Sex & Sexual Selection

Sexual Selection : when individuals differ in reproductive success either because:

1. of competition within one sex for access to mates and their gametes (*intrasexual selection*), or
2. one sex prefers the gametes received from certain members of the opposite sex (*intersexual selection* or *epigamic selection*).

First we must entertain a few ideas about

The Evolution of Sex

The spectrum of reproductive possibilities:

- •Asexual:
  - •Parthenogenetic (eggs developing without fertilization. Oftern females giving rise to females)
  - •Clonal (quaking aspens)
- •Sexual
  - •Self-fertilization (some dioecious plants) though often there are mechanisms for self-incompatibility or partial self-incompatibility
    - •In genera *Petunia* and *Oenethera*:
      - •Single locus with two alleles
      - •pollen and stigma must differ for the seed to develop
  - •Sex-switching: protandrous or protogynous species/individuals
    - •Order often related to which sex has a greater advantage if they are larger
    - •Reef fishes, plants

The Origin of Sex:
Long ago, given the
Near ubiquity in eukaryotes

The Maintenance of Sexual Distinction

Both of the above present difficult evolutionary problems with several hypotheses for each.

Why is this so?

Asexual Reproduction
advantages:

disadvantages:

Sexual Reproduction
advantages:

disadvantages:

Thus, how did the "longer term" benefits of sex evolve and how are they maintained in the face of short-term benefits to individuals of asexuality?

Males, Females, and Anisogamy

What typically distinguishes males from females?

Yeast, protozoa, some green algae:
Gametes are identical (isogamy)
Different mating types (but not sexes)

Most multicellular organisms:
Female gametes:
Large and few
Energetically expensive
Male gametes:
Small and many
Energetically cheap

Differentiation of gametes is known as anisogamy.

House Wren:
•Egg is >15% of body weight
•Males may have up to 8 billion sperm at any one time

Many mechanisms of:

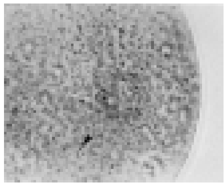
Sexual Determination

Haplo-Diploid (Hymenoptera)
Males haploid, females diploid
Chromosomal/Genetic (i.e. XX or XY)
whether females are heterogametic or homogametic varies across taxa
Environmental Sex Determination
Nutrition
Presence of conspecifics of different sexes
Sex-switching reef fishes
Temperature-dependent (crocodilians)

Also cominations of above. A difficult mess to untangle evolutionarily.

More bizarre: in parasitoid *Nasonia* wasps:

- •"Paternarnal Sex Ratio Factor" a non-chromosomal element that wipes out the paternal chromosomes in a zygote making it male (recall haplo-diploidy)
- •*Wolbachia*: a maternally transmitted, bacterial factor which kills male zygotes, so most of the female's offspring are females.



A *Nasonia* egg that was stained with lacmoid to visualize the *Wolbachia*. The darkly stained dots are the bacteria.

Fisher's Sex Ratio Theory

R.A. Fisher pointed out that in a sexually-reproducing population, every individual has exactly one mother and one father.

With Further assumptions:
- •Random mating
- •Equal cost to producing sons and daughters
- •Heritability of propensity to produce sons or daughters

Sex-ratio should evolve toward 50-50.

However, non-random mating is standard:
- •Positive assortative mating: like mates with like
- •Negative assortative mating (or disassortative mating)
  - •Drosophila and pheromones, the more dissimilar ones were more likely to mate
  - •"Rare male mating" in Drosophila

<u>A different idea</u>:

Operational Sex Ratio: the ratio of sexually receptive males to receptive females in a population at any given time.
- •Typically quite high for reasons of investment in gametes.

Differences in Parental Investment

Robert L. Trivers coined the phrase “parental investment” and made “Triver’s Prediction”

Mate choice should depend on parental investment, i.e.

1. Size and costs of gametes
2. Costs of mating
3. Costs of parental care

For the higher investment sex, choice (intersexual selection) should be more important.

For the lower-investment sex getting more matings should be important

The sex that invests less should be able to tolerate more variation in reproductive success

Trivers’ Predictions in the Field

Some examples

Rick Howard (1983) while a grad student in Michigan.

Spent almost every night at a pond on campus watching marked bullfrogs

- Recorded who mated with whom then watched which eggs hatched
- Female investment higher
- Male variance in reproductive success is 2 to 3 times greater than for females

With High Male Investment: Gwynne (1981) and katydids.

Male passes a spermatophore (up to 27% of body weight of male)to the female

The female also eats the spermatophore

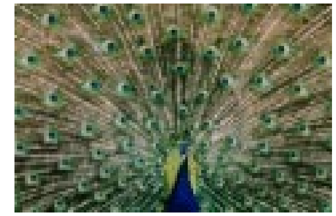
In high density populations

- Males have access to many mates
- Females readily accept the chance to mount

Males preferentially mate with larger (and more fecund) females

A similar example with an Australian katydid species---under low food conditions females fight for access to males

Selection for 2° Sexual Characteristics



Epigamic selection appears to be responsible for the maintenance of some very outrageous traits.

Darwin noted this

Peacock is a classic example

Darwin mused that perhaps this was due to the aesthetic whims of females.

Since then theorists have searched for more plausible/rigorous hypotheses.

Three Broad Hypotheses for Intersexual Selection

(when nuptial gifts are not involved)

Healthy Mate Hypothesis: females choose males that appear to be healthy and so will not transmit disease or parasites to the female’s offspring (a non-genetic explanation)

The Good Genes Theory: females informed by the courtship process choose healthy, well-conditioned mates because they will produce offspring that are more fit. (a genetic explanation)

- The handicap principle is a subset of this

The Runaway Process (Fisher): Starts with some females having genes that make them selective for a particular trait in a male. They will pass these genes on to daughters who will also prefer males with that trait. At the same time, if the trait is heritable, then the existence of females in the population with a preference for that trait will lead to higer reproductive success of the offspring of males with that trait, and things ratchet ahead like that.

Typically the runaway process “imagines” that there was some utilitarian purpose (giving rise to the female preference) for the trait in the first place.

Example:

Perhaps primordial peacocks with slightly longer tails were better foragers

However, more explicit theoretical models of the Runaway Process by Lande and Kirkpatrick suggest

- Needn’t have a utilitarian genesis
- Even *arbitrary* traits that decrease survival may spread through the population by a runaway process

Discriminating Between the Three Hypotheses

Very, very, very difficult:

- Not mutually exclusive
  - Runaway process could start as “good genes”
  - Healthy males that don’t infect their offspring with parasites may also have “good genes”
  - Advanced runaway process leading to handicap principle = “good genes” once again
- Example from peacocks studied by Petrie
  - Current evidence suggests “good genes” maintains male feather trains:
    - Offspring of highly ornamented (HO) males grow faster, and their sons have higher reproductive fitness
    - Peacocks taken by foxes typically have shorter tails and got fewer matings than other males the year before.
  - But, can’t rule out that the feather train traits originated out of “healthy males” or a runaway process (or both).

It’s difficult just demonstrating female choice in peacocks. Petrie et al. (1991)