Lecture 16
Kin selection
Challenges to Natural selection:

Sexual Selection

Kin Selection
Types of social interactions
Types of social interactions

“Actor” → “Recipient”

Actor benefits  Actor harmed
Types of social interactions

“Actor” → “Recipient”

Actor benefits  Actor harmed

Recipient benefits

Recipient harmed
Types of social interactions

“Actor” → “Recipient”

Actor benefits
Recipient benefits Cooperative

Recipient harmed
Actor harmed
Types of social interactions

“Actor” → “Recipient”

Actor benefits

Recipient benefits
Cooperative

Recipient harmed
Altruistic

Recipient harmed
Types of social interactions

“Actor” → “Recipient”

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### Types of social interactions

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The evolution of altruism
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- an altruistic act benefits a recipient at a cost to the actor
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• how can altruistic behaviors evolve?
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let \( C \) = cost to actor

let \( r \) = coefficient of relatedness between actor and recipient
The evolution of altruism

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An allele for an altruistic behavior will be favored if:

$$Br - C > 0$$
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• this is called “Hamilton’s rule”
Bill Hamilton (1936 – 2000)
What is the coefficient of relatedness?
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• r can be estimated from:

  1. pedigrees

  2. genetic estimates of relatedness
Estimating $r$ from pedigrees

**Half-siblings**

Actor $\times$  

$\frac{1}{2}$  

$\frac{1}{2}$  

Recipient

$r = \frac{1}{4}$
Estimating $r$ from pedigrees

**Full-siblings**

- **Mother**
- **Actor**
- **Father**
- **Recipient**

$r = 1/2$

Figure 12.1b Evolutionary Analysis, 4/e
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Estimating $r$ from pedigrees

Cousins

Actor’s parent  Actor’s aunt or uncle

1/2  1/2

Actor  Recipient

$r = 1/8$

Figure 12-1c Evolutionary Analysis, 4/e
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A black-tailed prairie dog giving an alarm call
Alarm calls are given to warn kin

(b) Prairie dogs without kin in home coterie versus prairie dogs with kin in home coterie

Percentage of simulated badger attacks in which prairie dogs gave alarm calls

- Males
- Females

P = 0.019
P = 0.027

Figure 12-2bc Evolutionary Analysis, 4/e
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Alarm calls are given to warn kin

Figure 12-3: Evolutionary Analysis, 4/e © 2007 Pearson Prentice Hall, Inc.
Helping at the nest in bee-eaters
Bee-eaters direct help to close relatives

(a)

(b)

Figure 12-6 Evolutionary Analysis, 4/e
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Hamilton’s rule and the concept of inclusive fitness
Hamilton’s rule and the concept of inclusive fitness

• “inclusive fitness” is equivalent to an individual’s total fitness
Hamilton’s rule and the concept of inclusive fitness

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Inclusive fitness

“Direct” component

(i.e., individual’s own reproduction)
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(i.e., act of individual that increases fitness of its relatives)
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Inclusive fitness

“Direct” component
(i.e., individual’s own reproduction)

“Indirect” component
(i.e., act of individual that increases fitness of its relatives)

• kin selection is a form of natural selection that acts on this indirect component of fitness
The evolution of eusociality
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Three characteristics of eusociality:
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Three characteristics of eusociality:

1. overlapping generations of parents and their offspring

2. cooperative brood care

3. specialized castes of non-reproductive workers.
Why should eusociality be so common in the Hymenoptera?
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• Hamilton suggested it was due to haplodiploidy:
Why should eusociality be so common in the Hymenoptera?

• Hamilton suggested is was due to haplodiploidy:
  • females develop from fertilized eggs (diploid)
  • males develop from unfertilized eggs (haploid)
Haplodiploidy skews relatedness

$\text{Mother} \quad \text{Father}
\quad \text{Actor} \quad \text{Recipient}$

$\frac{1}{2} \quad \frac{1}{2} \quad \frac{1}{2} \quad 1$

$r = \frac{3}{4}$!
<table>
<thead>
<tr>
<th>Comparison</th>
<th>Diploid</th>
<th>Haplodiploid</th>
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<tr>
<td><strong>Degree of relatedness (r)</strong></td>
<td></td>
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- the inclusive fitness of female workers is highest if they help produce more sisters!
Does haplodiploidy explain the evolution of eusociality?
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NO!
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3. Many eusocial colonies have more than one father.
   • the average \( r \) among workers is far below \( \frac{3}{4} \).
A phylogeny of the hymenoptera

Figure 12-13 Evolutionary Analysis, 4/e
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A eusocial mammal – the naked mole-rat
Naked mole-rat queens maintain control by bullying

![Bar chart showing relatedness class vs. shoves/recipient/hour. The categories are Nonrelatives, Uncles/Aunts, Offspring, and Siblings. The chart indicates that Nonrelatives receive significantly more shoves than the other categories.](image)
The evolution of reciprocal altruism
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Bob Trivers 1943 -
The evolution of reciprocal altruism

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2. Individuals that fail to reciprocate must be punished.
   - otherwise cheaters can invade the population.
Trivers proposed that three factors might facilitate reciprocal altruism:
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1. Groups are stable

2. Opportunities for altruism are numerous

3. Altruists interact in symmetrical situations
Blood-sharing in vampire bats
Blood-sharing in vampire bats

(a) All possible donors

(c) All possible donors

(b) Regurgitators

(d) Regurgitators

Number of individuals

Association

Relatedness

Figure 12-22 Evolutionary Analysis, 4/e
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