

How does evolution work?

1. Mutations (heritable variation) arise that change organism traits.

These mutations are random with respect to effect on fitness:

- A few are **good** (beneficial or advantageous)
- Some/most have **no effect** on fitness (neutral)
- Some/most are **bad** (deleterious)

2. What happens (selection) to a new mutant allele?

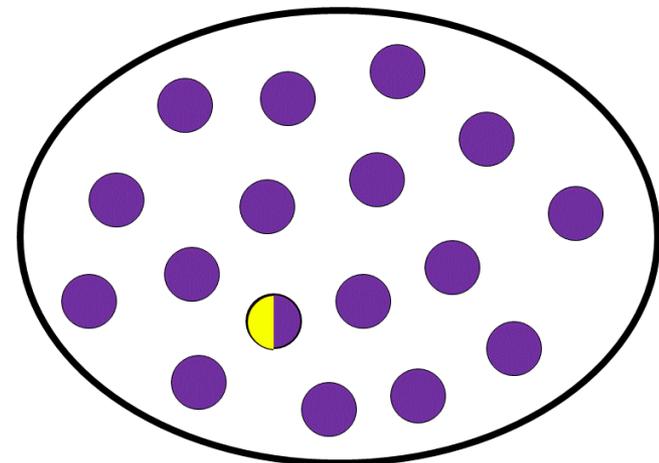
- Will that new mutant allele spread through the population and become fixed (100% of individuals have it)?

or

- Will that new mutant allele be lost?

3. We need to understand the fitness of traits (in a context of alternatives)

Section 3 of the course we will do the math



What comprises fitness?

Essentially, the success of an entity in reproducing

Two components, survival and reproduction

Surviving to reproduce (viability selection)

Fairly straightforward usually

Reproducing if alive (fertility selection)

Sexual selection (# or quality of reproductive events)

Intrasexual: vs same gender individuals.

Intersexual: involves other gender individuals

Often invoked to explain secondary sexual characters

Fecundity selection (# offspring per reproductive event)

Sexual asymmetry

Males and females differ in energy contributed to each mating:

Males: small investment (cheap sperm, little child-care)

Females: large investment (eggs, child-care)

Investment = risk

Advantage to increasing # matings depends on risk:

Males: many matings/offspring possible, each mistake no big deal = low risk.

Females: fewer matings/offspring possible, each mistake is big deal = high risk.

Advantage to ensuring quality mate depends on risk:

Males: If choose bad mate, next mate could be better = low risk.

Females: If choose bad mate, fewer potential better mates = high risk.

Males: selected to max. # matings & low choosiness

Females: selected to max. quality per mating (high choosiness)

Males: selected to max. # matings & low choosiness

Challenge: competition from other males for limited # of females

Male competition (intrasexual selection)

Females: selected to max. quality per mating (high choosiness)

Challenge: selecting the best quality males

Female choice (intersexual selection)

Types of male competition:

1. Contests
2. Territories
3. Sperm competition
 - Produce more sperm
 - Prevent additional sperm
 - Remove previous sperm
 - Sabotage other males
 - Remove previous offspring

Males compete with one another for social status
Females mate with higher social status males

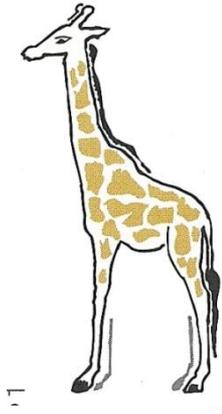
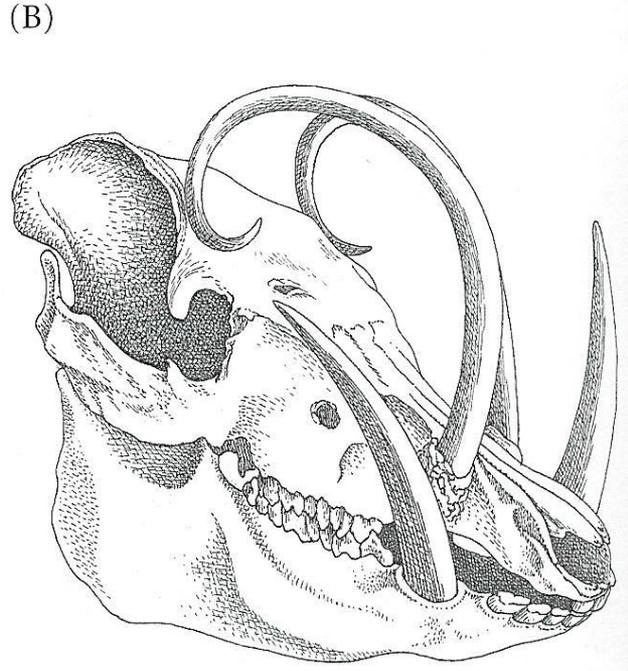
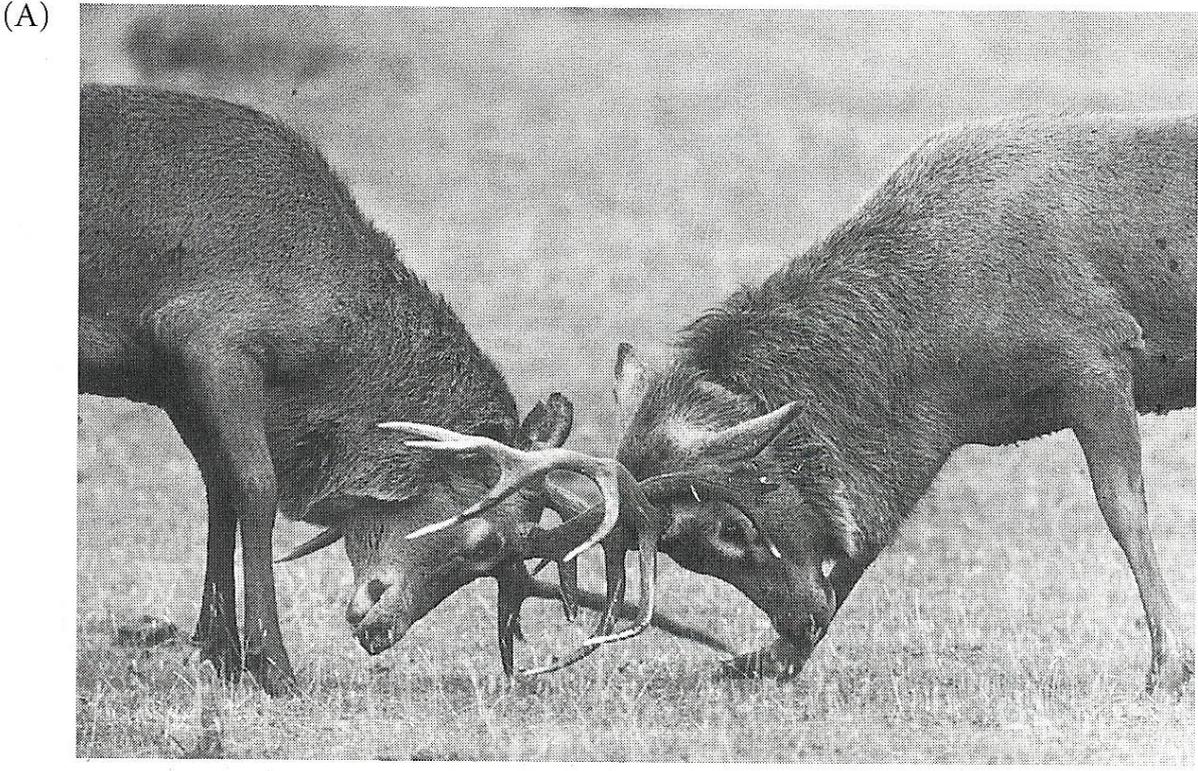


FIGURE 20.8 Some armaments of male mammals used in contests over mates: (A) The antlers of red deer (*Cervus elaphus*). (B) The extraordinary canine teeth of the babirusa (*Babirusa babyrussa*), a tropical Asian pig. (A courtesy of T. Clutton-Brock; B after Wallace 1869.)



Satin bowerbird (*Ptilonorhynchus violaceus*) males build bowers and give vigorous mating displays (i.e., dances)

1. Females tour bowers
2. Females return to best bowers and watch male perform
3. Females leave to build nests
4. Females return to best performers for final judgment

Younger females intimidated by big displays and choose based purely on blue content of bowers

Older females pick better display dances from good bowers

http://www.bluemountains.net/birds/bird.asp?bird_id=188



Male competition - territories

Males control territories containing females who mate with the controlling male

Redwing blackbirds: success determined largely by red epaulet size

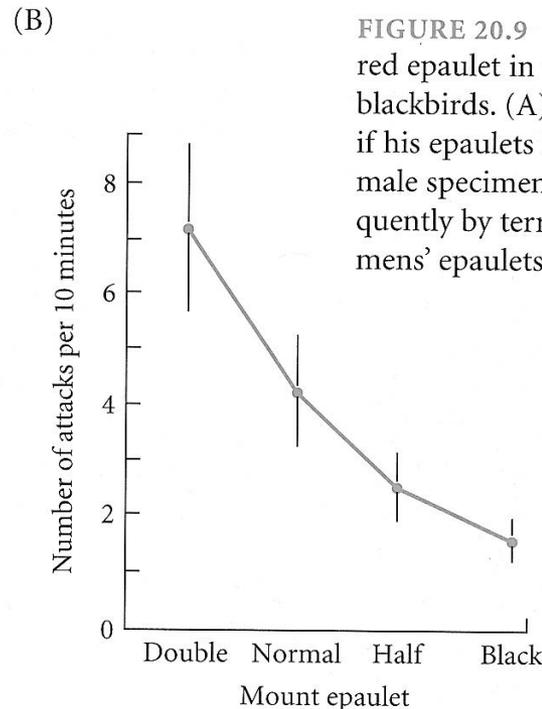
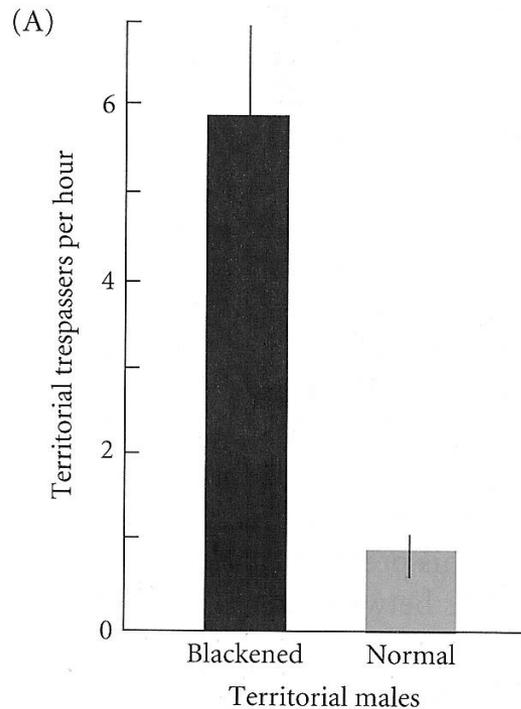
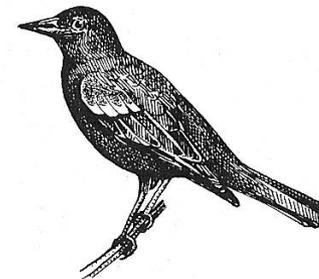
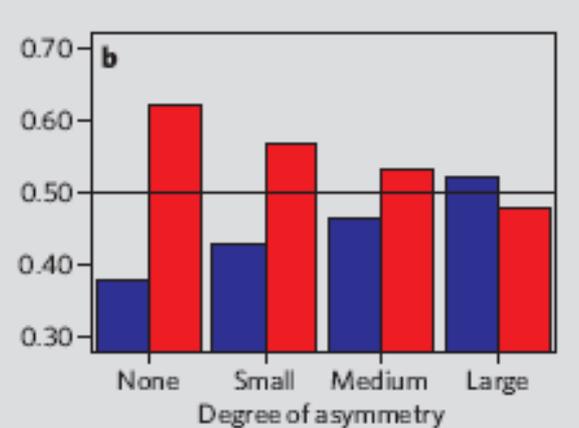
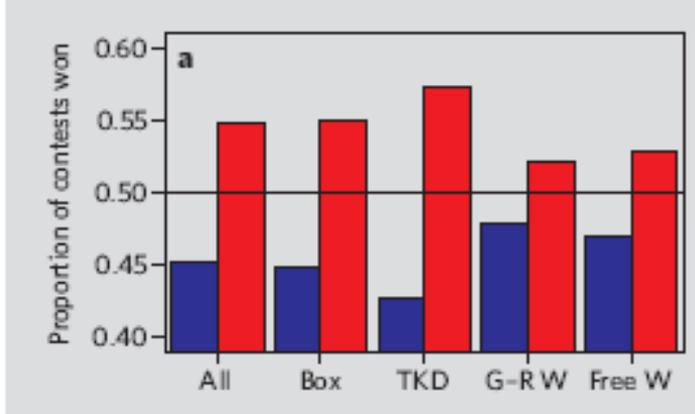


FIGURE 20.9 Experimental evidence of the function of the red epaulet in territorial contests among male red-winged blackbirds. (A) More trespassers invade the territory of a male if his epaulets have been experimentally blackened. (B) Stuffed male specimens placed in territories are attacked more frequently by territory owners, the larger the red area of the specimens' epaulets. (After Andersson 1994.)



Male competition - territories



England 1 Argentina 0

England 1, Brazil 2

England 3, Denmark 0



What if males can't compete?

Many cases in which males compete for females or control territories and other males sneak in to mate, these are sneaker males.

Iguanas (in your book)

Lady Tatiana's Sex Advice to all Creation

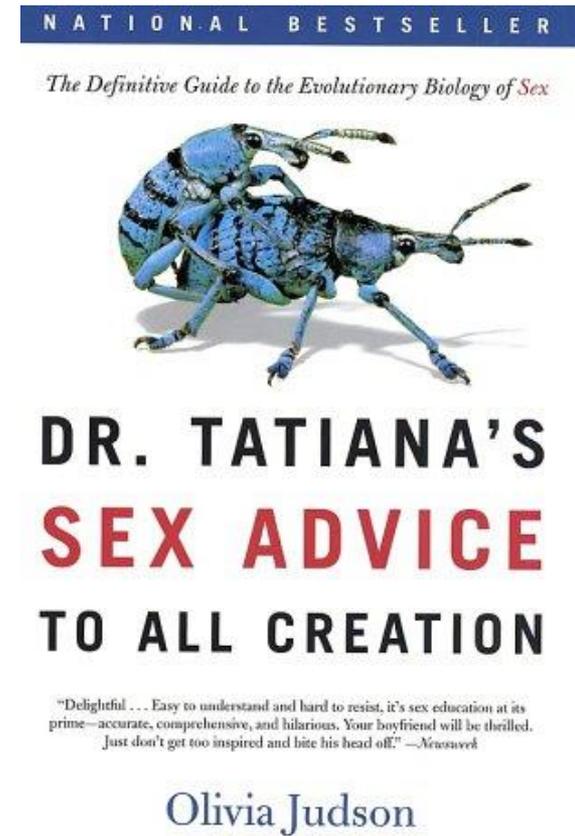
Bluegill sunfish (*Lepomis macrochirus*)

Territorial males

Satellite males (in drag)

Sneaker males

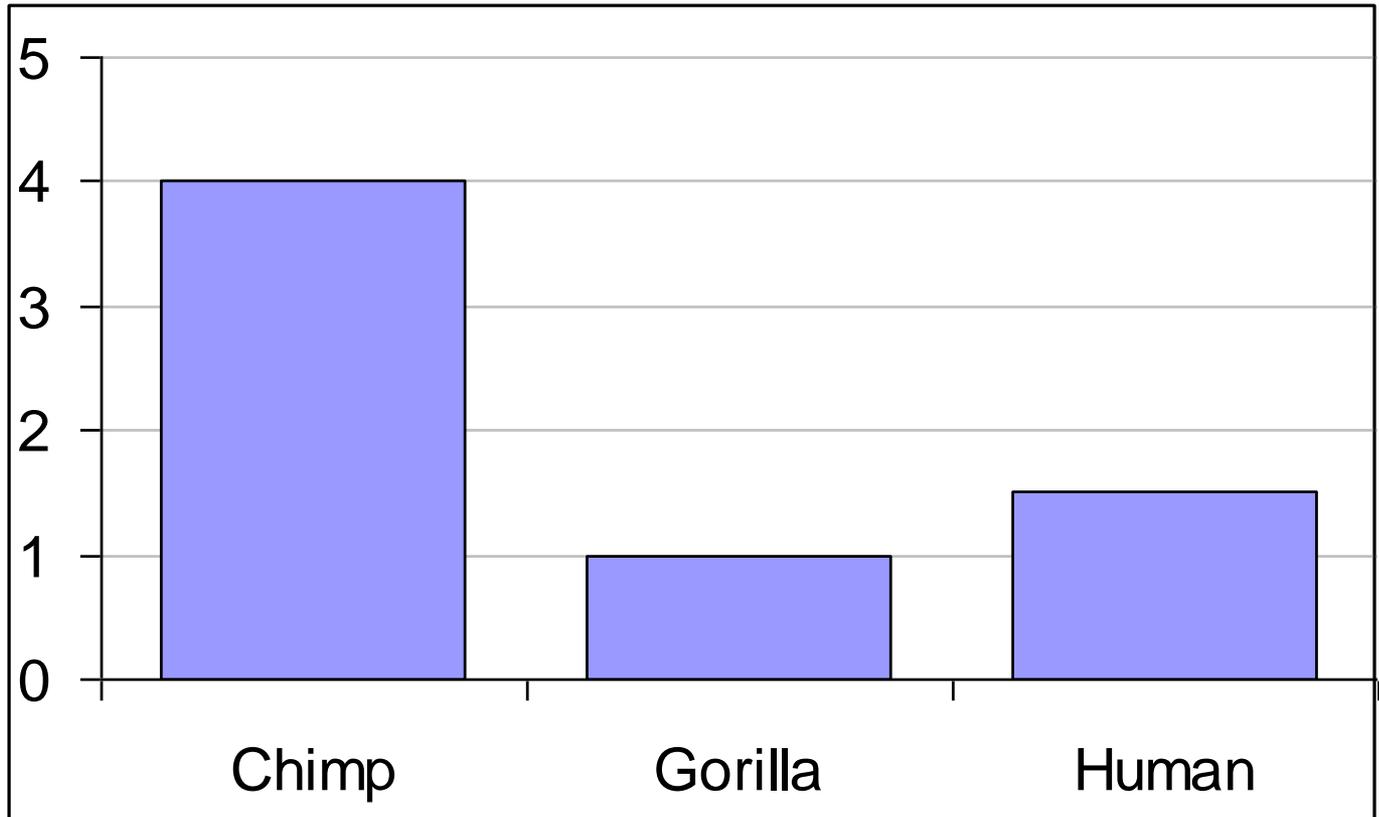
Females may even oblige/aid due to bet-hedging
(gorillas, humans, birds)



Male competition - sperm competition
- Produce more sperm

If females mate with many males then there is competition between sperm in the mixture

- Produce more sperm



Male competition - sperm competition
- Prevent additional sperm

Mating plugs

Coagulation prevents additional sperm (mice, *Drosophila*)

Penis breaks off (explosively) and stays inside (honeybees)

Bedbugs:

- Traumatic copulation (berlese's organ)
- Homosexual stabbings (*Xylocaris*)
- Transvestites (*Afrochimex*)



Fig 2. Traumatic insemination (mating) in *C. lectularius*. The bed bugs are placed upside down to show the point where the female is pierced by the male during sperm transfer.

Photo: R. Ignell



Mate guarding

Male stay with female after sperm delivery, preventing additional males from access to female. (frogs, crustaceans, insects, humans)

Male competition - sperm competition
- Prevent additional sperm

Physical damage

Damage female to prevent further acceptance
- Bean weevil penises damage female
and reduce additional matings
(Crudginton & Siva-Jolly, Nature 407:855-856)

Chemicals in sperm

Some *Drosophila* have semen containing
chemicals that: - lower female libido
- kill previous sperm,
- increase # eggs laid
- (poisonous as well though)

"good" or "bad" depends on POV

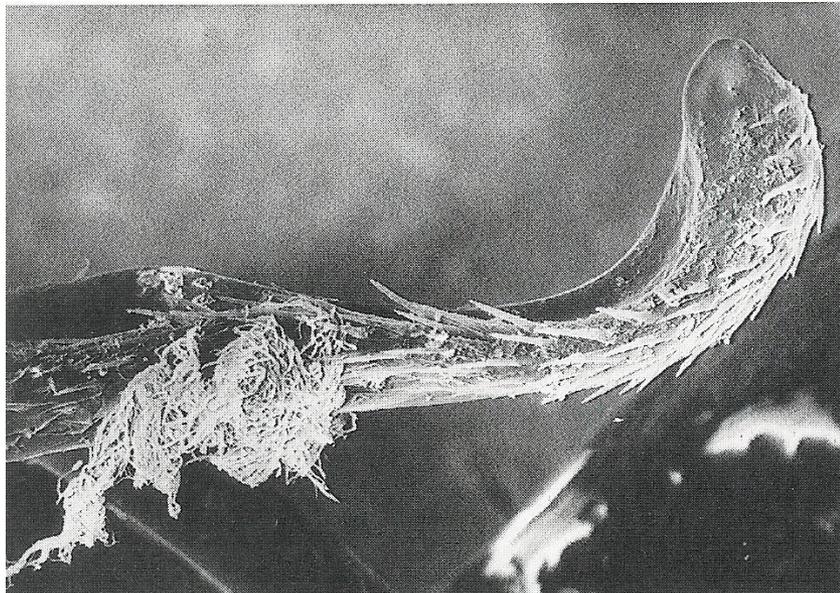


Male competition - sperm competition
- Remove previous sperm

Some *Drosophila* penises have special hooks and barbs to remove sperm from previous males



(B)



Male competition - sperm competition
- Sabotage other males

Salamanders: males imitate females to induce spermatophore deposit



Acanthocephalan worm: cap and plug other males.
(not a mistake, no sperm is transferred)

Red-sided garter snake: she-males (pheromones) in 15% of mating balls

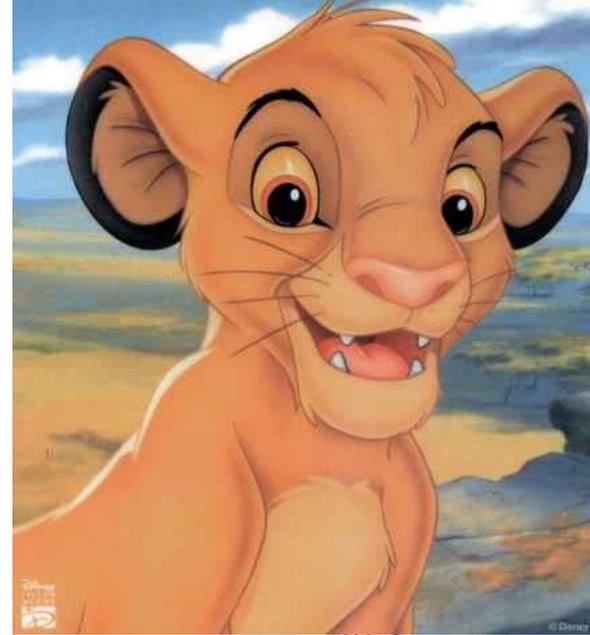
Male competition - sperm competition
- Remove previous offspring

Females won't mate while caring for young
- Kill young so that females become receptive

<http://www.primate.or.kr/gallery/Primates/monkeys/others.htm>

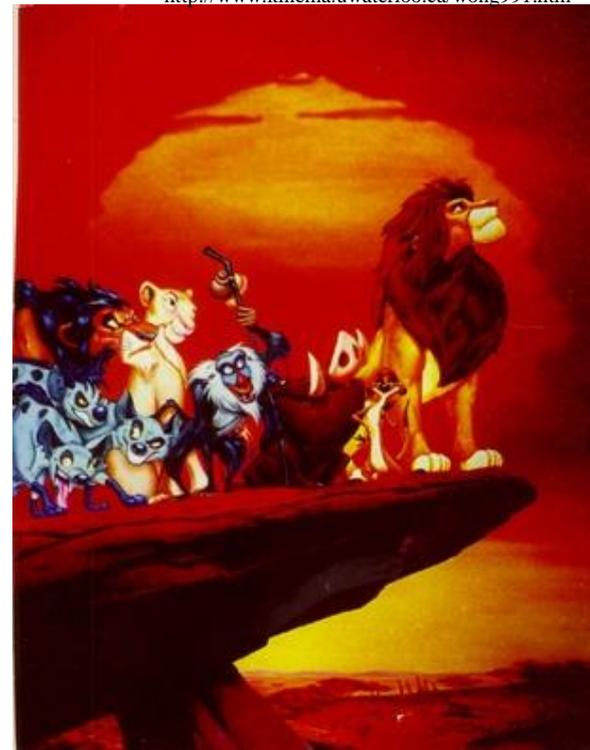


<http://www.weltweb.com/indejungle.htm>



www.nxbkimdong.com.vn/

<http://www.kinema.uwaterloo.ca/wong991.htm>



Aspects of female choice:

- 1. Hybridization avoidance
- 2. Direct benefit
- 3. Good genes
- 4. Handicap principle
- 5. Pre-existing bias
- 6. Runaway sexual selection



<http://www.nps.gov>



<http://www.ezthemes.com/previews/5/birdsong.jpg>



<http://animalpicturesarchive.com>



Jerry Bauer © 2004. All Rights Reserved.

<http://www.shieldsaroundtheworld.com>

Compton's Encyclopedia



Female choice
- hybridization avoidance

If there are many closely related species (and hybrids are bad), females are selected to choose males that are obviously from same species.

eg, *Anolis* lizards - males have colored dewlaps and characteristic push up displays that allow females to recognize species

Same structures allow *Anolis* to challenge other males and escape predators (combining male competition and female choice)



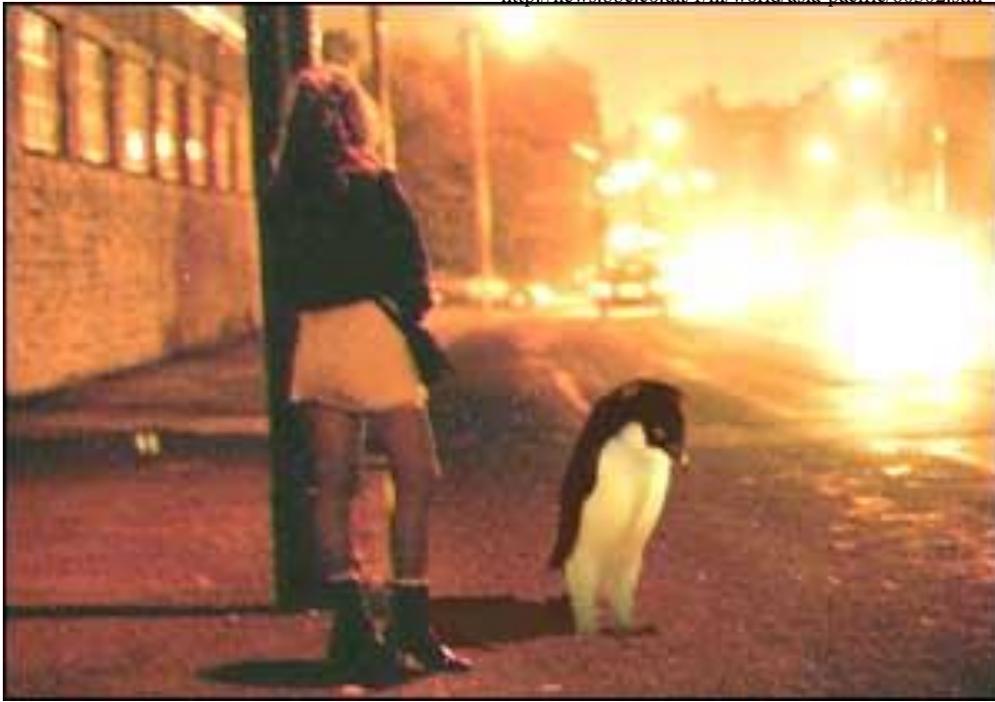
Female choice
- direct benefit

Females choose males with gifts - provides energy for offspring (and indirect assessment of male quality).

Male hangingflies (*Rittacus chlorocephalus*) give females food and are allowed to mate until the female is done feeding.

- Bigger food = more mating time = more sperm deposited
- Males are selected to provide the largest meals possible (females sometimes refuse small meals)

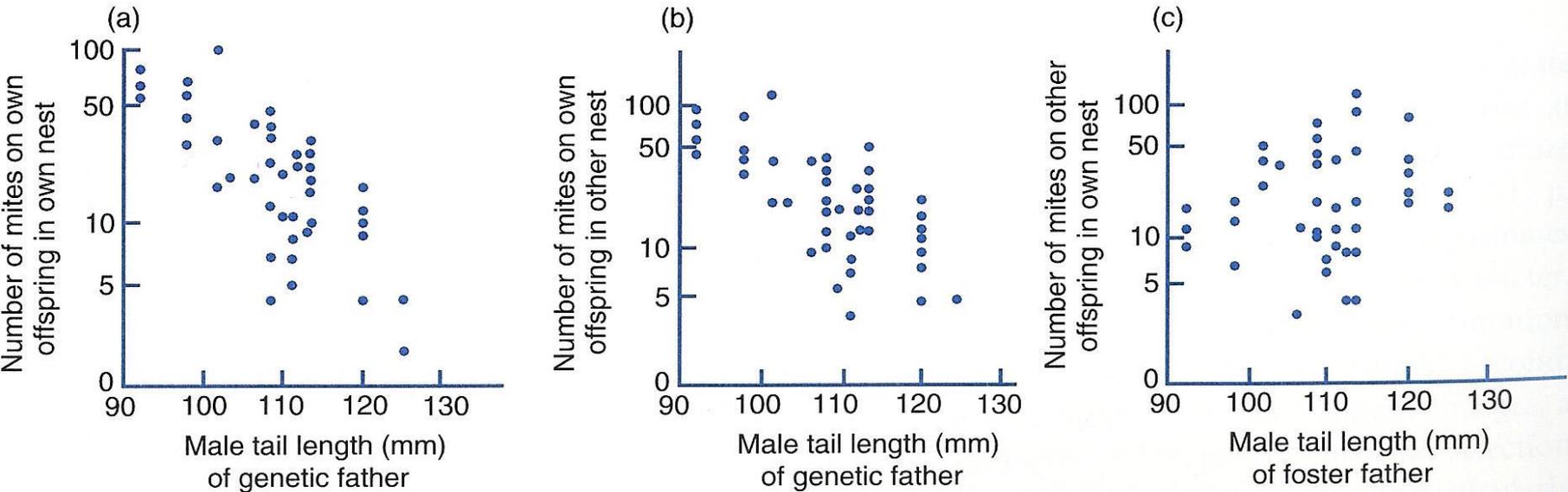
Penguins: *The coldest profession*



Female choice
- good genes

Females select their mates based upon some sign of good genes, external appearance reflecting the quality of the male.

Requires a direct link between the trait preferred and the advantage.

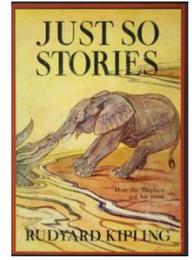


Humans?

Evolutionary psychology

DANGER: making up stories of behaviors A and B is very tempting.

e.g.: Humans are afraid of spiders because they can be poisonous.
Men prefer younger women because they are more fertile.



Making up an explanation that is consistent is not enough,
we need to be able to test hypotheses.

But, how to distinguish evolution from cultural factors
and/or upbringing that has nothing to do with evolution?

Modern popular art



Best tests are:

- Experiments with unconscious decisions.
 - spiders, snakes, outlets, cars
 - animals/objects
- Comparisons that show universal patterns.
 - youth, blemishes
 - group identity

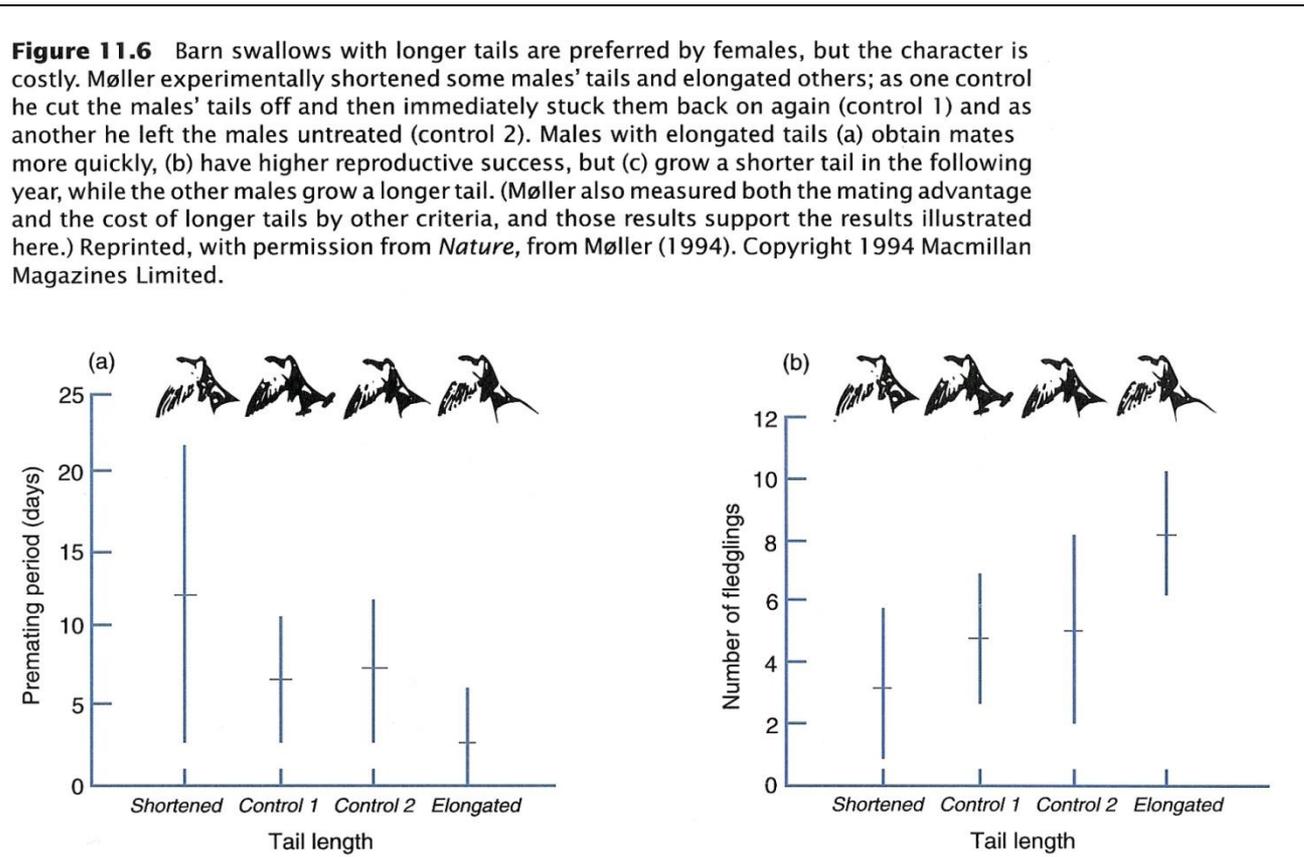


1630s popular art: Rubens: Venus & Adonis

Female choice
- handicap principle

Females mate with males having costly traits because only high quality males could afford these traits.

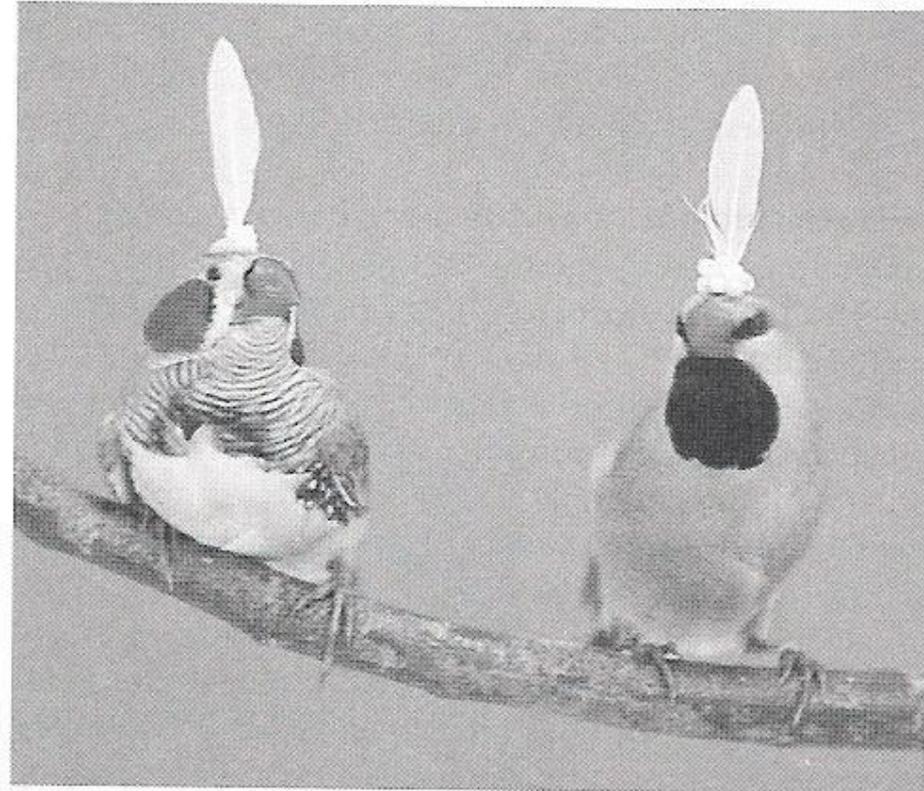
- Similar to good genes, but two key differences:
- Trait must be energetically expensive
 - Trait not directly connected to specific male advantage



Female choice
- pre-existing bias

For unknown reasons female of many species seem attracted to unusual features; including those never normally seen in males

FIGURE 20.13 Males of two species of grassfinches (zebra finch, *Taeniopygia guttata*, left, and long-tailed finch, *Poephila acuticauda*, right), fitted with feathers serving as artificial crests. Although none of the 120 species of grassfinches has a crest, females of these species preferred males with white artificial crests, compared to normal males. The experiment suggests that preferences for male features may exist before male features evolve, and may initiate the evolution of male traits by sexual selection. (Photograph by K. Klayman, courtesy of N. T. Burley.)



Female choice

- runaway sexual selection

If some females have a genetic preference for a male trait:

Male offspring more likely to have that trait (from father)
and carry preference (from mother)

Female offspring more likely to have preference (from mother)
and carry trait (from father)

This links the physical trait and preference genetically,
they occur together more than random expectation

Consider overall population:

Linked individuals choose other linked individuals more

Unlinked individuals choose both linked and unlinked equally

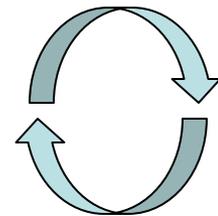
Overall advantage for linked

Note: this can occur for no other reason at all

- trait does not need to indicate higher quality

Note: this feedback would increase the trait without limit

- until viability or fecundity selection counters



Is this really a male/female thing?

Original argument used energy/risk

What if males incurred a higher cost than females?

Ex: Pipefish (relatives of seahorses) the females lays eggs in a male pouch and in some species the males have a pseudo-placenta

- Males now make larger investment, males are the choosy gender
- Two species with female ornaments



Giant water bugs (*Abedus herbertii*)

Females lay eggs on back of the males

Males stay near surface and aerate eggs
Eggs glue males wing covers shut, males are weighed down and must use substrate

Males are choosy and require copulation prior to egg acceptance, and insurance copulations during process to accept all eggs



http://www2.ville.montreal.qc.ca/insectarium/html/corps/aquari_c.htm

Jacana (Jesus birds)

Females have territories with up to 4 smaller males.
Egg destruction when take over (like lions and langurs).

<http://www.eastafricashuttles.com/safaris/bird-safaris.htm>



These different selection pressures lead to gender differences arising

sexual dimorphism

This is a strong predictor of the presence of sexual selection.

These distinct selection pressures also create a tension and ongoing selective competition between and among the genders, an arms race.

Can involve positive feedback, sexual selection until viability or fecundity selection reins it in.

<http://www.anselm.edu/homepage/jpitocch/genbio>



Gender matters less than the energy/time investment
We saw this from pipefish, jacana, etc.

What other selective forces favor certain mating systems?
How can a population go from one state to another?

Environment type

Harsh: Two parents needed
(or lots of parental care needed)

Environment improves

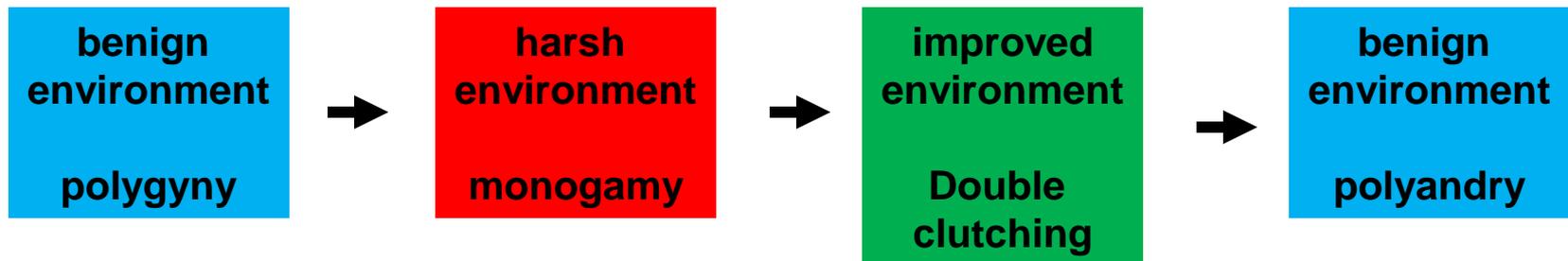
Benign: enough resources for
1 parent to raise offspring

Optimal mating system

Monogamy

Double clutching possible

Polygamy: polygyny, polyandry



Gender switching

In systems with territories

Female better for small individuals (ensures mating)

Male better for large individuals (can exceed single mating)

protogynous: females grow up to be males

Ex: cleaner wrasse (*Labroides dimidiatus*) in Australia

- One large male controls territory with females.
- If male is removed, largest females changes gender and takes over (in hours).



Gender switching

In systems with large female investment

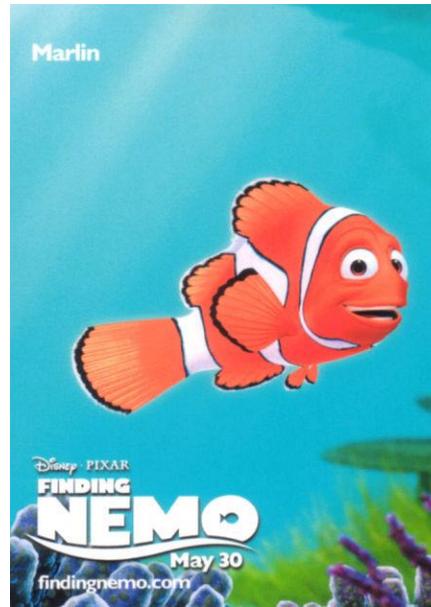
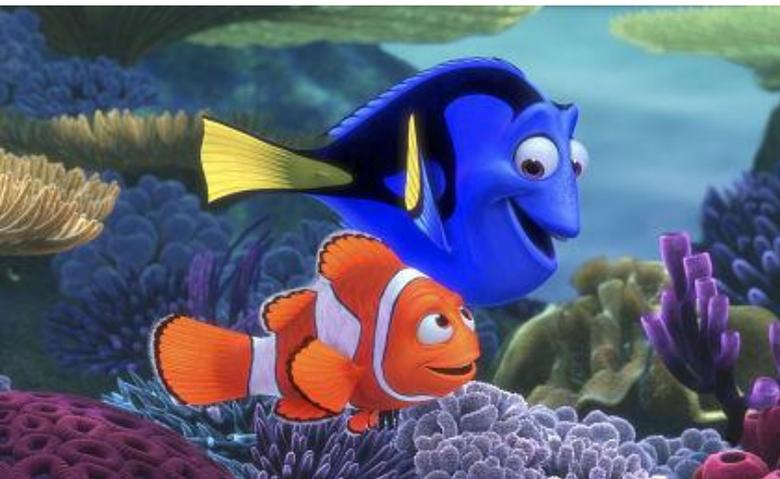
Male better for small individuals (can't afford to be female)

Female better for large individuals (can guarantee single mating)

protandrous: males grow up to be females

Ex: Clownfish (*Amphiprion percula*)

- Live in groups of: one large female, one resident male and a number of genderless juveniles.
- When female dies: male changes into the female, largest juvenile becomes the new male.



If mates are rare there is little male/male competition or female choice

Barnacles (crustaceans)

- Lengthy penises
- Resident parasitic male

