The evolution of altruism

Attendance code

BA-EZ-SJ

Upcoming learning content

This week (Wk 9)

- Genetic Mechanisms II
- Exam questions 1 & 2

Next week (Wk 10)

- Evolution of Species
- DNA Sequence Analysis
  - Tuesday 13:05 or 16:05
  - Cottrell 2A17
  - Phylogenetic Lab Assignment

Exam Question 1A

A. Reflect on how all of the concepts that you have learned in the Unit 2 (weeks 4-6) lecture content might be relevant for biological conservation. Focusing on just one session in Unit 2 of your choice (e.g., Session 4.5 or 5.1), and using at least 1 real-world example, explain how the key concepts in this session have important applications for conserving biodiversity.

Exam Question 1B

B. Reflect on how all of the concepts that you have learned in the Unit 2 (weeks 4-6) lecture content might be relevant for food security (e.g., agricultural management). Focusing on just one session in Unit 2 of your choice (e.g., Session 4.5 or 5.1), and using at least 1 real-world example, explain how the key concepts in this session have important applications for food security.

Exam Question 1C

C. Reflect on how all of the concepts that you have learned in the Unit 2 (weeks 4-6) lecture content might be relevant for human health. Focusing on just one session in Unit 2 of your choice (e.g., Session 4.5 or 5.1), and using at least 1 real-world example, explain how the key concepts in this session have important applications for delivering outcomes in human health.

Exam Question 2

What is the most interesting biological question that you have encountered from the Week 8 learning material? This can be a scientific question introduced in any of the synchronous sessions, asynchronous mini-lectures, or required reading chapters from week 8. Briefly state why this question is interesting to you and where you first encountered it, then explain the evolutionary reasoning for a hypothesis (or hypotheses) that biologists have introduced in attempt to answer it. Discuss how the results from 1 or 2 specific studies do or do not support the hypothesis.

Exam (Short answer essay journal portfolio)

- Replaces the traditional 4 hour exam setting
  - **Must work independently**
  - Cannot use ChatGPT (or similar AI tools)
  - Turned in during final exam time
  - **Cannot be turned in late**
- Expected word count 500 ($\pm$ 100)
- Expected references 2-6
- Rubric available on Canvas

Kin-selection and social behaviour

A behavior pattern is called *altruistic* if the individual performing the behavior (the *actor*) pays a fitness cost and the individual on the receiving end (the *recipient*) benefits.

Question: Examples of altruistic behavior in nature?

Question: Why is altruistic behavior paradoxical from the perspective of Darwin's theory of evolution by natural selection?

Kin-selection and social behaviour

	Actor benefits	**Actor harmed**
Recipient hepled	Cooperative	Altruistic
Recipient harmed	Selfish	Spiteful

- **Cooperative**: Fitness gains for both
- **Altruistic**: Actor fitness cost, recipient benefits.
- **Selfish**: Actor benefits, fitness cost to recipient.
- **Spiteful**: Fitness losses for both participants.

Question: Under what conditions should altruistic behavior evolve?

Kin-selection and the evolution of altruism

A simple genetic model showing that an allele that favors altrusitic behavior could spread under certain conditions[1,2].

Hypothetical example where someone's life is at risk

- Altruist attempts to save them at cost C to its own fitness due to risk.
- Recipient gains benefit B from altruist in terms of increased probability of survival
- If altruists dispensed their altruism indiscriminately in the population, selfish individuals would always benefit at no cost to themselves.

Alleles increasing altruism should be selected against?

---

[1] Hamilton, W. D. (1964). The genetical evolution of social behaviour. I. Journal of Theoretical Biology, 7(1), 1-16. [PDF]

[2] Hamilton, W. D. (1964). The genetical evolution of social behaviour. II. Journal of Theoretical Biology, 7(1), 17-52. [PDF]

Hamilton's rule

What if altruists only aid genetically related individuals?

Gene's-eye point of view: 3 points

- A gene for altruism may be favored if the fitness cost to that gene of being altruistic is more than offset by the gain in fitness to that gene conferred through relatives.
- The altruist will pay a fitness cost C for performing the act while the recipient receives fitness benefit B.
- The chance that the relative and the altruist share a copy of the altruistic gene identical by descent from a recent common ancestor is r, the coefficient of relatedness or relationship.

Hamilton's rule

When $B \times r$ exceeds C, altruists will have a net fitness gain on average

Alleles underlying altruism increase because the loss of copies from the death or lowered reproduction of individuals who perform altruistic acts is more than compensated for by the excess survival and reproduction of relatives who receive the benefit.

Hamilton's rule

The condition for natural selection to favor altruism among relatives,

$$Br > C$$

Where B and C measured in surviving offspring.

New Concepts: Inclusive Fitness and Kin Selection

Direct fitness: individual reproduction.

Indirect fitness: Additional reproduction by relatives that is made possible by an altruistic individual's own actions, (i.e., reproductive success above and beyond what those relatives would have achieved on their own).

Inclusive fitness: "Sum of the fitness effects that [organisms] have on all their relatives (including themselves), each increment or decrement being weighted by their genetic relatedness"[1]

[1] Gardner, A., & West, S. A. (2014). Inclusive fitness: 50 years on. Philosophical Transactions of the Royal Society B, 369, 20130356. [PDF]

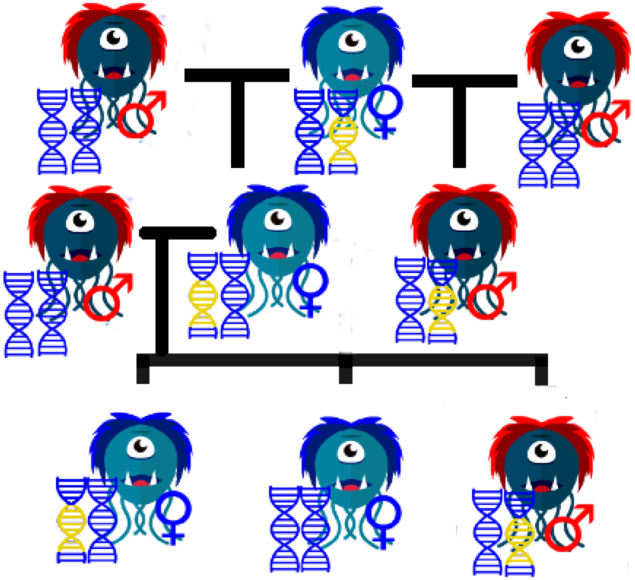
[2] Grafen, A. (2006). Optimization of inclusive fitness. Journal of Theoretical Biology, 238(3), 541-563. [PDF]

New Concepts: Inclusive Fitness and Kin Selection

How inclusive fitness relates to $Br > C$

- Br will be greater than C when the gains in indirect fitness through altruistic behavior outweigh the cost of the behavior to ones own direct fitness.
- Natural selection that favors the spread of alleles increasing the indirect component of fitness is given a special name: kin selection.
- Most instances of altruistic behavior in nature are the result of kin selection.

Calculating the coefficient of relationship



Calculating the coefficient of relationship

Relationship	**r**
Self	1
Identical twin	1
Parent	1/2
Offspring	1/2
Full siblings	1/2
Half siblings	1/4
Cousins	1/8

r is the probability that the homologous alleles in 2 individuals are *identical by descent* from a recent common ancestor

Assumes

- Autosomal loci
- Sexual reproduction
- No inbreeding

Alarm calling in Belding's ground squirrels

Assumes

- 14 years of observation
- 256 predator attacks
- **Whistle** in response to attacking hawk
  - Whistler killed 2%
  - Non-whistler killed 28%
- **Trill** in response to attacking mammal
  - Triller killed 8%
  - Non-triller killed 4%

Whistles are selfish; trills are altruistic

[1] Sherman, P. W. (1985). Alarm calls of Belding's ground squirrels to aerial predators. Behavioral Ecology and Sociobiology, 17, 313-323. [PDF]

[2] Image: Public Domain (Alan Schimierer)

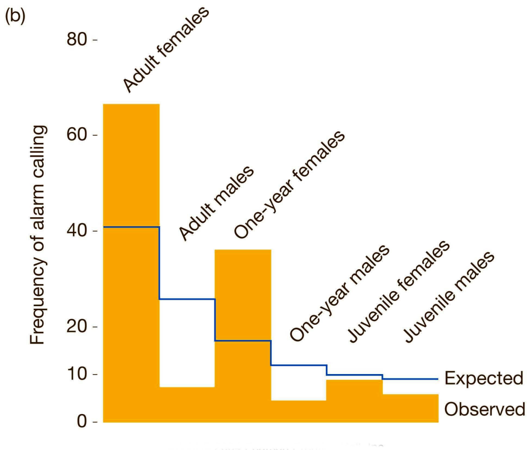
Alarm calling in Belding's ground squirrels

- Males disperse far from natal burrow
- Females remain and breed nearby
- Females in proximity close relatives

[1]Sherman, P. W. (1985). Alarm calls of Belding's ground squirrels to aerial predators. Behavioral Ecology and Sociobiology, 17, 313-323. [PDF]

[2]Image: Public Domain (Alan Schimierer)

Alarm calling in Belding's ground squirrels



Result 1: Females much more likely to sound alarm calls

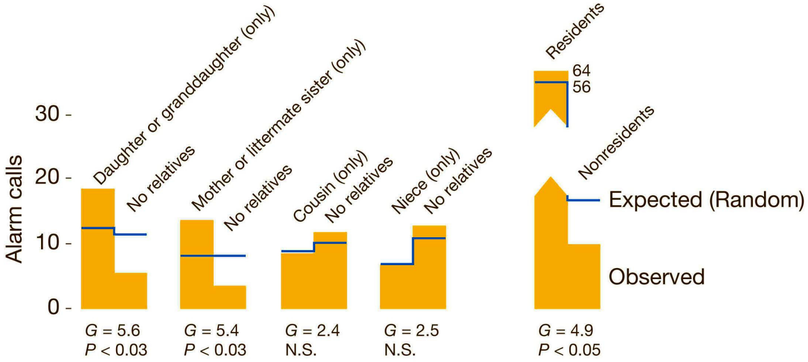
Observed and expected frequencies based on 102 encounters with predatory mammals

[1] Sherman, P. W. (1985). Alarm calls of Belding's ground squirrels to aerial predators. Behavioral Ecology and Sociobiology, 17, 313-323. [PDF]

[2] Freeman S. & Herron J. C. (2007). *Evolutionary analysis* (Fourth). Pearson Prentice Hall. p. 453 Figure 12.6.

Alarm calling in Belding's ground squirrels

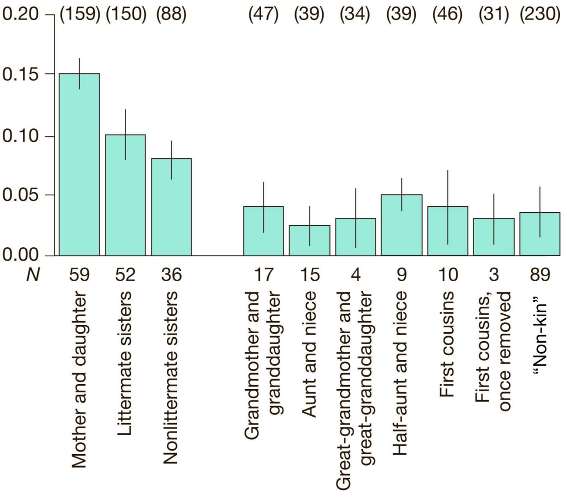
Result 2: Females call more if close relatives nearby



[1]Sherman, P. W. (1985). Alarm calls of Belding's ground squirrels to aerial predators. Behavioral Ecology and Sociobiology, 17, 313-323. [PDF]

[2]Freeman S. & Herron J. C. (2007). *Evolutionary analysis* (Fourth). Pearson Prentice Hall. p. 453 Figure 12.6.

Alarm calling in Belding's ground squirrels



Result 3: Closely related females more likely to cooperate when chasing trespassing squirrels away.

[1] Freeman S. & Herron J. C. (2007). *Evolutionary analysis* (Fourth). Pearson Prentice Hall. p. 452 Figure 12.4.

Alarm calling in Belding's ground squirrels

Remember: Calling decreases the fitness of the caller, but increases the fitness of nearby squirrels.

1. Females much more likely to sound alarm calls
2. Females call more if close relatives nearby
3. Closely related females more likely to cooperate when chasing trespassing squirrels away.

[1] Image: Public Domain (Alan Schimierer)

Reciprocal Altruism

If individuals reciprocate cooperative acts, natural selection may favor cooperative (altruistic) behavior if:

1. Cost to the actor is less than the benefit to the recipient
2. Individuals that fail to reciprocate are punished in some way

[1] Trivers, R. L. (1971). The evolution of reciprocal altruism. The Quarterly review of biology, 46(1), 35-57. [PDF]

[2] Trivers, R. (1985). Social evolution. Benjamin Cummings, Menlo Park.

Reciprocal Altruism

Most likely to evolve given the following:

1. Individuals repeatedly interact with the same other individual
2. Many opportunities for altruism occur over an individual's lifetime
3. Individuals have good memories
4. Potential altruists interact in symmetrical situations (both need and can offer favors)

Reciprocal Altruism in vampire bats

[1]Image: CC BY-SA 4.0 (Uwe Schmidt)

Reciprocal Altruism in vampire bats

- Roost together
- Feed on large ungulate blood
- Failure to feed high risk
- Regurgitate blood to others
- Kin selection & reciprocal altruism observed

[1] Wilkinson, G. S. (1984). Reciprocal food sharing in the vampire bat. Nature, 308(5955), 181-184. [PDF]

[2] Image: CC BY-SA 3.0