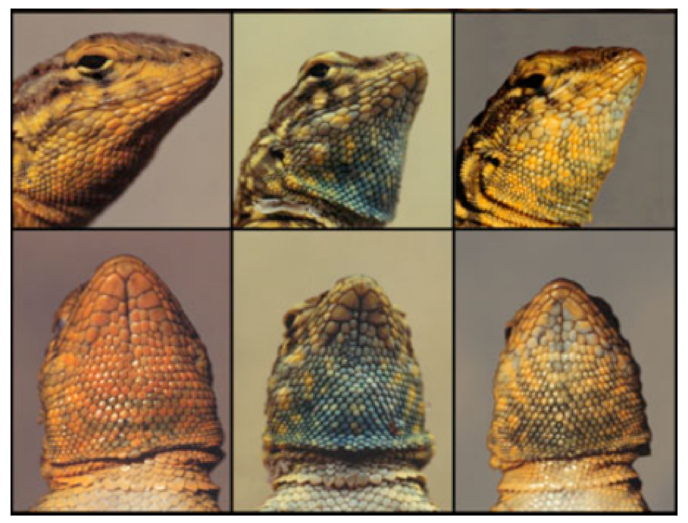
Rock Paper Lizards: Modeling Male Mating Strategies in Uta stansburiana

Tristan Wells, Sam Orientale, Alec Kong, Eric Strawn
MATH 30.04 - Evolutionary Game Theory

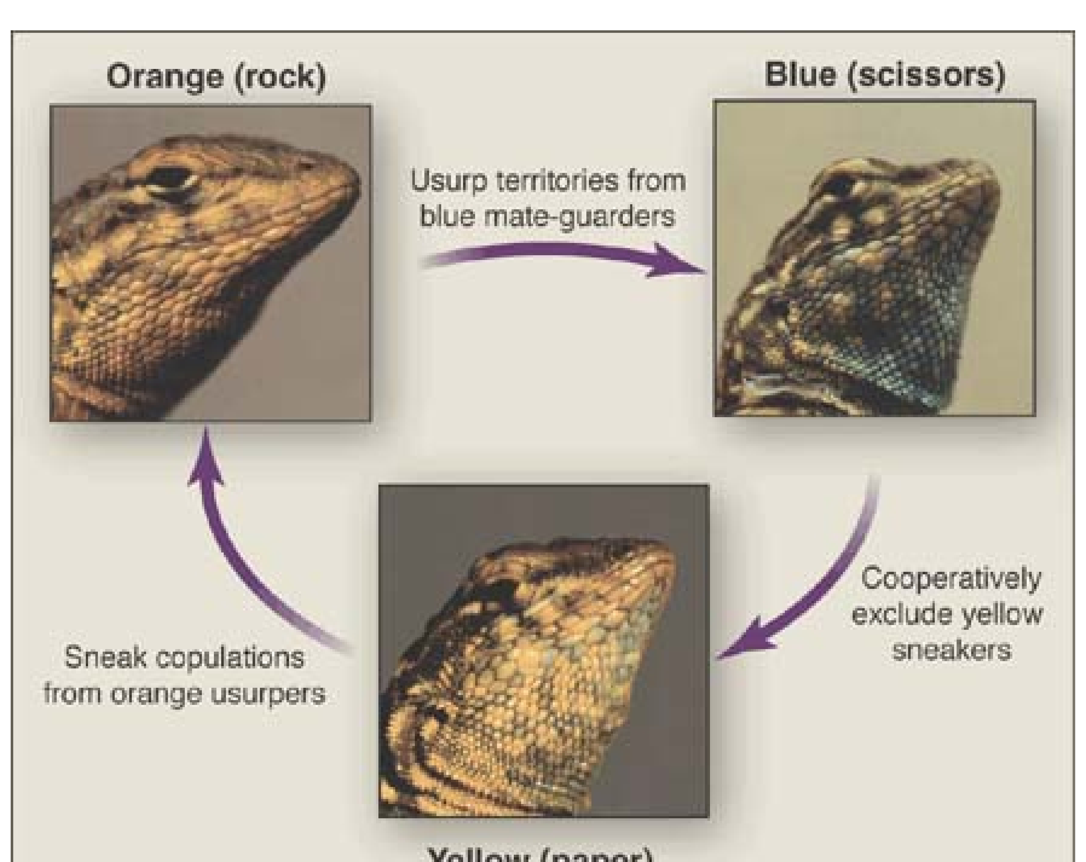
Side-Blotched Lizard Ecology



- 1.5-2.5" Snout-Vent Length
- ~1 year lifespan
- Inhabit the Desert and Coastal regions of the Southwest
- Males have 3 color morphs according to throat color: Orange, blue, yellow
- Sinervo and Lively 1996

ROCK-PAPER-SCISSORS

- Orange
  - Dominant, territorial
  - Many females
- Blue
  - Less aggressive
  - Single female
- Yellow
  - Female mimics
  - Do not defend territory but sneak copulations
- No ESS, all lizards are vulnerable when common
  - They cycle between dominant morphs



Sinervo and Lively 1996

ALTRUISM-MUTUALISM

- Nested game within RPS
- Blue morph males form dyads (pair) with neighboring blue male to improve collective fitness against orange males, with donor male sacrifices own survival for the increased fitness of recipient
- Potential altruism as one willingly cooperates as the other defects
- Sinervo et al. 2006

Central Question: Does this change the stability of the RPS game and how?

Leilani Ganser and Piper Rodolf, Courtship and Mating Behaviors

MODEL - RPS

	Orange	Blue	Yellow
Orange	0.5	0.6	0.2
Blue	0.4	0.5	0.6
Yellow	0.8	0.4	0.5

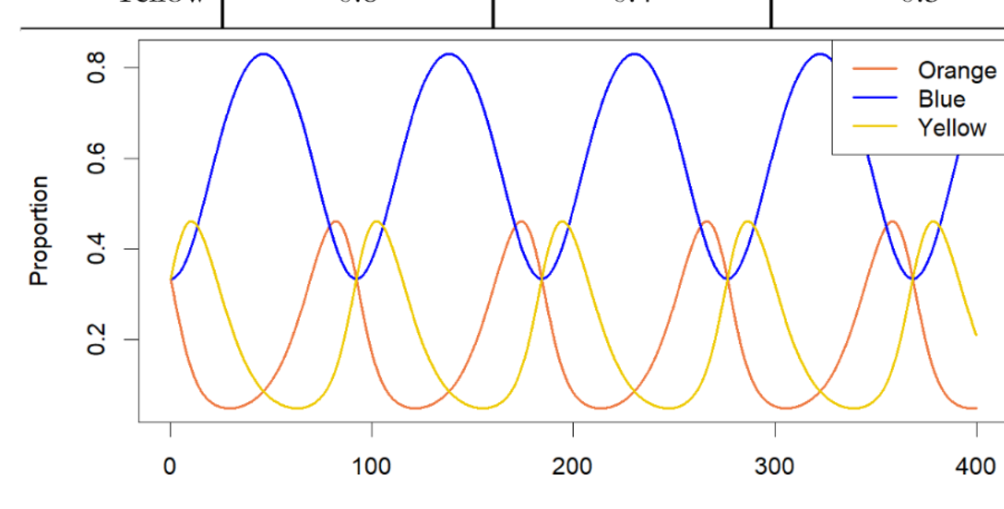
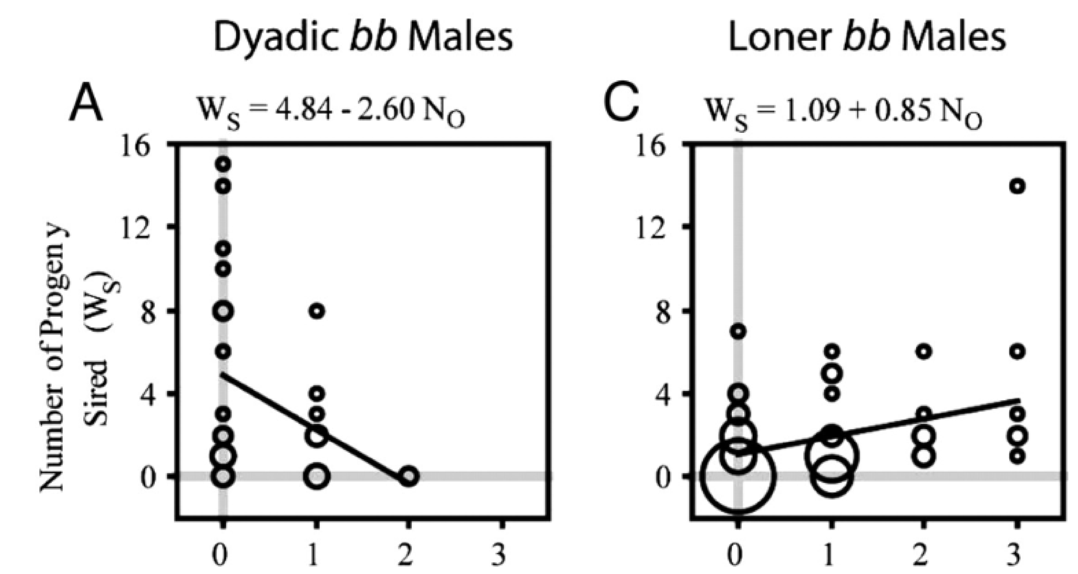


Table 1. Simplified payoff matrix for rock-paper-scissors dynamics by male color morph. Not parameterized to real data, but captures the stable, unequal cycling.

Figure 1. Replicator dynamics of U. stansburiana color morphs over time, using the simplified payoffs from Table 1.

MODEL - ALTRUISM




```
# Calculate the fitness of loner and dyad male
fitness_loner <- 1.09 + 0.85 * (c + orange_proportion)
fitness_dyad_male <- 4.84 - 2.60 * (c + orange_proportion)

# c increases the cost of cooperation when orange is common
c = 0.475
```

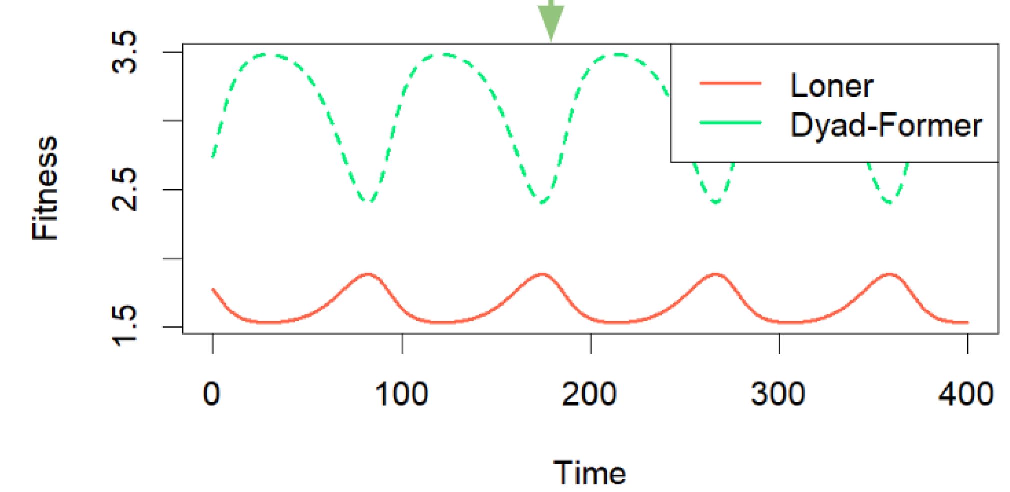


Figure 2. Fitness of dyad-forming and loner males with respect to the number of orange neighbors. From Sinervo et al. 2006.

Figure 3. Using the relationships from the Fig. 2 and the oscillating frequency of orange from Fig. 1, the fitnesses of the two strategies oscillate, varying with the cost of cooperation.

FEEDBACKS

These two games interact with one, producing a potential feedback:

1. The frequency of orange lizards mediates the relative fitness of dyad-formation, captured in Fig. 3.
2. The proportion of blue lizards forming dyads, p_{DYAD}, changes the payoff of blue playing orange,

We first modeled this by adding a benefit term (0.4 + p_{DYAD} * 0.08) to the blue-orange payoff that still can't make blue immune to orange.

RESULTS

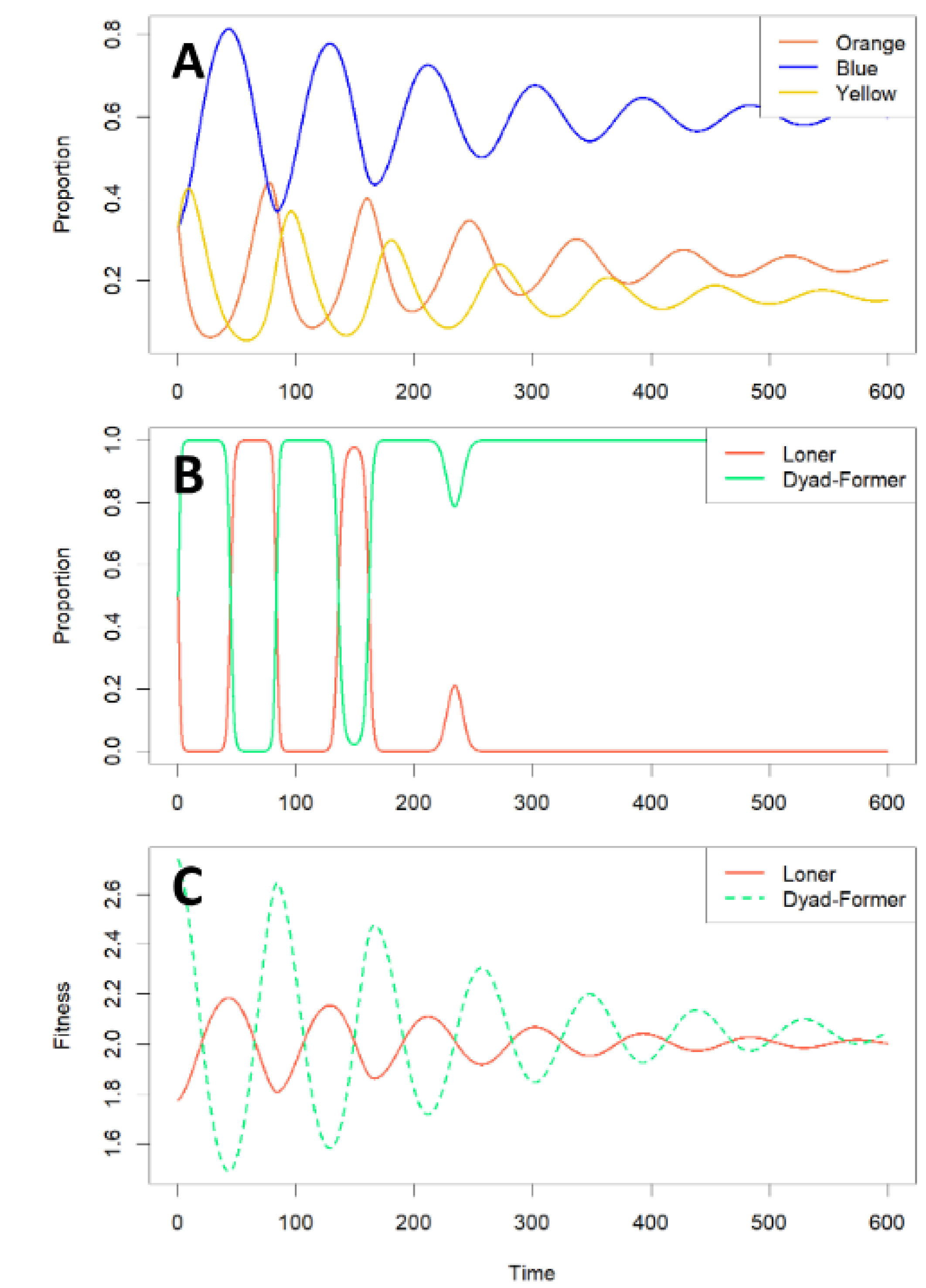


Figure 4. When the cost of cooperation is moderate (c = 0.475), the altruism feedback **A.** damps the oscillations of the RPS game, and thus **B & C.** damps the oscillations of the altruism game over time.

However, if you change the feedback model term to be (0.5 - p_{DYAD}) * 0.16 and/or increase the cost of cooperation, the cycles become unstable and the RPS game falls apart. **Key takeaway:** cooperation within a strategy is not guaranteed to drive the system to instability, and complex feedbacks can actually generate stability.

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