Sex-specific fitness effects

- single-locus model: three fitness parameters for each sex
  - w_{11}, w_{12}, w_{22} (females), v_{11}, v_{12}, v_{22} (males)
- what happens if selection works in opposite directions in the two sexes?
  - stable polymorphism and/or multiple equilibria
- what might be the long-term evolutionary "solution"?
- similar considerations for X-linked genes
  - male allele frequency determined by females in previous generation

Frequency Dependent Selection

- fitness is a function of allele, genotype, or phenotype frequencies
- fitness may either increase (positive frequency dependence) or decrease (negative frequency dependence) with the frequency of a given allele or phenotype

Borer M, van Noort T, Rahier M, Naisbit RE (2010) Positive frequency-dependent selection on warning color in alpine leaf beetles. *Evolution* 64: 3629-3633.

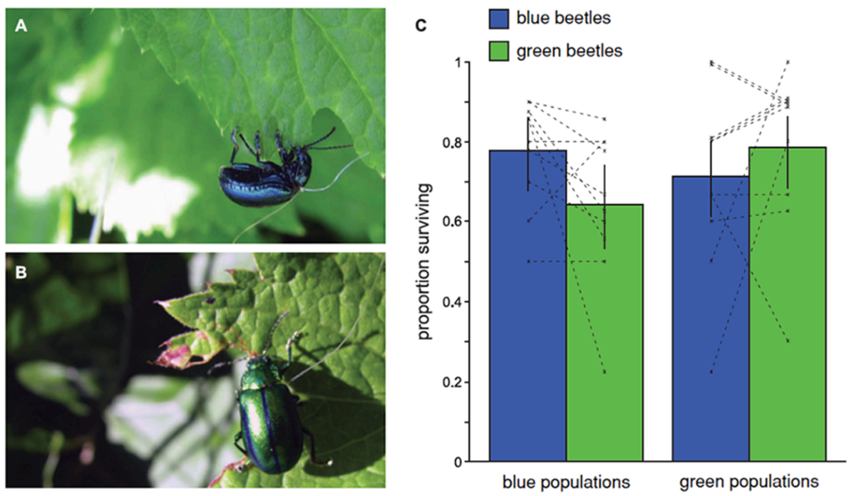


Figure 1. (A) Blue and (B) green *Oreina gloriosa* beetles tethered on fine plastic leashes. Photographs by Tom van Noort. (C) Week-long survival estimates for blue and green beetles at blue- and green-dominated sites (10 replicates for each bar). Error bars show exact binomial (Clopper–Pearson) 95% confidence intervals for survival probability. Crosses and dashed lines indicate the results for each individual site.

Frequency Dependent Selection

- **negative** frequency dependent selection
  - fitness declines as the frequency of a given genotype/phenotype increases
  - why would this be?

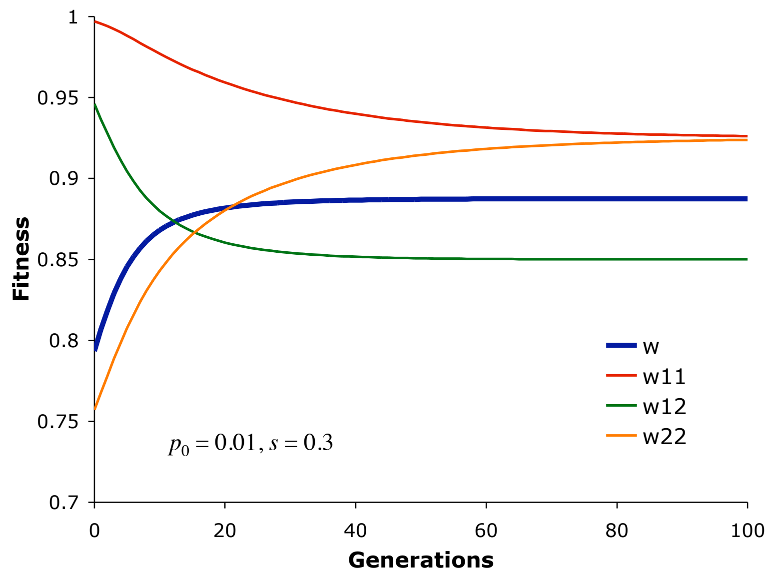
$$AA:\ w_{11} = 1 - s_{AA}p^2$$

$$Aa:\ w_{12} = 1 - s_{Aa}2pq$$

$$aa:\ w_{22} = 1 - s_{aa}q^2$$

assuming $s_{AA} = S_{Aa} = S_{aa}\ldots$

$$\Delta p = \frac{spq(q-p)(p^2 - pq + q^2)}{\overline{w}}$$



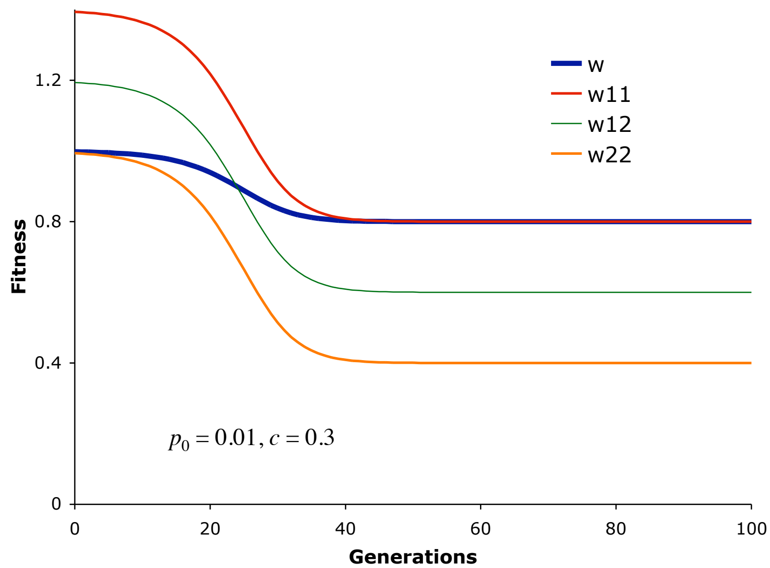
Frequency Dependent Selection

- suppose fitness for all genotypes/phenotypes declines with the frequency of the most fit genotype…
  - why would this be?

$$AA: \; w_{11} = 1.4 - c(2p^2 + 2\text{pq})$$

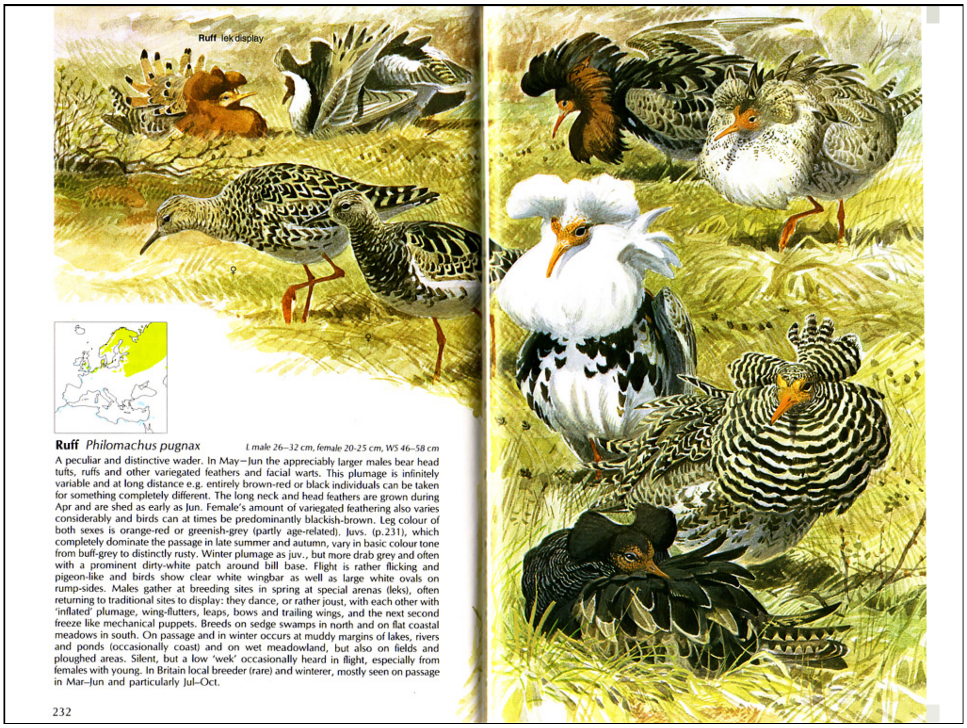
$$Aa: \; w_{12} = 1.2 - c(2p^2 + 2pq)$$

$$aa: \; w_{22} = 1 - c(2p^2 + 2pq)$$



Frequency Dependent Selection

- likely responsible for:
  - extraordinarily high polymorphism in immune system genes (MHC)
  - self-incompatibility genes in plants
  - variation in "personality" traits
- may result in selection **reducing** the mean fitness of the population
  - e.g., 50:50 sex ratio
  - many different kinds of social behavior, whenever individuals are competing for resources …or mates (sexual selection)



Ruff *Philomachus pugnax* *L male 26–32 cm, female 20-25 cm, WS 46–58 cm*

A peculiar and distinctive wader. In May–Jun the appreciably larger males bear head tufts, ruffs and other variegated feathers and facial warts. This plumage is infinitely variable and at long distance e.g. entirely brown-red or black individuals can be taken for something completely different. The long neck and head feathers are grown during Apr and are shed as early as Jun. Female's amount of variegated feathering also varies considerably and birds can at times be predominantly blackish-brown. Leg colour of both sexes is orange-red or greenish-grey (partly age-related). Juvs. (p.231), which completely dominate the passage in late summer and autumn, vary in basic colour tone from buff-grey to distinctly rusty. Winter plumage as juv., but more drab grey and often with a prominent dirty-white patch around bill base. Flight is rather flicking and pigeon-like and birds show clear white wingbar as well as large white ovals on rump-sides. Males gather at breeding sites in spring at special arenas (leks), often returning to traditional sites to display: they dance, or rather joust, with each other with 'inflated' plumage, wing-flutters, leaps, bows and trailing wings, and the next second freeze like mechanical puppets. Breeds on sedge swamps in north and on flat coastal meadows in south. On passage and in winter occurs at muddy margins of lakes, rivers and ponds (occasionally coast) and on wet meadowland, but also on fields and ploughed areas. Silent, but a low 'wek' occasionally heard in flight, especially from females with young. In Britain local breeder (rare) and winterer, mostly seen on passage in Mar–Jun and particularly Jul–Oct.

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Results of crosses are consistent with a single locus genetic model in which the *s* (satellite) allele is dominant but also at low frequency

Hugie DM, Lank DB (1997) The resident's dilemma: a female choice model for the evolution of alternative mating strategies in lekking male ruffs (*Philomachus pugnax*). *Behavioral Ecology* 8:218-225.

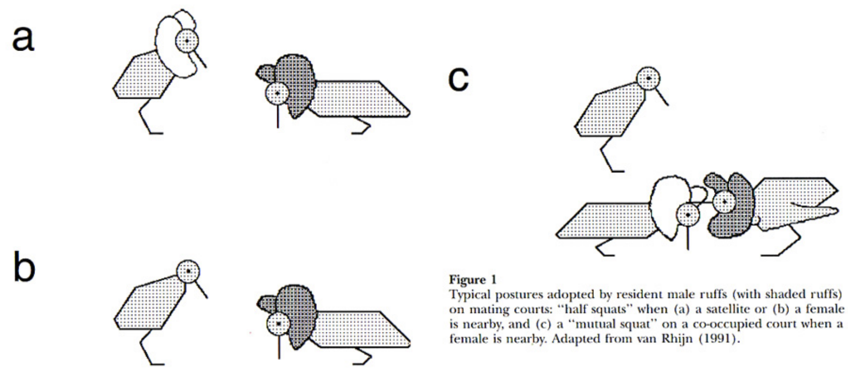

Figure 1
Typical postures adopted by resident male ruffs (with shaded ruffs) on mating courts: "half squats" when (a) a satellite or (b) a female is nearby, and (c) a "mutual squat" on a co-occupied court when a female is nearby. Adapted from van Rhijn (1991).

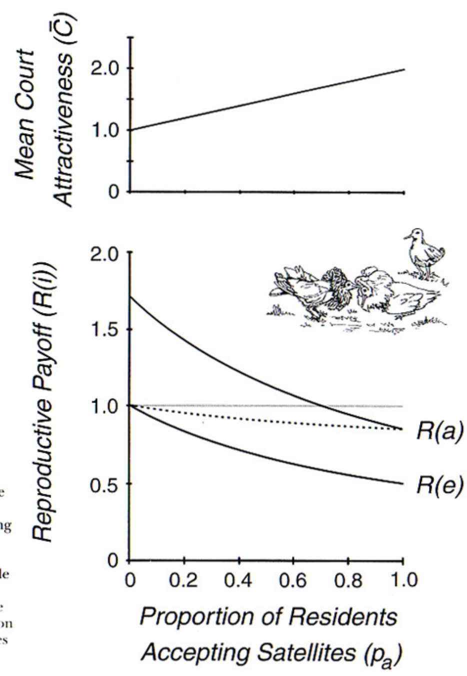

Figure 2
A graphical example of the resident's dilemma model given a constant proportion of satellites (P_s). The bottom panel shows the reproductive payoffs for accepting [$R(a)$] and excluding [$R(e)$] residents as a function of the proportion of the residents accepting satellites (p_a). The mean reproductive payoff of residents ($\bar{R}_r$) is indicated by the dashed line. The vertical axis of this panel is arbitrarily scaled such that the payoff to residents when all exclude satellites (i.e., $p_a = 0$) is 1, indicated by the grey horizontal line. The absolute scale of this axis will depend on the value of P_s. The top panel plots the mean court attractiveness ($\bar{C}$) in the population as a function of the proportion of the residents accepting satellites (p_a). See text for details of parameter values.

Fecundity Selection

- viability selection
  - "hard selection" – fitness is a life or death proposition
- fecundity selection
  - "soft selection" – everyone survives but with differences in reproductive success
  - standard model assumes that fecundity (production of offspring) depends on both genotypes of a mated pair
- outcome of selection depends on details, but fecundity selection often results in fixation and loss of alternative alleles (as in viability selection)

Table 7.4 Fitness values based on the fecundities of mating pairs of male and female genotypes for a diallelic locus along with the expected genotype frequencies in the progeny of each possible male and female mating pair weighted by the fecundity of each mating pair. The frequencies of the AA, Aa, and aa genotypes are represented by *X*, *Y*, and *Z* respectively.

		Fitness value		
Male genotype	**Female genotype . . .**	**AA**	**Aa**	**aa**
AA		f_{11}	f_{12}	f_{13}
Aa		f_{21}	f_{23}	f_{23}
aa		f_{31}	f_{32}	f_{33}

			Expected progeny genotype frequency		
Parental mating	**Fecundity**	**Total frequency**	**AA**	**Aa**	**aa**
AA × AA	f_{11}	X^2	X^2	0	0
AA × Aa	f_{12}	XY	$^1/_2XY$	$^1/_2XY$	0
AA × aa	f_{13}	XZ	0	XZ	0
Aa × AA	f_{21}	YX	$^1/_2YX$	$^1/_2YX$	0
Aa × Aa	f_{22}	Y^2	$Y^2/4$	$(2Y^2)/4$	$Y^2/4$
Aa × aa	f_{23}	YZ	0	$^1/_2YZ$	$^1/_2YZ$
aa × AA	f_{31}	ZX	0	ZX	0
aa × Aa	f_{32}	ZY	0	$^1/_2ZY$	$^1/_2ZY$
aa × aa	f_{33}	Z^2	0	0	Z^2