

Darwin's Finches

- Colonized Galapagos Islands about 2 million years ago
- Lots of resources, few other species present
- Diversified and filled different feeding niches

Even a 'vampire' finch!

small ground finch <i>Geospiza fuliginosa</i>	medium ground finch <i>Geospiza fortis</i>	large ground finch <i>Geospiza magnirostris</i>
cactus finch <i>Geospiza scandens</i>	large cactus finch <i>Geospiza conirostris</i>	large cactus finch <i>Geospiza stricklandi</i>
sharp-beaked ground finch <i>Geospiza stricklandi</i>	small tree finch <i>Camarhynchus parvulus</i>	large tree finch <i>Camarhynchus parvulus</i>
woodpecker finch <i>Certhidea fuscescens</i>	vegetarian finch <i>Parusina inornata</i>	warbler finch <i>Certhia olivacea</i>

Adaptive radiation

Original Colonizer

Resource

No Competition

Little Competition

Strong Competition

Species A, Species B, Species C

High Fitness, Medium Fitness, Low Fitness

An isolated population diverges to become larger, and eventually becomes a new species, then encounters the original species

Another species enters or colonizes

<http://www.bellarmine.edu/learn/RootWeb/Competitor04.pdf>

Evidence for character displacement in beak size in populations of the Galapagos finches *Geospiza fortis* and *G. fuliginosa*.

Allopatric (alone)

Sympatric (together)

Allopatric (alone)

Beak size distributions for *G. fortis* on Daphne Major. Compared to the population on Daphne Major, the beaks of *G. fortis* are significantly larger on the island of Santa Cruz, where it is sympatric with *G. fuliginosa*.

Beak size distributions for sympatric populations of *G. fortis* and *G. fuliginosa* on Santa Cruz island. Similarly, compared to the population on Los Hermanos, the beaks of *G. fuliginosa* are significantly smaller on Santa Cruz, where it is sympatric with *G. fortis*.

Beak size distribution for *G. fuliginosa* on Los Hermanos.

Character Displacement

- "Divergence of two otherwise similar species when together (sympatric), because of competition between them"
 - Evolutionary change - reduces niche overlap
 - Phenotypes that experience less competition will be more successful
- Experiments are necessary in study of competition
- Book has other requirements needed to demonstrate character displacement

Muddy Points about the Lotka Volterra Competition Equations

- General Discomfort and Confusion (12)
- General (8)
- Coefficients (8)
- Isoclines (17)

Competition Equations

Gray Squirrel (*Sciurus carolinensis*)

Fox Squirrel (*Sciurus niger*)

- Modeling Interspecific Competition
- Begin with the intraspecific competition model
 - Logistic model

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

Competition equations (contd.)

- Who are the Competitors?
 - Intraspecific Model
 - All individuals of a spp. are considered competitors
 - N = # of competitors
 - Interspecific model
 - Still N intraspecific competitors: N_1
 - Also some interspecific competitors: N_2
 - Most obvious thing to do is:

$$\frac{dN_1}{dt} = r_1 N_1 \left(1 - \frac{N_1 + N_2}{K_1}\right)$$

WRONG!!!

- must "weight" interspecific competitors by their relative competitiveness
- a_{12} = effect ON species 1 OF species 2

Coefficient of Competition

- How do Interspecific Competitors Compare to Intraspecific Competitors?
- Coefficient of competition ($a_{ij} \approx a_{12}$)
 - Effect of each individual of the other species (Interspecific) relative to an individual of the same species (Intraspecific)
 - $a_{ij} = 1$: interspecific = intraspecific
 - $a_{ij} > 1$: interspecific > intraspecific
 - $a_{ij} < 1$: interspecific < intraspecific
 - $a_{ij} = 0$: No competition
 - no effect on species i of species j
 - no niche overlap (no shared resource)

Putting Competition into the Model

$$\frac{dN_1}{dt} = r_1 N_1 \left(1 - \frac{N_1}{K_1} - \text{competition}\right)$$

- Add competition to the basic logistic model
- Competitors should decrease the population growth rate, so the competitive effect is subtracted

Putting Competition into the Model

- Competitive effects should increase when:
 - There are more competitors (N_2)
 - The effect of each competitor (a_{ij}) is strong

- Total Effect on Species 1 of Species 2 = $\frac{a_{12}N_2}{K_1}$

- (K_1 lets this reflect the number of species 1 individuals that would have an equivalent impact on resource availability)

Competition Equation (the 'Lotka-Volterra Model')

Species 1 Intraspecific competition (Logistic) Interspecific Competition

$$\frac{dN_1}{dt} = r_1 N_1 \left(1 - \frac{N_1}{K_1} - \frac{a_{12}N_2}{K_1}\right)$$

Species 2

$$\frac{dN_2}{dt} = r_2 N_2 \left(1 - \frac{N_2}{K_2} - \frac{a_{21}N_1}{K_2}\right)$$


What does this mean?

$$\frac{dN_1}{dt} = r_1 N_1 \left(1 - \frac{N_1}{K_1} - \frac{a_{12}N_2}{K_1}\right)$$

- Species 1 grows slower with competitors because competitors use resources
- Example:
 - $a_{12}=0.5$, $N_2=20$, $K_1=100$
 - 20 individuals of species 2 has the same effect on species 1 as having 10 individuals of Species 1

Model Behavior

- What does this model say about coexistence?
 - Both species must reach a stable size >0
 - That will occur when $\hat{N}_1 = \frac{K_1 - a_{12}K_2}{1 - a_{12}a_{21}}$
- One thing for sure, this means that:


 $a_{12}a_{21} < 1$

Equilibrium

$$a_{12}a_{21} < 1$$

$$a_{ij}a_{ji} < 1$$

- What does this condition mean?
 - Coexistence is possible only if interspecific competition is weaker than intraspecific competition ($a_{12}a_{21} < 1$)
 - "Limited more by your own species than by the other"
 - Stable coexistence is more difficult. That requires:
 - $K_2/a_{21} > K_1$
and
 - $K_1/a_{12} > K_2$

$$\hat{N}_1 = \frac{K_1 - a_{12}K_2}{1 - a_{12}a_{21}}$$

Isoclines – making sense of those ugly conditions for coexistence

- There is an equilibrium when neither population grows:
 - $dN_1/dt = dN_2/dt = 0$
- This happens when:
 - $N_1 = -a_{12}N_2 + K_1$
 - $N_2 = -a_{21}N_1 + K_2$
- These are equations for lines
 - "Zero net growth isoclines" = ZNGI
 - Combinations of N_1 and N_2 that stop population growth for each species (by utilizing all available resources)

