

Darwinian Natural Selection

Chapter 3.

Charles Darwin, 1809-1882

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3.1 ARTIFICIAL SELECTION

1. Plant and animal breeders employ artificial selection.
2. Darwin studied the mechanism of evolution under domestication.
3. Identification of alleles responsible for traits selected by breeders
 - A. Fig. 3.1 Wild and domestic tomatoes
 - B. Figure 3.2 A genetically determined difference in fruit size
4. Fig 3.3 Domestic and wild varieties of *Brassica oleracea*

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3.2 EVOLUTION BY NATURAL SELECTION

DARWIN'S FOUR POSTULATES

1. Individuals within populations vary
2. Some of these variations are passed on to offspring
3. In every generation some individuals are more successful in surviving or reproducing than others.
4. Survival and reproduction are not random. Individuals with the most favorable variations are more likely to survive and reproduce.

- Natural selection produces descent with modification
- Example packrats eating milder chilies (Fig. 3.4)

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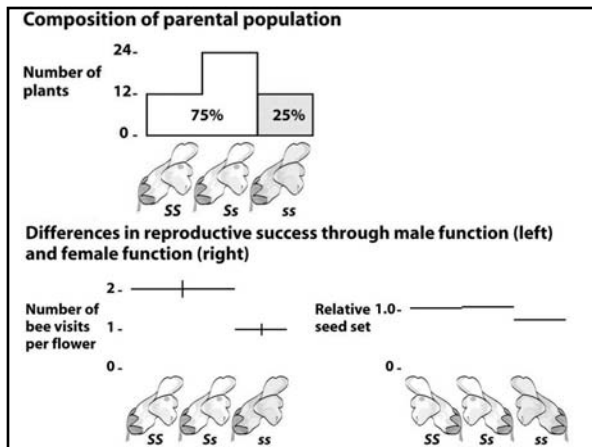
1. Darwinian fitness: ability to survive and reproduce in a particular environment
2. adaptation: a trait that increases the fitness of an individual.

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3.3 THE EVOLUTION OF FLOWER COLOR IN AN EXPERIMENTAL SNAPDRAGON POPULATION

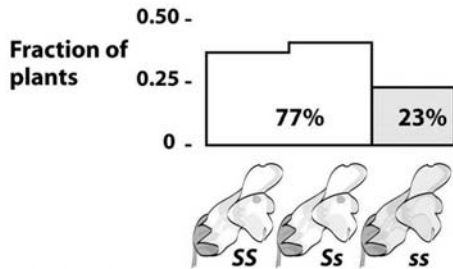
1. Could natural selection by bumblebees control the evolution of a floral trait controlled by alleles of a single gene? (Fig. 3.5)
2. Postulate 1: There is variation among individuals
3. Postulate 2: Some of the variation is heritable.
4. Testing Postulates 3 and 4: Do individuals vary in their success at surviving and reproducing? Is reproduction nonrandom?

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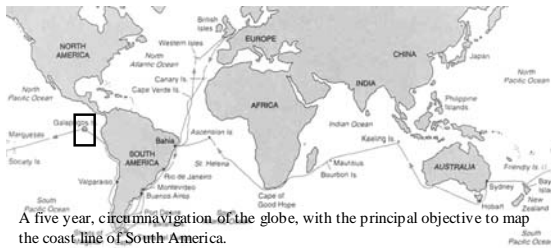


Testing Darwin's Prediction: Did the populations evolve?

Composition of offspring population



Charles Darwin and the Voyage of the Beagle, 1831-1836



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Voyage of the Beagle

1. fossils of Patagonia:
 - A. Principle of succession
 - B. descent with modification
2. fauna of Galapagos Islands
 - A. divergence in isolation
3. origin of coral atolls
 - A. time

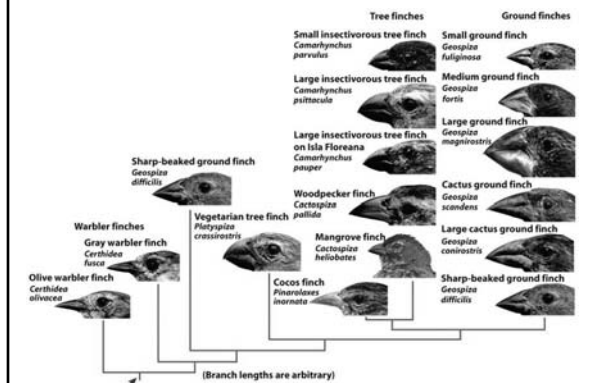
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3.4 THE EVOLUTION OF BEAK SHAPE IN GALAPAGOS FINCHES

1. 13 species of Galapagos and one Cocos finches [Fig. 3.6].
2. Peter Grant and Rosemary Grant
3. *Geospiza fortis* (the medium ground finch) on Daphne Major is a seed eater.
4. Beaks are tools
5. Size and shape correlates with seed size.
6. Size and shape of the beak has an important consequence for fitness.
7. Natural selection

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Fig. 3.6 Phylogeny of the 14 species of Galápagos finches



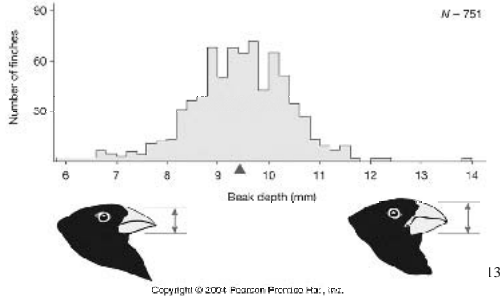
Test of Four Postulates on *Geospiza fortis* from the island of Daphne Major

1. Testing Postulate 1: Are Populations Variable?
2. Testing Postulate 2: Is Some of the Variation Among Individuals Heritable?
3. Testing Postulate 3: Is There an Excess of Offspring So That Only Some Individuals Survive?
4. Testing Postulate 4: Are Survival and Reproduction Nonrandom?

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Testing Postulate 1: Are Populations Variable?

1. 1976 beak measurements form a bell shaped curve [Fig. 3.6].

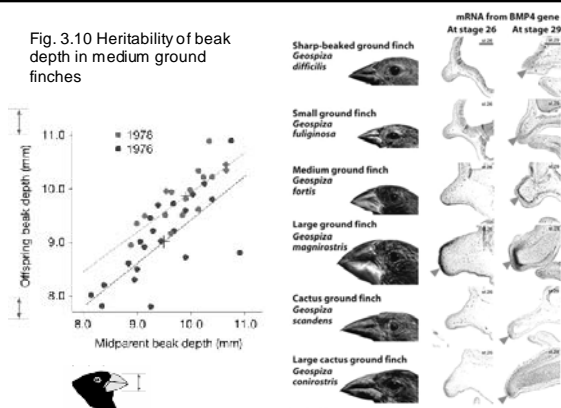


Testing Postulate 2: Is Some of the Variation Among Individuals Heritable?

1. Is the variation caused by environment or genetics?
2. Heritability of beak depth in *Geospiza fortis* [Fig. 3.10].
3. Issues that complicate how heritabilities are measured [Box 3.1].
4. Fig 3.11 Genetic basis for beak development in Darwin's finches
 - A. Ground finches with larger beaks make BMP4 mRNA earlier and in larger quantities

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Fig. 3.10 Heritability of beak depth in medium ground finches



Testing Postulate 3: Do individuals vary in their success of surviving or reproducing?

1. A drought in 1977 produced a dramatic selection event [Fig. 3.12].

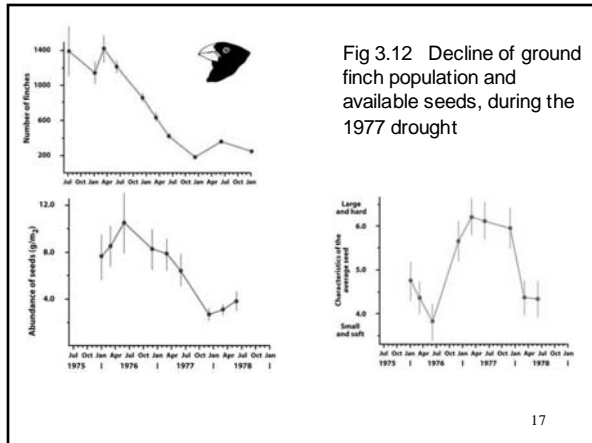
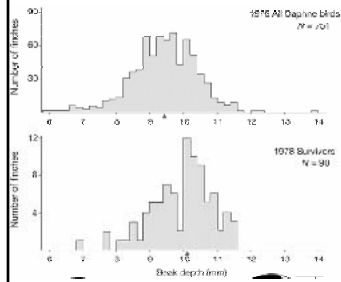


Table 3.1

1. Even in normal times, 89% of *Geospiza conirostris* die before breeding.
2. Thomas Malthus
3. In stable populations, each parent leaves on average of one offspring in spite of astonishing reproductive capacity (biotic potential)

Testing Postulate 4: Are Survival and Reproduction Nonrandom?



1. Fig 3.9 Beak depth before and after natural selection
2. Change in average beak depth is correlated to change in seed hardness

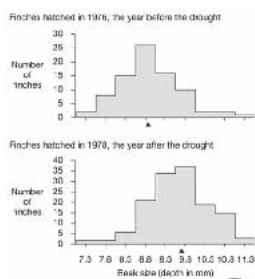
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Testing Darwin's Prediction: Did the population Evolve?

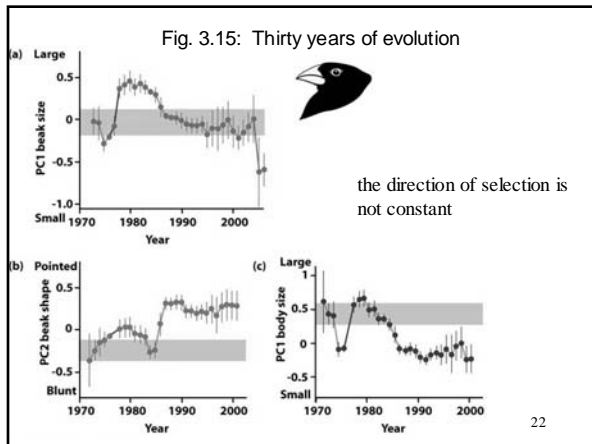
1. The drought caused the finch population to evolve.
2. Selection occurs within generations.
3. Evolution occurs between generations.
4. Evolution involves populations.

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Fig 3.10: Finch beak depth in hatchlings the year before and the year after the drought.



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3.5 THE NATURE OF NATURAL SELECTION

1. Natural Selection Acts on Individuals, but Its Consequences Occur in Populations
 - A. individuals and their genes are not modified
 - B. Natural selection changes the characteristics of populations
 - C. E.g., HIV or Finches (Fig. 3.16)

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THE NATURE OF NATURAL SELECTION, 2

2. Natural Selection Acts on Phenotypes, but Evolution Consists of Changes in Gene Frequencies
 - A. unless the genotype frequency changes there is no evolution (Fig. 3.17)

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Nature of Natural Selection, 3

3. Natural Selection is Not Forward Looking

- A. each generation is the result of selection on the previous generation.
- B. It cannot predict the future

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Nature of Natural Selection, 4

1. New Traits Can Evolve, Even Though Natural Selection Acts on Existing Traits.

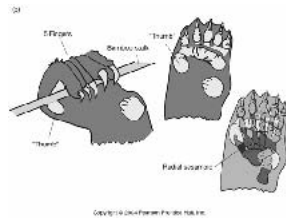
- A. selection works on variation already present.
- B. Fig. 3.18. Tripling the oil content in corn by artificial selection over 60 generations



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Fig. 3.13 -- The panda's thumb

- 1. selection can lead to new characteristics by changing functions of preexisting traits, genes, etc.
- 2. preadaptations, exaption



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5 Natural Selection is Not Perfect

1. *Geospiza fortis* with narrow bills were also favored; can better concentrate forces.
 - A. body size, bill depth, and bill width are all controlled by the same genes and correlate with each other
 - B. selection for large bills results in larger body size and wider bills, even if narrower bills should have been favored
2. Mosquito fish gonopodia (Fig. 3.20)

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6 Natural Selection is Nonrandom, but It is not Progressive

1. selection is not teleological,
 - A. but it does increase adaptation to the environment.
2. evolution has tended to increase complexity, but some organisms have changed very little (e.g., bacteria) or become less complex (e.g., tape worms).
3. all life has evolved for the same amount of time, not higher or lower organism

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7 Fitness is Not Circular

1. fitness is testable, not a tautology
2. research can determine why certain nonrandom groups are favored
3. fitness can be measured

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8 Natural Selection Act on Individuals, Not for the Good of the Species

1. altruism does not occur in nature.
2. behavior maximizes individual fitness

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3.4 THE EVOLUTION OF DARWINISM

1. Three serious problems with Darwin's original proposals.
 - A. Darwin was unaware of mutation, and did not give a correct interpretation of the source of variation.
 - B. Darwin did not know the nature of heredity
 - a. blending inheritance.
 - b. traits which appear to show blending are controlled by many genes and can be subject to selection [Fig. 3.21]
 - c. Darwin adopted Lamarckian explanations
 - C. Kelvin determined that the earth was 30 million years old
 - a. calculations did not take radioactivity into account

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The Modern Synthesis

1. variation is created by mutation and recombination
2. genes are passed on independent of other genes
3. excess reproductive capacity and competition for resources
4. individuals with advantageous alleles survive and reproduce.

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3.7 THE DEBATE OVER "SCIENTIFIC" CREATIONISM

1. History of the Controversy

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Perfection and Complexity in Nature

1. Natural theology versus the blind watchmaker
 - A. Argument from Design
2. A complex, highly-integrated structure can evolve through small changes.
 - A. Fig. 3.15 Variation in mollusk eyes

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Irreducible Complexity

1. Creationists.
2. Intelligent design.
3. Argument from incredulity

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