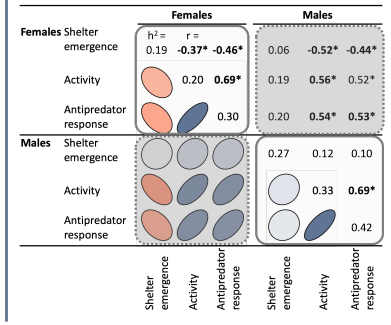


FIGURE 2. Genetic variance-covariance matrix. Heritabilities (h^2) are indicated on the diagonal and genetic correlations (r) on the off-diagonal elements. Shelter emergence was genetically uncoupled between sexes (r = 0.07, *Pmcmc* =0.61). The shelter emergence-activity syndrome had opposite correlations between sexes

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More information here!

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Acknowledgements

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Lab volunteers:

- Jonathan Albers, Amy Buckleaw, Kathelyn Cannon, Sarah Felde, Marissa Geyer, Ishan Joshi, Brady Klock, Jenna LaCoursiere, Hanna Lambert, Alondra Neunsinger, Jaxon Renn, Hayley Viner

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- ND EPSCoR

ND EPSCoR
Advancing Science Excellence in North Dakota
Experimental Program to Stimulate Competitive Research

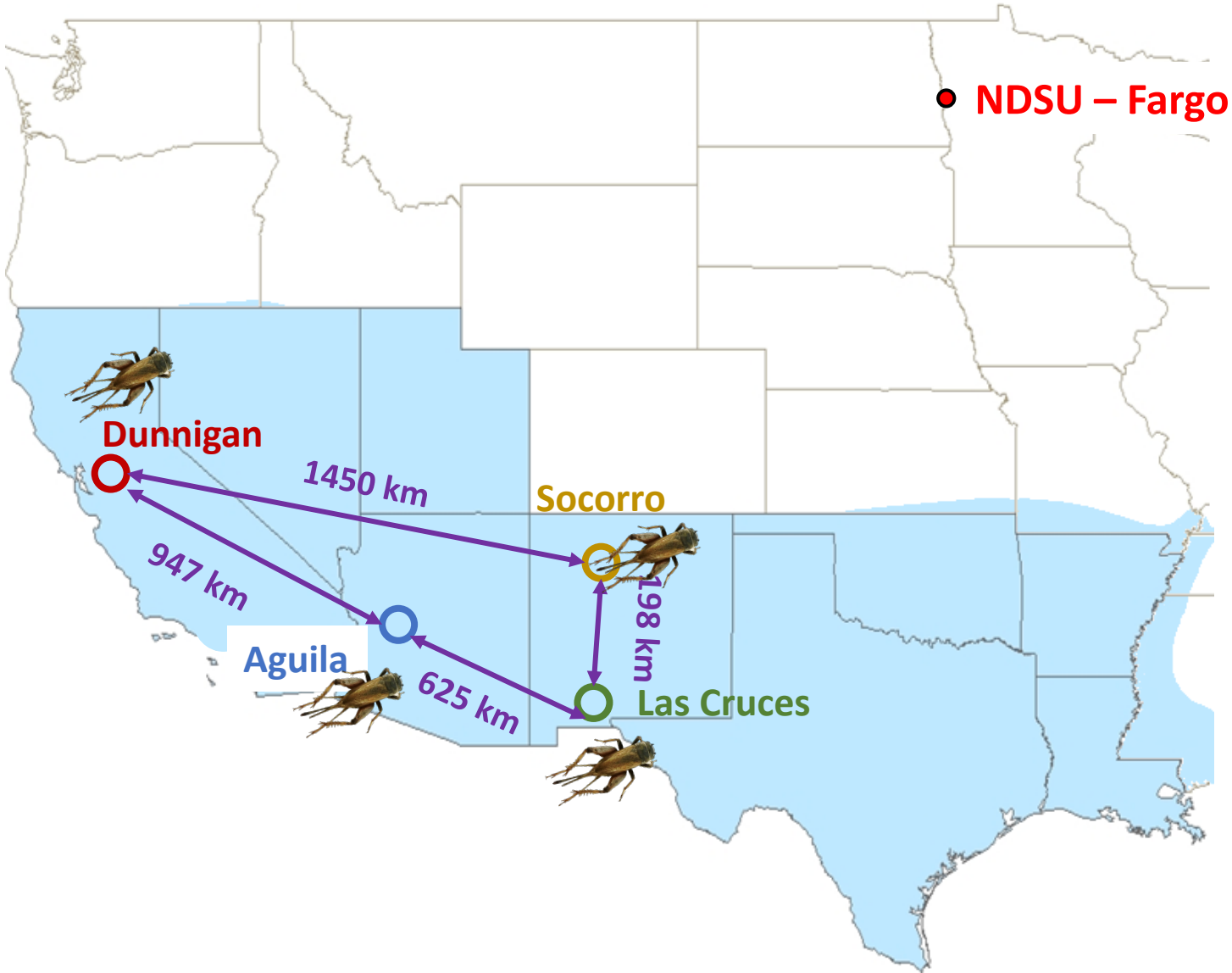
NSF

Next Steps

- Are all cross-sex correlations < 1?

- Does the structure of cross-sex correlations bias evolutionary responses?
  - random skewer analysis with antagonist and concordant selection gradients

Field Collection



Habitat types

- Urban

- Agricultural/semi-natural

Quantitative Genetics in a Nutshell

$$P = G + E$$

$$\Delta\bar{z} = h^2 S$$

$$\Delta\bar{\mathbf{z}} = \mathbf{G\beta}$$

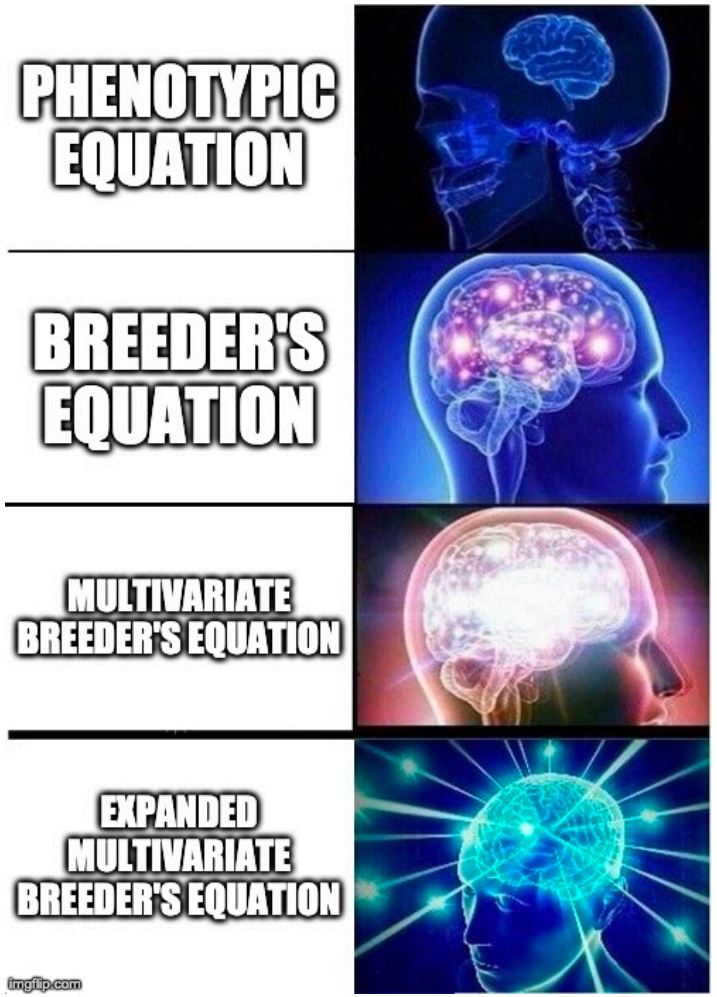
Sex-specific genetic correlation

$$\begin{bmatrix} \Delta\bar{z}_F \\ \Delta\bar{z}_M \end{bmatrix} = \frac{1}{2}\begin{bmatrix} \mathbf{G_F} & \mathbf{B}' \\ \mathbf{B} & \boldsymbol{G}_M \end{bmatrix}\begin{bmatrix} \boldsymbol{\beta}_F \\ \boldsymbol{\beta}_M \end{bmatrix}$$

Changes in male phenotypes

Cross-sex genetic correlation

Selection gradients on male phenotypes



Quantitative Genetics in a Nutshell

$$\begin{bmatrix} \Delta\bar{z}_F \\ \Delta\bar{z}_M \end{bmatrix} = \frac{1}{2}\begin{bmatrix} \mathbf{G_F} & \mathbf{B'} \\ \mathbf{B} & \boldsymbol{G}_M \end{bmatrix}\begin{bmatrix} \boldsymbol{\beta}_F \\ \boldsymbol{\beta}_M \end{bmatrix}$$

Changes in male phenotypes

Cross-sex genetic correlation

Male genetic correlations

Selection gradients on male phenotypes

Anatomy of a G matrix

		Trait Expression in Females			Trait Expression in Males		
		Behavior 1	Behavior 2	Behavior 3	Behavior 1	Behavior 2	Behavior 3
Females	Behavior 1	*Var(B1)*					
	Behavior 2	*Cov(B1, B2)*	*Var(B2)*				
	Behavior 3	*Cov(B1, B3)*	*Cov(B2, B3)*	*Var(B3)*			
Males	Behavior 1	*Cov(B1F, B1M)*	*Cov(B2F, B1M)*	…	…		
	Behavior 2	*Cov(B1F, B2M)*	…	…	…	…	
	Behavior 3	…	…	…	…	…	…

Are syndromes expressed the same way across sexes?

Are traits expressed the same way across sexes?

Are cross-sex correlations consistent?

		Females			Males		
Females	Shelter emergence	h^2 = 0.19	r = **-0.37***	**-0.46***	0.06	**-0.52***	**-0.44***
	Activity		0.20	**0.69***	0.19	**0.56***	0.52*
	Antipredator response			0.30	0.20	**0.54***	**0.53***
Males	Shelter emergence				0.27	0.12	0.10
	Activity					0.33	**0.69***
	Antipredator response						0.42

Are syndromes expressed the same way across sexes? ✓

Are cross-sex correlations consistent? ✗

Shelter emergence

Activity

Antipredator response

Shelter emergence

Activity

Antipredator response