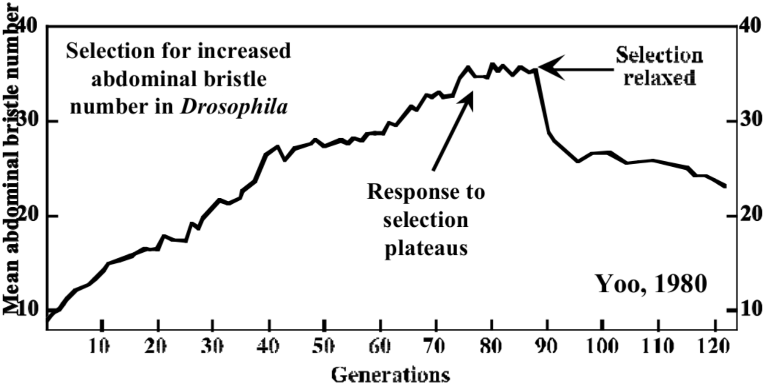
Mutation and migration

Natural selection depends on variation



Mutation and gene flow are sources of new genetic variation, introducing new alleles into a population.

---

[1] Yoo, B. H. (1980). Long-term selection for a quantitative character in large replicate populations of *Drosophila melanogaster*: 1. Response to selection. *Genetics Research*, 35:1-17. [Link]

Mutation-selection balance

A recurrent disadvantageous mutation will evolve to a calculable equilibrial frequency

What are allele frequencies at equilibrium between mutation and selection?

- Selection on a deleterious dominant mutation
- Selection on a deleterious recessive mutation

Mutation-selection balance

What are allele frequencies at equilibrium between mutation and selection?

Deleterious dominant: $p^* = \frac{\mu}{s+\mu} \approx \frac{\mu}{s}$

Deleterious recessive: $q^* = \sqrt{\frac{\mu}{s}}$

In the above, μ is mutation rate and s is selection strength.

Dominant lethal alleles (s = 1) should be rare

If an allele is *lethal*, then $s = 1$.

$$p^* \approx \mu/s$$

Freq. of the allele (p) should equal the mutation rate (μ).

Recessive lethal alleles (s = 1) more frequent

Recessives hide in heterozygotes.

$$q^* \approx \sqrt{\mu / s}$$

- Freq. of the recessive allele (q) equals the square root of mutation rate (μ).
- Note, e.g., $\sqrt{0.001} = 0.032$

Migration (Gene Flow)

Is migration a positive or negative force for adaptive evolution?

Negative effects

- Gene flow homogenises (evens out) gene frequency differences among populations
- May limit natural selection's ability to fine-tune populations to their local environments

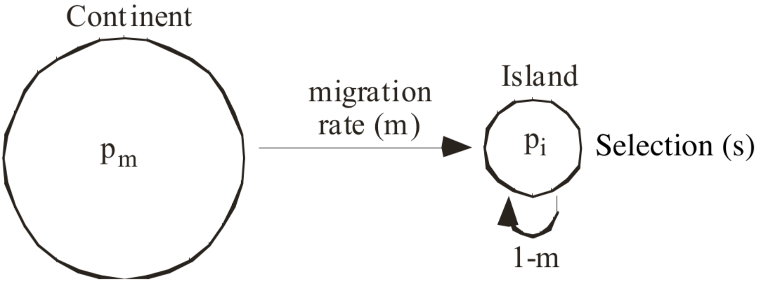
Positive effects

- Spreads around genetic variation for natural selection to work on

Migration-selection balance

- Assume a continent-island model of migration in which migrants into a smaller, 'island' subpopulation can be treated as if originating from a single large, 'continent' population.
- In general, this model applies to any population structure in which the gene frequency of immigrants into a finite target population is constant over time.

Continent-island model of migration



A balance of selection and migration can maintain genetic variation within subpopulations.

Implications of migration-selection balance model

1. If migration is much higher than selection ($m >> s$), then migration is powerful with respect to natural selection and the rate of gain of A alleles by immigration will exceed the rate of loss due to natural selection. In this case, local populations will be 'swamped' by migrants and migration will homogenise (i.e., unify or even out) gene frequencies across subpopulations.

Implications of migration-selection balance model

2. If migration is much lower than selection ($m << s$), then migration is weak relative to the effects of natural selection and the frequency of A in the local population will greatly decrease. In this case, selection will be strong enough to generate regional differences in gene frequencies among populations. That is, the frequency of allele A will be close to zero in the island population even if this allele is favored by selection in surrounding populations.

Implications of migration-selection balance model

3. If migration and selection are about equal ($m \approx s$), then a balance or equilibrium will be reached between the effects of migration (gain) and selection (loss) on gene frequencies. In this case, polymorphism may be maintained within population by migration even though an allele may be locally disadvantageous.

Implications of migration-selection balance model

Migration-selection balance can maintain polymorphism, with migration acting to unify and selection to differentiate gene frequencies among populations.

Migration as a mechanism of evolution

Migration of individuals from the mainland appears to be preventing the divergence of island populations of Lake Erie water snakes (*Nerodia sipedon*)

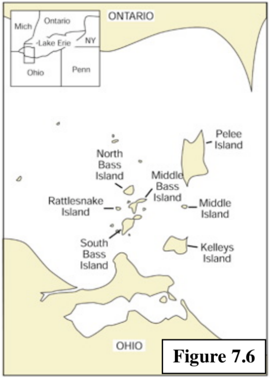


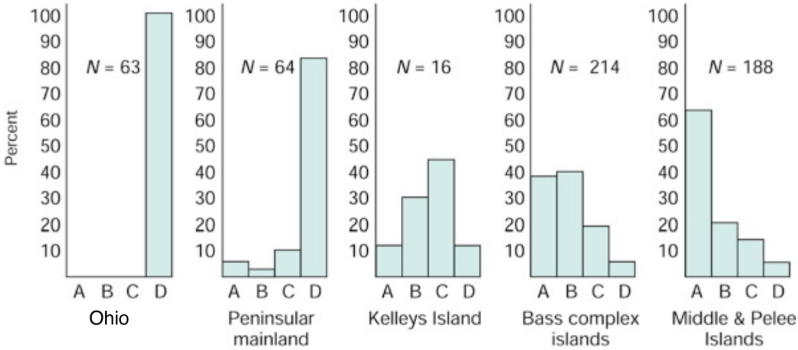
Figure 7.6

[1] King, R. B. (1987). Color pattern polymorphism in the Lake Erie water snake, *Nerodia sipedon insularum*. *Evolution*, 41:241-255. [Link]

[2] Image: Freeman S. & Herron J. C. (2004). *Evolutionary analysis*. Pearson Prentice Hall.

Migration as a mechanism of evolution

On islands, relative fitness of unbanded snakes is 1 while relative fitness of banded snakes is 0.78-0.90.



A: Unbanded, B & C: Intermediate, D: Banded

[1] King, R. B. (1987). Color pattern polymorphism in the Lake Erie water snake, *Nerodia sipedon insularum*. *Evolution*, 41:241-255. [Link]

[2] Image: Freeman S. & Herron J. C. (2004). *Evolutionary analysis*. Pearson Prentice Hall.