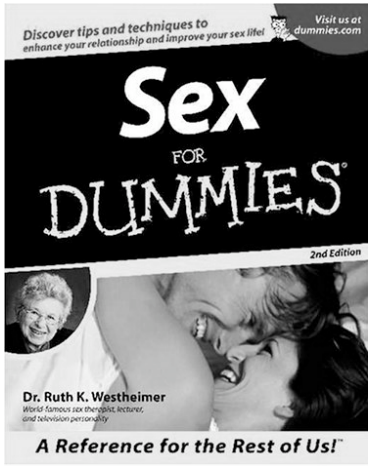
Behavioral Evolution and Sexual Selection

BIOL 4415: Evolution
Dr. Ben Waggoner



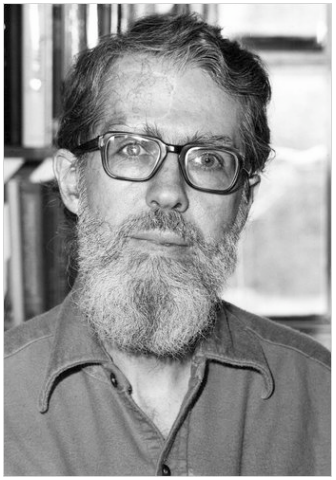
Genetic influences on behavior, and the "gene-centered" view of evolution, will play a large role in understanding a major area in which evolution and behavior intersect: *sexual selection*.

What's the point of sex, anyway?

- One would think that asexuals would have greater fitness—since every asexual can reproduce, whereas it takes two sexuals to reproduce
  - This is the *twofold cost of sex*, pointed out by John Maynard Smith (1920-2004)
- Sexual reproduction also carries costs with it (cost of seeking mates, producing gametes, etc.)
- There's also the risk that an organism which mingles its genes with a partner will produce offspring with a less-fit genotype
- So why is sexual reproduction nearly universal?

What's the point of sex, anyway?

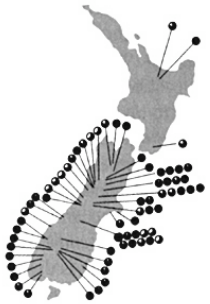
- Sexual reproduction turns out to be evolutionarily quite beneficial:
  - It breaks up *linkage disequilibrium* (selection at one locus affecting allele frequencies at a different locus, either through physical linkage on a chromosome or through other effects that can mimic it).
  - It breaks *Müller's ratchet* (the tendency of an asexual line to accumulate more and more negative mutations)
  - It generates variability, which is beneficial in itself, especially if the population is exposed to changing environments or pathogens/parasites (the *Red Queen Hypothesis*)

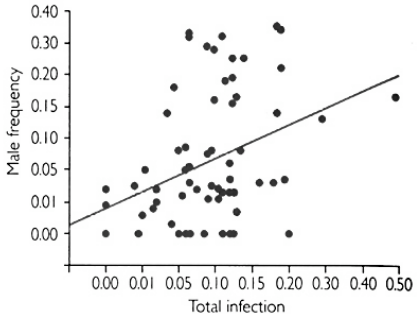


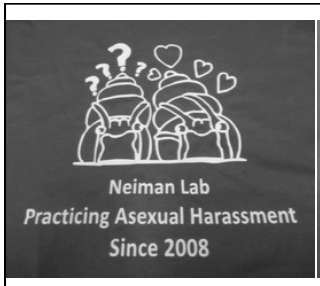
Leigh Van Valen devised the *Red Queen hypothesis*: biotic ecological interactions among species are the primary driving force behind evolution. Every adaptation in one species forces others in its ecosystem to adapt, and so each species must constantly adapt just to hold its niche. A species must constantly change just to keep ahead of parasites, predators, and pathogens—and sex is an important way to maintain variability and capacity for change.

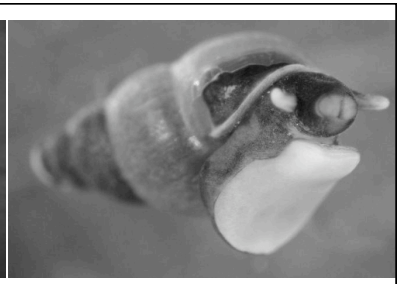
By the way, the Red Queen hypothesis is named for the Red Queen in Lewis Carroll's *Through the Looking Glass*, who said "Now, HERE, you see, it takes all the running YOU can do, to keep in the same place."

Curtis Liveley, Thomas Dybdahl, and colleagues have studied the New Zealand freshwater snail, *Potamopygus antipodarum*, in which sexuals and asexuals may coexist in the same population. Sexual individuals are most common in populations with a high parasite load —which seems to support the Red Queen hypothesis.









More recent work on the same snail by Maurine Neiman shows that asexual lineages of *P. antipodarum* accumulate mutations at about half the rate of sexual populations in the mitochondrial genomes. This seems to support the model of "Müller's Ratchet". (Work on the nuclear genomes is still going on.)

Two main aspects of sexual selection

- Competition between members of one sex for "breeding rights"
  - Usually, this is competition between males
- Selection of mates by members of one sex
  - Usually this amounts to choice by the females
- Both of these may act independently of, together with, or in opposition to natural selection

Usually males fight over females, and females are choosy about which males they allow to mate with them—a rule of thumb known as *Bateman's rule*. . .

Male elk in the Canadian Rocky Mountains "bugling" and fighting

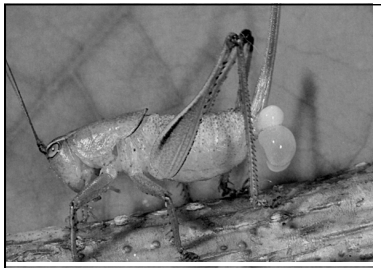
But there are exceptions. . . and looking at these exceptions helps to understand why sexual selection acts the way it does.

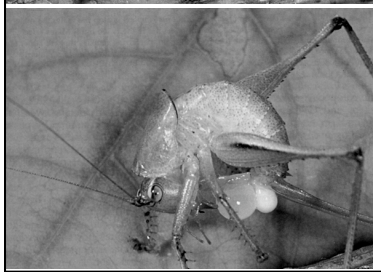
Mormon cricket,
Anabrus simplex

Australian katydid,
Requena sp.

Case Study: Katydids

- Male katydids produce both a *spermatophore,* a packet of sperm, and a *spermatophylax*, a protein-rich structure.
  - In "Mormon crickets" the spermatophylax may amount to 25% of a male's total body weight.
- At mating, females eat the spermatophylax, which is quite nutritious.
- Female katydids compete with each other for access to males—the reverse of the usual pattern!
- Competition is strongest when food is scarce.

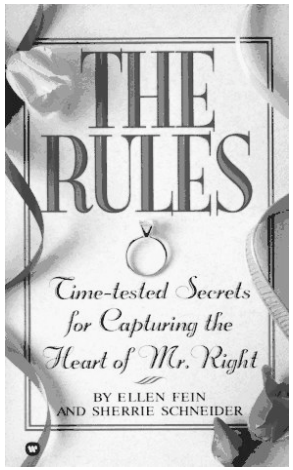




Female cricket with a male's spermatophore and spermatophylax.

Pipefish are another "exception that proves the rule."

At mating, female pipefish lay eggs inside a specialized pouch on the male's belly, and he carries them around and eventually gives birth. Male pipefish are choosy about females, and females compete with each other for access to "choice" males.



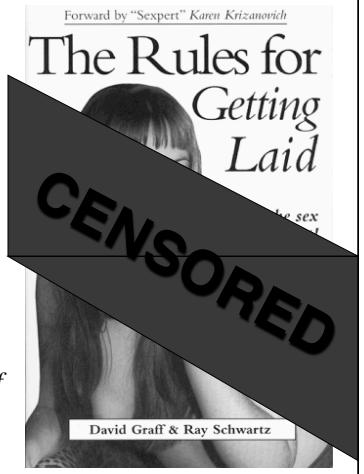
The Rules

1. Whichever sex invests more energy in reproduction "has more to lose", and has fewer opportunities to reproduce. Selection will favor behavior patterns by that sex which select only high-quality mates.

The Rules

2. Whichever sex invests less energy in reproduction can increase its fitness by reproducing as often as possible.

This difference between the "long-term interests" of sexes is called *asymmetry of sex*.



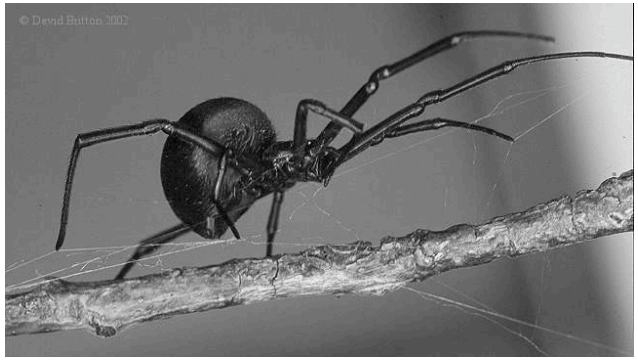
The Rules?

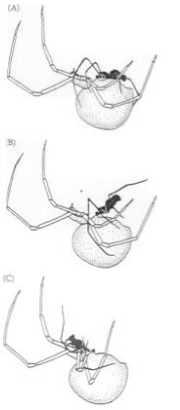
NO RULES. JUST RIGHT.®

In the real world, however, so many other factors can affect the evolution of sexual behavior that it's hard to really come up with *any* rules that don't have exceptions all over the place. Consider a famous Aussie organism—no, not the Bloomin' Onion. . .

. . . but rather the Australian redback spider, *Latrodectus hasselti*, a close relative of our black widow spiders.

(Image borrowed with thanks from David Brittons's WWW page)





Pity the male redback spider. . .

- Male redbacks are much smaller than females, and don't live as long (2-4 months for males, 2 years for females).
- A male mating with a female must somersault directly onto the female's jaws.
- The female usually then eats the male as he copulates—a behavior known either as "sexual cannibalism" or "copulatory suicide".

How can this be adaptive?

- Males who are eaten actually have higher fitness!
  - Cannibalism has been shown to decrease the chance that a female will accept mating with another male later.
  - It also boosts the female's nutrition, making her that much better able to lay and care for eggs. . .
  - . . . and copulation goes on longer when the male is being eaten, allowing him to transfer more sperm
  - In the few cases where a male does survive after mating, he never leaves the female's web, never feeds, and eventually dies.
    - Source: M. C. B. Andrade, *Science* 1996

Another fun example: In the pseudoscorpion *Cordylochernes scorpioides*, genetic incompatibility means that not all male-female pairings succeed. Females that made with multiple males have a better chance of producing offspring.