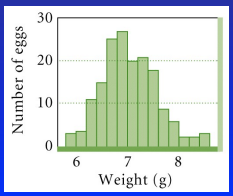
Lecture 18 Selection on Quantitative Traits

- 'Bean Bag Genetics' - phenotype (=shape, in this case) determined by many 'invisible' genes (=beans) plus the environment (the little girl!)

Quantitative Traits

- Traits such as height, weight, speed, photosynthetic rate, allocation of resources, intelligence, risk-taking, etc., are continuously varying quantitative traits

Egg weight in Starlings:

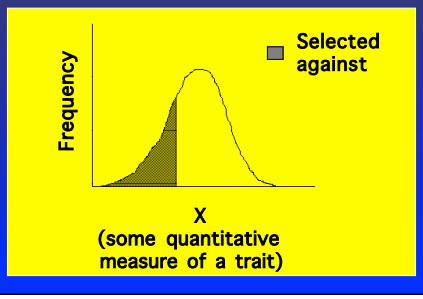


Quantitative Traits

- Quantitative traits are:
  - _____
  - _____
- Can we model evolution with more complex multi-gene models including additive and multiplicative effects of genes?

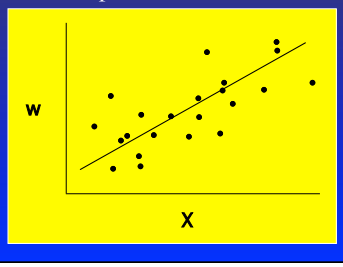
Phenotypic selection

- Directional selection (old-fashioned depiction)



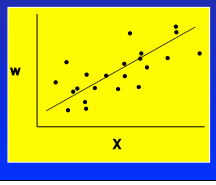
Phenotypic selection

- Directional selection - indicated by linear regression slope ≠ 0.



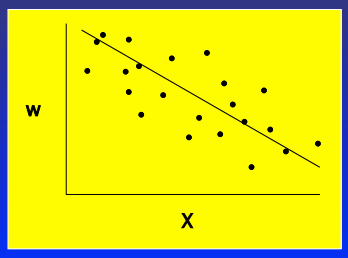
Clicker: Phenotypic selection

- With phenotypic selection as shown below:
- (A) X will evolve to a lower mean
- (B) X will evolve to a higher mean
- (C) X will stay the same
- (D) We cannot determine whether X will increase or decrease



Phenotypic selection

- Directional selection: reverse sign



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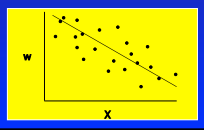


Does phenotypic selection result in evolution?

- We have established:
  - The trait is variable
  - There is an association of the trait with fitness
  - Missing information? Yes.
  - **Is at least part of that variation heritable?**

Heritability

- Phenotypic variation

_____

- In the language of statistics:

Heritability

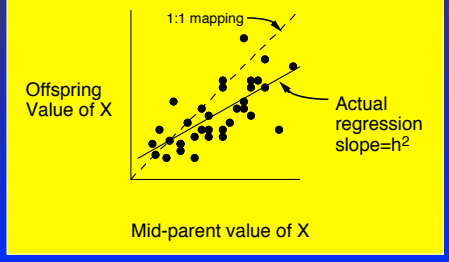
- Heritability is the fraction of phenotypic variance that is genetic variance:

$$h^2 = \frac{V_G}{V_P}$$

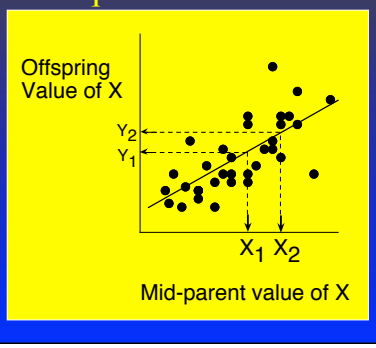
- h^2=0 -> _____
- h^2=1 ->_____

How is heritability determined?

- Parent-offspring regression



Model of selection on quantitative traits

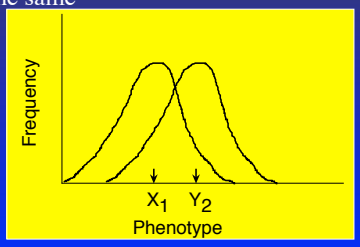


Phenotypic Evolution Model

- How can we predict the 'response' to selection?

Predictions of the Model

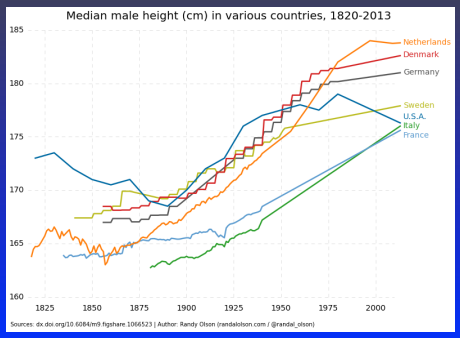
- Shift in phenotypic mean. Variance remains the same



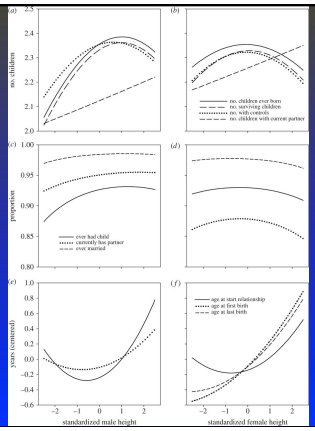
Sample Problem

- A breeder of American bison wishes to increase the mean body mass of his prize bison through artificial selection. The mean mass of his current herd is 500 kg. If he wants to increase this by 10% in one generation, and the heritability of body mass is 0.20, what should be the mean mass of the cows he allows to breed?

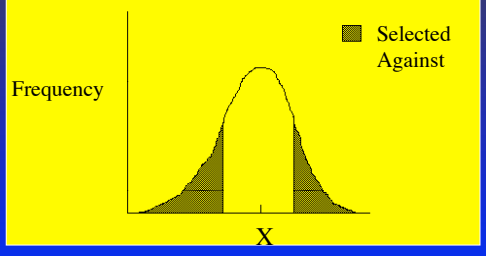
Directional Selection in Humans



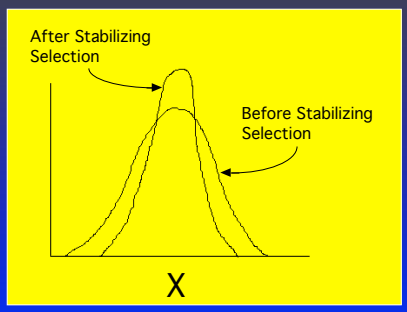
Underlying Evidence



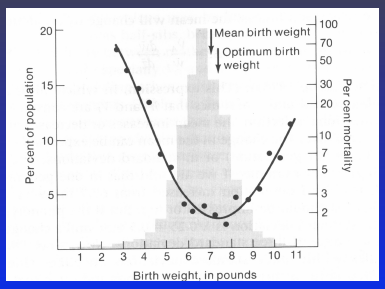
Other Patterns of Selection



Stabilizing Selection

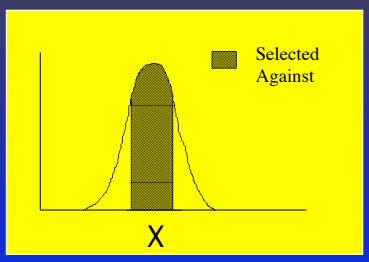


Stabilizing Selection Example

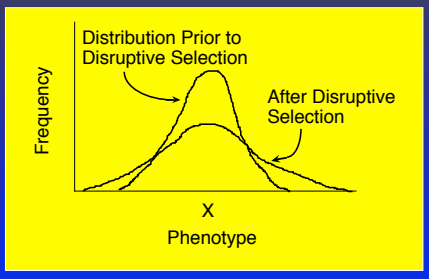


Note: Probably most traits are subject to stabilizing selection
Until the environment changes!

Disruptive selection



Consequences of Disruptive Selection



Cepaea nemoralis

- High level of variation maintained by disruptive selection: mechanism - predation by birds against varying backgrounds

More *Cepaea* pictures

Summary of Selection on Quantitative Traits

- Most traits of ecological interest are quantitative traits, determined by many genes, and influenced by the environment
- Heritability (h^2) is measured by the regression of offspring values (Y) on mid-parent values (X).
- Directional selection quantified by regressing fitness (W) on X.
- Model: $R=h^2S$
- Stabilizing selection: mean X remains the same, variance in X declines
- Disruptive selection: mean X remains the same, variance in X increases

Re-visiting Darwin's theory

- If a population is phenotypically variable…
- If at least some of this variation is heritable…
- If the phenotypic variation affects fitness…
- Then a population will evolve.

- ***Each assertion has a counterpart in the evolutionary model for quantitative traits***

Summary of Selection on Quantitative Traits

- Most traits of ecological interest are quantitative traits, determined by many genes, and influenced by the environment
- Directional selection can be modeled simply, as an extension of a statistical regression analysis ($R=h^2S$)
- Stabilizing selection: mean X remains the same, variance in X declines
- Disruptive selection: mean X remains the same, variance in X increases

Does Selection Lead to New Species?

- Darwin's arguments:
  - 1. Variation under domestication (i.e., artificial selection as an analogue of natural selection)
  - 2. Natural variation among varieties within species grades into species differences (i.e., ecotypes are common)
  - 3. Consistencies in the fossil record (i.e., primitive to advanced forms in progressively younger strata)
  - 4. Patterns of geographic variation among species on islands are consistent with evolution by natural selection (microevolution on islands is likely)