The Ecology of Sex Part 4: Sex Ratios

Michael Noonan

Biol 417: Evolutionary Ecology

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Review & Overview

Review

Last lecture we covered an important consequence of sexual reproduction, male and female phenotypes.

There is no pure genetic basis for sex, multiple factors can influence sexual phenotypes, and they are nor fixed in time (or even in the same individual), so we define an individual's functional sex based on the gametes that it produces. Small = male, large = female.

Irrespective of the mechanisms, anisogamy and differential investment into gametes has important consequences for the ecology of male and female phenotypes.

Today we'll begin focusing on the ecological and evolutionary consequences of male and female phenotypes.

Sex Ratio ESS

A consequence of anisogamy is male and female phenotypes, which means parents have the option to produce either sons or daughters.

All else being equal the Evolutionary Stable Strategy (ESS) is to invest equally in sons and daughters (Fisher, 1958).

This is the case because, as the sex ratio moves away from 0.5, the rare sex gains fitness (more access to mates under random mating).

... but in the real world all else *is not* equal and most real populations deviate from the 0.5 ESS.

The fact that populations deviate from the ESS is not surprising, the interesting question is ‘Why?’.

Condition Dependent Sex Ratios

Condition dependent fitness

In most species females are the larger sex because female gametes are more expensive to produce.

A corollary is that females in good condition should have greater fitness.

Male gametes are cheap, so male fitness is not expected to correlate strongly with size.

When these conditions hold, female reproductive success is more variable than male reproductive success and mothers in good condition should produce daughters (and vice versa).

Condition dependent fitness cont.

Source: nematodes.org

Petersen *et al.* (1968) introduced nematodes (*Romanomermis culicivorax*) into their mosquito host at different densities.

The nematodes produced more sons when they lived at higher densities and had access to fewer resources.

In all trials, the largest progeny tended to be females.

i.e., resource availability will influence sex ratios.

The Trivers-Willard Hypothesis

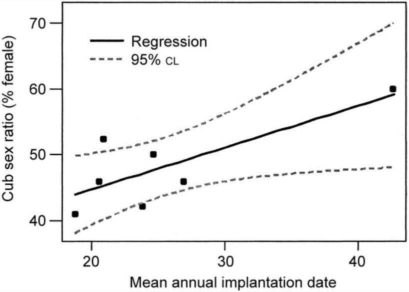
In species where males are the larger sex the opposite trend is expected (e.g., birds and mammals).

Females have good access to mates irrespective of condition, whereas males have to compete for access to females.

When male reproductive success is more variable than female reproductive success, the fitness of a male good condition can exceed that of a female in good condition.

When these conditions hold, mothers in good condition should produce sons and vice versa (Trivers & Willard, 1973).

Condition dependent fitness

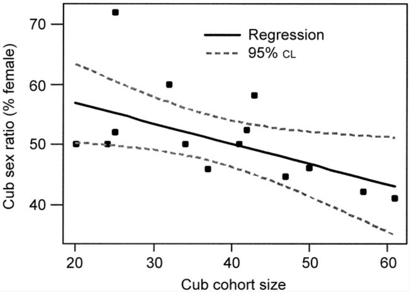


(Dugdale *et al.*, 2003)

Using 15 years of demographic data, Dugdale *et al.* (2003) looked at the relationship between female condition and offspring sex ratio in European badgers (*Meles meles*).

Female badgers in good condition implanted earlier in the year, and produced more sons.

Condition dependent fitness



(Dugdale *et al.*, 2003)

Using 15 years of demographic data, Dugdale *et al.* (2003) looked at the relationship between female condition and offspring sex ratio in European badgers (*Meles meles*).

When the population experienced a good year, more sons were produced.

In bad years daughters were favoured.

i.e., Condition influences sex ratios.

Fertility dependent sex ratio

Source: Wikipedia

In red deer (*Cervus elaphus*) male reproductive success is substantially more variable than female reproductive success Clutton-Brock *et al.* (1982).

What offspring sex should be favoured by individuals in good condition?

Fertility dependent sex ratio

Source: Wikipedia

Gomendio *et al.* (2006) artificially inseminated female red deer (*Cervus elaphus*) with the sperm from multiple males.

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Females were all in good condition.

All were artificially inseminated to eliminate any potential effects of male-female contact.

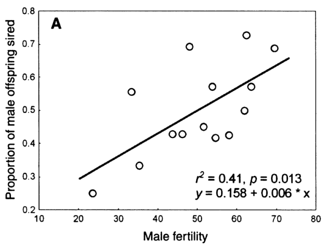
All were inseminated at the same time in relation to their ovulation.

All had unlimited access to food.

Fertility dependent sex ratio

Source: Wikipedia

Gomendio *et al.* (2006) artificially inseminated female red deer (*Cervus elaphus*) with the sperm from multiple males.



(Gomendio *et al.*, 2006)

Male fertility (# of fem. preg./# of fem. insem.) ranged between 24-70%.

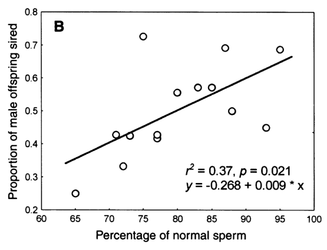
The proportion of male offspring ranged between 25-72%.

There was a strong positive correlation between male fertility and the proportion of male offspring sired.

Fertility dependent sex ratio

Source: Wikipedia

Gomendio *et al.* (2006) artificially inseminated female red deer (*Cervus elaphus*) with the sperm from multiple males.



(Gomendio *et al.*, 2006)

Gomendio *et al.* (2006) also found a positive correlation between the % of normal sperm and the proportion of male offspring sired.

Healthier fitter males produced more sons. i.e., males can also contribute to biasing sex ratios.

Condition Dependent Sex Ratios

When condition affects the fitness of one sex more than the other there should be a correlation between parental condition and offspring sex ratio.

When female fitness is more affected by condition, parents in poor condition should produce males whereas parents in good condition should produce females (occurs frequently in insects, unicellular organisms, etc.).

The opposite is expected when male fitness is more affected by condition (occurs frequently in birds and mammals).

Structure Dependent Sex Ratios

Structure Dependent Sex Ratios

A key assumption of the Fisher sex ratio ESS model is random mating.

In most real systems populations are structured and mating is non-random.

Population structure and non-random mating will have clear influences on sex ratios.

Local Mate competition

If an unoccupied patch is colonised by a pregnant female, her offspring can eventually saturate the patch.

Sons can mate with sisters, so the population growth rate is slowed by the overproduction of males (due to mating competition).

Local mate competition should lead to female biased sex ratios in *unsaturated* environments.

Competition dependent sex ratios

Source: nematodes.org

Petersen *et al.* (1968) introduced nematodes (*Romanomermis culicivorax*) into their mosquito host at different densities.

The nematodes produced more daughters when they lived at low densities and local mate competition was low.

i.e., mate competition will influence sex ratios.

Local resource competition

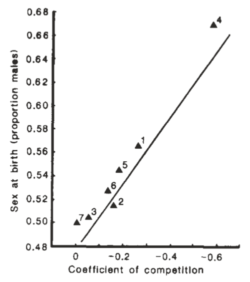
If there is any sex bias in the extent to which members of one sex help/hinder their parents, specific sex ratios can be selected for.

E.g., if one sex is philopatric and the other disperses, local resource abundance and competition will dictate the extent to which philopatric/dispersing offspring are produced.

Local resource competition cont.

(Perry, 2012)

In many species of primates, females settle for life within the home ranges of their mothers, whereas males disperse.



(Johnson, 1988)

Johnson (1988) showed how the intensity of competition for resources within kin groups is strongly and positively correlated with sex ratios.

i.e., local resource competition can contribute to biasing sex ratios.

Sex Ratio Take Home Messages

All else being equal the ESS is to invest equally in sons and daughters (Fisher, 1958)... but in the real world all else *is not* equal and most real populations deviate from 50:50 sex ratios.

When condition affects the fitness of one sex more than the other there should be a correlation between parental condition and offspring sex ratio.

Local competition for mates and resources can influence sex ratios when the offspring of different sexes have a differential contribution to local competition.

Next lecture we'll continue along this line of thinking with a focus on sexual selection.

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