Breeding System Problems

1. Determine the conditions for invasion of a cosexual population by a **female**-sterility mutation, using the phenotypic fitness with the model below.

Introduction: The phenotypic fitness approach assumes that we can define the fitness of individuals with a given phenotype, *i*, as the fraction of the gametes present among adults of the next generation that are contributed by those individuals, divided by the total number of gametes carried in individuals of this class in the present generation. The mean fitness of the population on this definition is always 1.

To take account of contributions through female and male gametes, denote these by w_i^f and w_i^m, respectively. Either or both of these can be affected by the frequencies of the different phenotypes in the population. Different relations apply to different modes of inheritance, for example:

> **Autosomal inheritance**: there are equal contributions to each zygote from male and female gametes, so that $w_i = ½[w_i^f + w_i^m]$
>
> **Maternal transmission**: $w_i = w_i^f$

Assume that there are three genotypes A_1A_1, A_1A_2, and A_2A_2, but only two phenotypes, 1 and 2, i.e. the number of phenotypes in the system is less than the number of alleles at the locus controlling them.

> **NOTES:** This is a general requirement for this method to give the correct outcomes (i.e. to give results identical with those using the full genetic analysis, following genotype frequencies, and thus allele frequencies, from a parent generation to the adult progeny): Lloyd 1977; Slatkin 1978). In the present case, it corresponds to assuming that either A_2 or A_1 is dominant, with A_1A_1 individuals having phenotype 1, and A_2A_2 individuals phenotype 2. An expression for the change in frequency of A_2 can easily be derived (Charlesworth and Charlesworth 1978), and shows that that the frequency of A_2 and hence of phenotype 2, will increase whenever $w_2 > w_1$ and will decrease when $w_2 < w_1$, and that there is an equilibrium with both phenotypes present when $w_1 = w_2$.

Assumptions

Assume that A_2 is dominant, with only A_1A_1 individuals having phenotype 1 (cosexual), and A_1A_2 and A_2A_2 individuals having phenotype 2 (male).

Cosexuals (phenotype 1) have a selfing rate, *S* (the mixed mating model)

The progeny produced by selfing suffer reduced fitness (inbreeding depression), with a fitness δ relative to the fitness of outcrossed progeny

Males produce 1 + *K* times as much pollen as cosexuals.

QUESTIONS

(i) Females have a higher net fitness than cosexuals if $k > 1 - 2S\delta$. Explain the differences in the result for invasion by males.

(ii) What does this difference predict in biological terms?

2. Apply the phenotypic fitness method to determine the equilibrium frequency of a recessive **male**-sterility mutation, using the same model as for problem 1.

Assumptions

Assume that A_1 is dominant, with A_1A_1 and A_1A_2 individuals having phenotype 1 (cosexual), and only A_2A_2 individuals being female (phenotype 2).

Let the frequency of individuals with phenotype 2 be X.

Females produce $1 + k$ times as many seeds as cosexuals

QUESTIONS

(i) Recessive advantageous mutations are expected to invade a population only if homozygotes appear that express the advantage. Why do we consider a recessive male-sterility mutation in this model, and why might it be able to invade?

(ii) What else has been assumed in addition to the assumptions listed in the question?

(iii) Why can males sometimes invade such a polymorphic population?