Behavioral Adaptations for Survival 1

Co-evolution of predator and prey ("evolutionary arms races")
Outline

• Mobbing Behavior
  • What is an “adaptation”? 
  • The Comparative Method
  • Divergent and convergent evolution

• Cost-Benefit Analyses
  • Camouflage

• Darwinian Puzzles
  • Conspicuous coloration
  • Conspicuous behavior
What is an adaptation?

- An adaptation - a heritable trait / phenotype that:
  1) spread in the past because of natural selection and has been maintained by selection to the present…OR…
  2) is currently spreading relative to alternative traits because of natural selection

- Benefits > Costs for trait to be an adaptation (net benefit)
- Better than existing alternative traits / phenotypes
Descent with modification

• Any 2 species can be traced back to a common ancestor
• Differences & similarities between them are the result (in part) of adaptations
• The more recent their common ancestor, the more similar they are
• The more similar their environments, the more similar they are
Homology vs. Analogy

Homology = similarities due to common ancestry
Analogy = similarities due to similar environment / function
Not all traits are adaptive!

- Failure of appropriate genetic mutations to occur. Genetic mutations arise randomly. Natural selection can only work with the genes that exist. Cannot create certain genes or traits (evolution is not a directed process!).

- Environments change, so some traits that used to be adaptive may no longer be so. In this case, the traits may become “neutral,” or if they are detrimental (costly), they will be selected against.

- Some traits are costly but are genetically linked to other traits that provide benefits.
  - “by products”
  - “pleiotropy”
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<thead>
<tr>
<th>Reason</th>
<th>More examples</th>
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<td>1. The trait evolved under conditions that no longer exist, but persists because insufficient time or the absence of appropriate mutations prevented the replacement of the now non-adaptive trait. Some arctic moths fly in regions where bats are absent, but still cease locomotion upon exposure to an experimental ultrasonic stimulus [1005].</td>
<td>Arctic ground squirrels live where snakes do not, but when they are experimentally exposed to snakes, they show some of the same responses as other ground squirrel species whose ranges overlap with dangerous predatory snakes [245].</td>
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<td>2. The trait develops as a maladaptive side effect of an otherwise adaptive proximate mechanism—that is, one that generally causes an adaptive outcome. Female rodents living in a communal nest may sometimes give milk to offspring other than their own as a by-product of their strong parental drive, which usually results in adaptive care of their own genetic offspring [500].</td>
<td>A strong, generally adaptive drive to care preferentially for genetic offspring may lead some human stepparents to engage in criminal child abuse that seems certain to reduce the fitness of the child abuser [284]. (See p. 482 for more on this case.)</td>
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Mobbing behavior of colonial, ground-nesting gulls
Mobbing behavior

- Many birds will “mob” predators -- harass predators to drive them away.
- This can protect eggs and chicks (reproductive success)
- While mobbing is often effective, it takes time and energy and can even lead to death of the “mobber”

- Is mobbing adaptive? If so, then the costs should be outweighed by the benefits
Mobbing behavior

- Hans Kruuk – student of Niko Tinbergen
- Black-headed gulls in Netherlands

- **Hypothesis**: mobbing behavior distracts predators, reducing the chance that predators will find the mobbers’ offspring
- **Experiment**: placed 10 chicken eggs, one every 10 meters, from inside of colony to outside of colony (did this multiple times in different colonies)
Can you conclude that mobbing behaviour is an adaptation?
Is mobbing an adaptation?

- Kruuk’s data partially support this hypothesis.
- The definition of adaptation invokes natural selection, which produces a change in gene frequency within populations over time.
- Kruuk did not measure whether mobbing affects gene frequency.
- Fitness (or “reproductive success”) isn’t just making eggs. A fitness benefit is not realized until an animal’s offspring reproduce.
- The actual change in gene frequency which occurs because of a particular trait is what defines an adaptation.
Measuring fitness

• For practical reasons, scientists accept certain fitness-related “proxies” (correlates of fitness) without measuring fitness directly.

• Researchers will often look at variables that are probably correlated to fitness - number of surviving young, success in territory defense, amount of food procured, etc.

• These measures are imperfect approximations.
Discussion question: With a partner, discuss the strengths and limitations of using the following fitness-related proxies. Can you think of any other suitable proxies that are not included in this list?

- Egg size
- Clutch size (number of eggs in a nest)
- Territory size
- Parasite load
The Comparative Method

• Another way to determine whether a trait is adaptive is to look at species that face different or similar selection pressures. Separate the effects of phylogeny and current environment.

• One can look at closely-related species with different selection pressures. This might reveal divergent evolution.

• One can look at distantly-related species with similar selection pressures. This might reveal convergent evolution (i.e., independent evolution of the same trait).
  • Increases the probability that the behavior is adaptive
  • Homology or analogy?
The Comparative Method

- **Currently:** 50 species of gulls: nesting behavior varies
  - Ground-nesting or cliff-nesting

- Genetic techniques allow us to construct evolutionary trees (phylogenies) based on DNA similarities.
  - We can then map behavioral traits onto these DNA-based trees
Gull phylogeny and nesting behavior

Which hypothesis is *more likely* to be correct?
The Comparative Method

• **Prediction:** if mobbing by ground-nesting gulls is an adaptation to predation, then gull species whose eggs are at low risk of predation should show less mobbing behavior.

Kittiwake gulls

chicks
Cliff-nesting gulls

• Fewer nest predators
  • Small mammals, predatory birds – deterred
  • Fewer benefits of mobbing

• Size of adults is reduced
  • More vulnerable to predator attack
  • Increased costs of mobbing

• Kittiwakes show little mobbing behavior
  • Divergent evolution – suggests that mobbing is adaptive
Convergent evolution in mobbing

• Many species that breed in groups (colonies) face the problem of having many nests and young visible to predators.

• Many such birds (e.g., colonial swallows) show mobbing behavior

• So do colonial ground squirrels

http://www.youtube.com/watch?v=DZp_nX3g9Ec
Colonial California ground squirrels have evolved mobbing behavior

- Partial antivenin – reduces costs
- Assess size and body temperature – reduces costs
The logic of the comparative method

Convergent evolution
Distinct ancestry
Shared mobbing behavior

Divergent evolution
Shared ancestry
Divergent behavior

Rough-winged
and other solitary
nesting swallows

Bank swallow
and other
colonial swallows

Ground-nesting gulls

Kittiwake

Swallow lineage
Family: Hirundidae

Gull lineage
Family: Laridae

Similar selection pressures

Different selection pressures
Multiple lines of evidence

• Looking at both divergent evolution and convergent evolution can provide us with increasing amounts of confidence about the adaptive functions of certain behaviors.

• Researchers can collect various types of evidence to determine whether a trait is an adaptation → accumulation of evidence → increasing confidence (probability).

• **Multiple** lines of evidence that are **consistent**