Conditionals, custom functions, and game theory

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Sorry I didn’t have time to post a pre-lab quiz for today

But not really

Learning objectives

1. Learn how to use conditional statements and custom functions in R
2. Understand the applications of game theory to studies in biology

Today's outline

1. Conditionals and custom functions
2. Game theory simulations

Conditional statements and custom functions

See the Handout for this week

Simulations in biology

- As we discussed last week, stochastic simulations are essential for understanding stochastic processes.
  - Drift, mutation, dispersal, developmental noise, etc.
- Analytical methods often fail in the face of complexity, in these cases simulations can be quite insightful.

Game theory

- Game theory is a useful method for simulating patterns across biology
- When a phenotype’s fitness depends on its frequency
- Predator-prey dynamics
- Coevolution
- Etc.

Rock paper scissors

- Rock paper scissors is a great example of game theory:
  - If rock and scissors meet, rock wins
  - If paper and rock meet, paper wins
  - If scissors and paper meet, scissors wins

Rock paper scissors

- Link to video

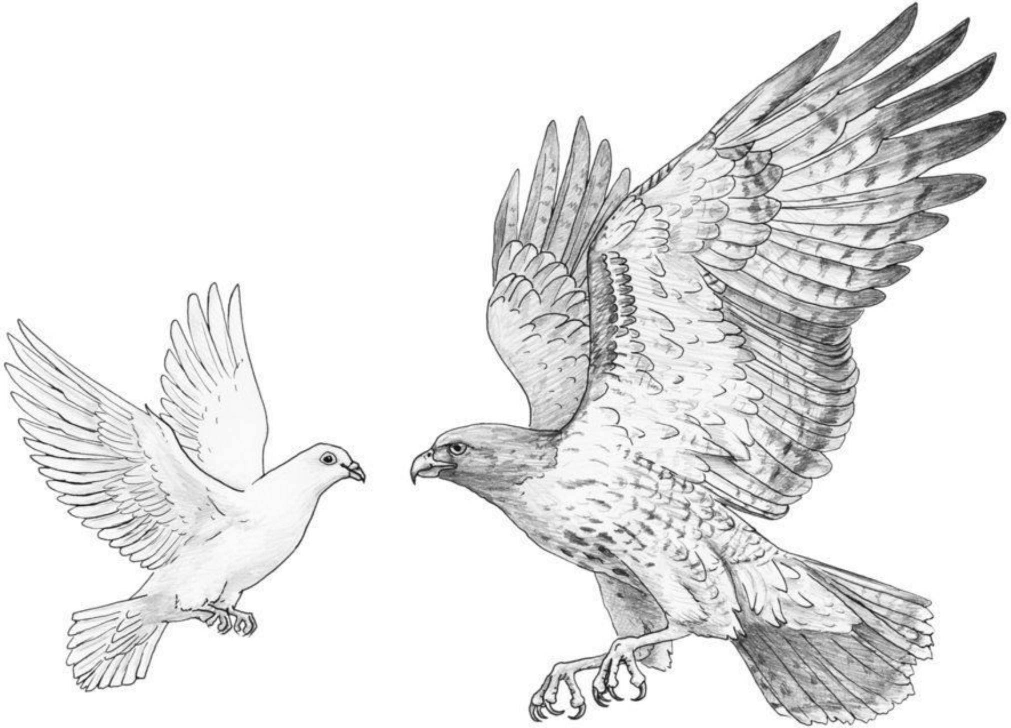
Game theory and Evolutionarily Stable Strategies (ESS)

- One way in which game theory used extensively in biology is to model the fitness of competitive strategies (i.e. phenotypes) over time.
- Strategies that cannot be beaten by new (mutant) strategies are considered to be Evolutionarily Stable

Game theory and Evolutionarily Stable Strategies (ESS)

- One way in which game theory used extensively in biology is to model the fitness of competitive strategies (i.e. phenotypes) over time.
- Strategies that cannot be beaten by new (mutant) strategies are considered to be Evolutionarily Stable
- Populations can be in Evolutionarily Stable states even when not fixed for a single strategy
- Game theory can be used to study ESS related to the evolution of sociality, cooperation, competition, sex-ratio evolution, and more

Hawk-Dove game



Hawk-Dove game

- Two animals compete for resource with value V, where V is the gain in Darwinian fitness
- Animals have three moves: display, escalate, or retreat
- "Hawks" escalate until injured or opponent retreats
- "Doves" escalate but retreat if opponent escalates
- If two opponents escalate, one is injured with fitness cost C

Hawk-Dove game

- Dove meets dove: Doves split resource
- Dove meets hawk: Dove retreats, hawk steals resource
- Hawk meets hawk: hawks split resource after deducting resource cost

	Hawk	Dove
Hawk	$\frac{1}{2}(V - C)$	V
Dove	0	$\frac{V}{2}$

Hawk-Dove game

- p = Hawk (H) frequency
- w_H and w_D denote H and D fitness
- $E(H,D)$ = payoff for H against D

$$w_H = w_0 + pE(H,H) + (1-p)E(H,D)$$

$$w_D = w_0 + pE(D,H) + (1-p)E(D,D)$$

Hawk-Dove game

- p = Hawk (H) frequency
- w_H and w_D denote H and D fitness
- $E(H,D)$ = payoff for H against D

$$p_{t+1} = p_t \frac{w_H}{\bar{w}}$$

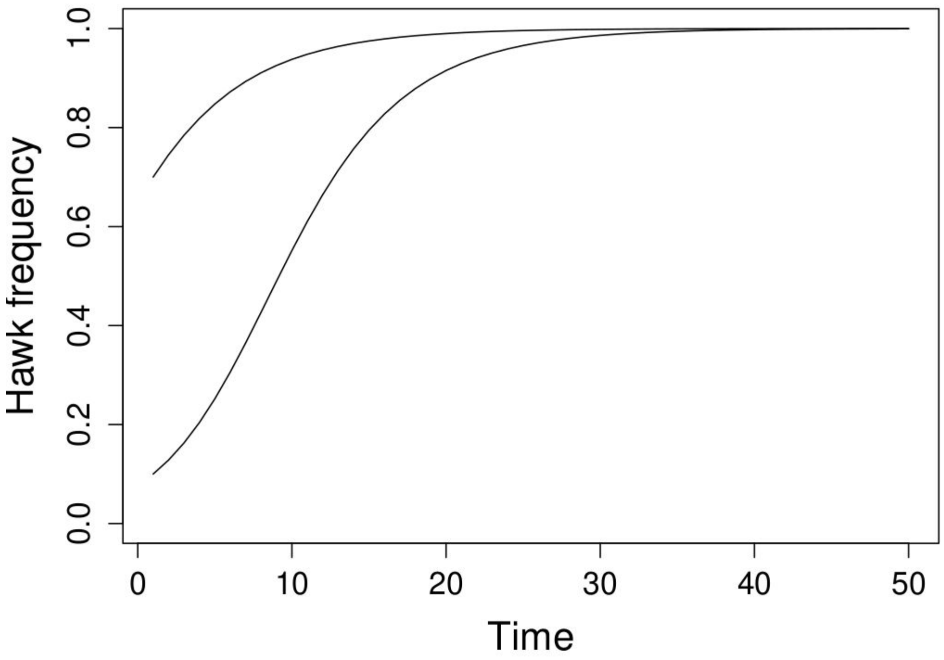
where

$$\bar{w} = p_t w_H + (1 - p_t) w_D$$

Making predictions

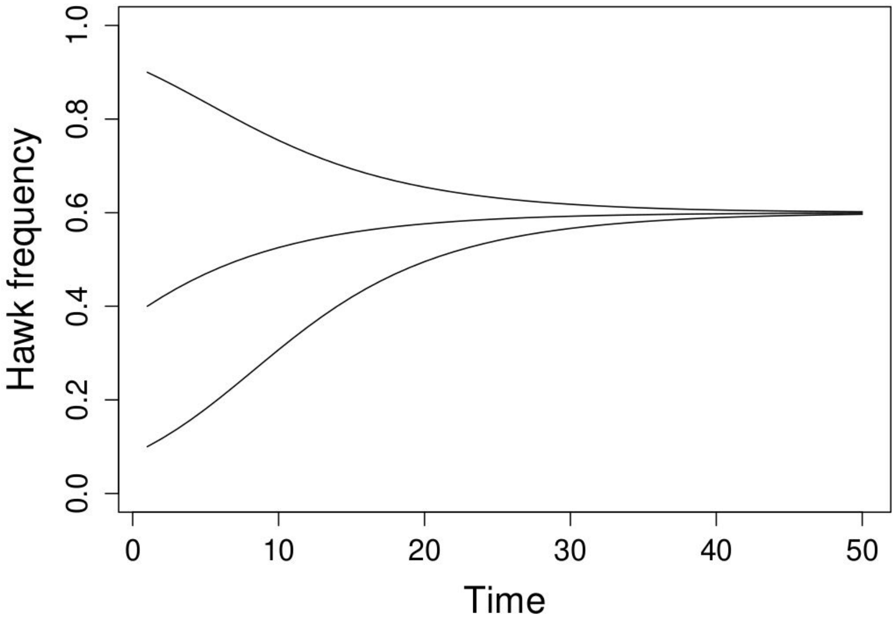
How do we think the Hawk-Dove game will play out? Is one strategy better than the other? Is there likely a stable (ESS) state? Would this change with different values of V and C? How about on the initial conditions of the population? Discuss for ~5 minutes?

Hawk is a ESS if $V > C$



$V = 0.5, \ C = 0.3$

P = V/C is stable if $V < C$



$V = 0.3, \; C = 0.5, \; \hat{p} = 0.6$

Coding the Hawk-Dove game

See the week 4 worksheet.