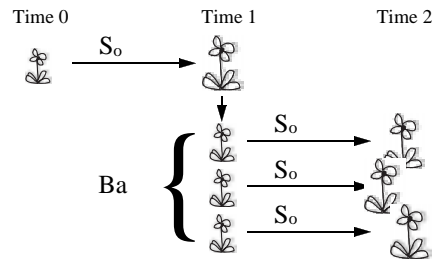
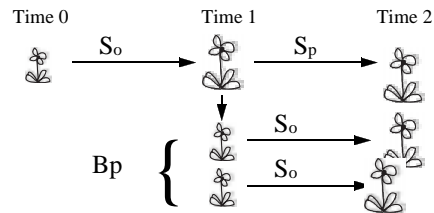


Annual vs. Perennial

Annual Life History



Perennial Life History



Broad Patterns of Plant Life Histories

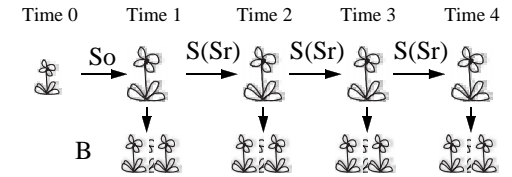


Desert floras dominated by annual plants---> Few adults can survive the dry seasons, but seedlings are seldom space limited and may grow well (low S_p/S_o ratio)

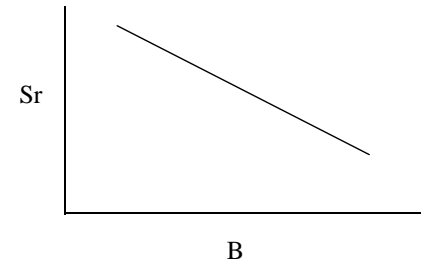


Tropical rain forest zones: seedling survival is low due to competition for space and light from other plants. Mostly perennials. (High S_p/S_o ratio.)

Reproductive Life-span vs reproductive investment



Assume a negative relationship between S_r and B



Semelparity vs. Iteroparity

Salmon survival schedule:

- egg to fry: abysmal!
- fry to smolt: lousy!
- smolt to adult: poor
- pre-reproductive adult: much better



So, why not have a more "perennial life history?"

- Hypothesis: massive expenditure on reproduction.

Agave:

Semelparous reproduction
Hypothesis: environmental conditions seldom suitable for seedling survival.



Many broad predictions, but with greater detail things become much more complicated...

Semelparity versus Iteroparity in Scarlet gilia

Paige and Whitman 1987

Ipomopsis aggregata in Arizona typically exhibits a semelparous pattern, but is facultatively iteroparous, depending on the environmental conditions!

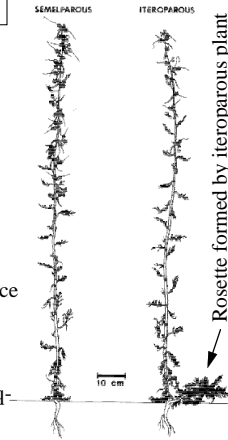
genotype $\xrightarrow{\text{environment}}$ phenotype

Three Manipulations:

1. Pollinator exclusions
2. Flower chopping
3. Herbivory simulation

Results:

- 1 and 2 increased incidence of rosette production 5 to 7-fold
- 3 did not increase the frequency of iteroparity.



Scarlet gilia



Phenotypic Plasticity

Some terms and defns

Canalization: one genotype produces a single phenotype, regardless of environment

Phenotypic plasticity: a general term covering all types of environmentally induced phenotypic variation

Polyphenism: a type of phenotypic plasticity in which the change is between two or more *discrete* phenotypes:

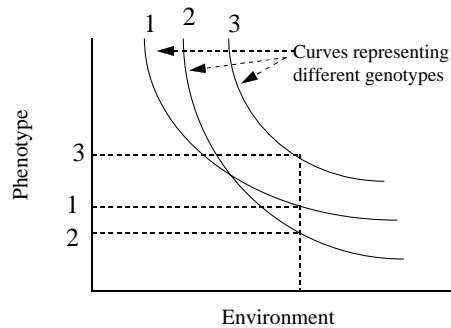
- environmental sex determination
- castes of social insects
- locust behavior (isolated/sedentary vs. gregarious)
- semelparity or iteroparity in *Gilia*

Reaction norm: the continuous relationship between a trait changing due to phenotypic plasticity, and some feature of the environment.

“A mirror that reflects environmental effects into phenotypes”

With all this phenotypic plasticity, how can natural selection “grab onto” different genotypes?

Reaction Norms



G x E interaction: when reaction norms for different genotypes cross

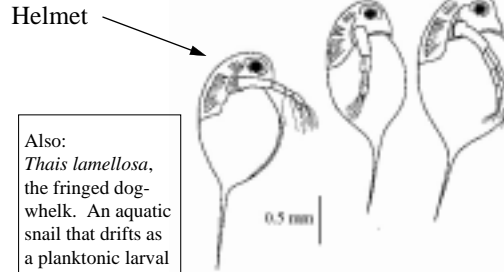
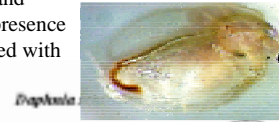
- Expected to be pervasive (Stearns 1989)
- Are commonly observed
- Due to trade-offs?

The reaction norm itself is under genetic control!

This is how natural selection can “grab” the genotype, even in the presence of phenotypic plasticity

Predator Induced Phenotypic Plasticity

Daphnia grow thicker and spinier helmets in the presence of compounds associated with their predators



Also:
Thais lamellosa, the fringed dogwhelk. An aquatic snail that drifts as a planktonic larval veliger. If it “lands” in an area with *Cancer productus* (a crab predator) it develops a thicker shell.



Prey-induced plasticity

Cichlid fishes fed different diets developed different jaw morphologies. These changes were reversible. (Meyer 1987)



Grasshopper mandible morphology changes in response to diet.
• Soft leaves versus hard leaves
• Having the right mandibles makes a difference in energy accumulation. (Thompson 1988)

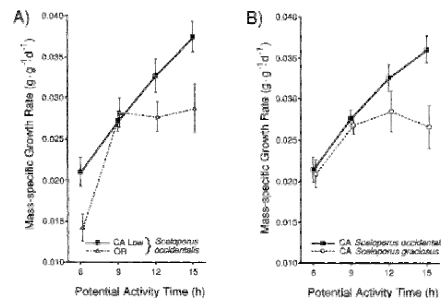
Comparative Study of Reaction Norms in Lizards

2 lizard species

Sinervo & Adolph 1994

Sceloporus occidentalis
Sceloporus graciosus

- Taken from three different elevations (low, med, high) in CA and one population from OR.
- High elevation/latitude populations have fewer active hours
 - Activity = body temp high enough for growth to occur
- Hatchlings raised in 4 expmtal condns: 6, 9, 12, and 15 hours of potential activity time. (Incandescent light bulb)
- Results: 1) Short-day specialists (high altitude/latitude lizards) growth rate did not increase with >9 hr of potential activity
 - 2) Lower elevation lizards could capitalize on longer potential activity days in the laboratory
 - 3) Among family variation in reaction norms
 - 4) Family x treatment interaction-->G x E interaction



Evolutionary Theories of Aging and Senescence

Some observations:

Raised under **good** conditions with **no predation risk**:

- Birds typically live longer than mammals
- Bats typically live longer than terrestrial rodents
- Flightless birds live shorter than flying birds
- Thick-shelled bivalves live longer than other molluscs
- Tortoises live longer than other reptiles

Interesting Features:

- Death occurs, eventually with certainty
- Ideal-condition lifetimes vary greatly across taxa

An Early Explanation for “Programmed Death” (by Wallace)

“...when one or more individuals have provided a sufficient number of successors they themselves, as consumers of nourishment in a constantly increasing degree, are an injury to those successors. Natural selection therefore weeds them out, and in many cases favours such races as die almost immediately after they have left successors” (quoted in Rose 1991).

Senescence

- If you survive to a ripe old age:
 - Shouldn't your extra experience increase your probability of survival into the future?
- Maybe so, but it doesn't work that way.
- Senescence** = greater susceptibility to injuries, disease, and death as one grows older
 - Neural degeneration
 - Reduction in kidney filtration
 - Decreased respiratory capacity, etc

Environmental (proximate) causes

- Sure, but senescence is still inevitable, it seems

An evolutionary/genetic explanation: Medawar (1946)
"What is important from our point of view is that the contribution which each age-class makes to the ancestry of the future decreases with age"

The key is reduced selection on older age classes. This could lead to senescence by two mechanisms:

- 1) antagonistic pleiotropy
- 2) accumulation of late-acting mutations

A 5-Minute Review

Evolutionary Ecology covers themes from many different disciplines (which overlap themselves). Notably:

Evolution:

- Quantitative genetics, natural selection, sexual selection, phenotypic plasticity, kin-selection, life-history theory

Behavioral Ecology:

- Foraging theory, signalling, and reproductive behavior

Sociobiology

- Kin-selection, mating systems, territoriality

We've encountered four main methods for interpreting variation in strategies in an evolutionary context:

1. Optimality modeling (optimization ideas are ubiquitous in the field)
 - Most notable in Optimal Foraging Theory, but elements of it appear everywhere
2. Game theoretic perspective (ESS's)
3. Comparative method
4. Population/Quantitative genetic perspectives

Antagonistic Pleiotropy

Basic Premise: "Senescence later in life is the price of youthful vigor."

pleiotropy = when one gene affects two or more traits

Williams (1957) "Selection of a gene that confers an advantage at one age and a disadvantage at another will depend not only on the magnitudes of the effects themselves, but also on the times of the effects. An advantage during the period of maximum reproductive probability would increase the total reproductive probability more than a proportionately similar disadvantage later on would decrease it."

Experimental Evidence:

- Quantitative genetic correlations between early fecundity and longevity (sib analysis, line crosses)
- Mendelian inherited, pleiotropically acting mutations:
 - C. elegans* age-1 mutant (Friedman and Johnson 1988)
 - D. subobscura* grandchildless mutation---female offspring have much longer lifespan, but no ovaries!

Regarding the Exam

- Covers everything from the first day of class.
- It will be closed book, closed notes, closed handouts, etc.
- Readings versus lectures:
 - You are expected to have done the readings, but won't be asked questions of exasperating detail from them.

The readings have been of two types:

1) "textbook" type readings---sections of texts or edited volumes that describe general themes or methodologies. Typically in my lectures I have covered the aspects of those readings that I find most important and relevant. The lectures are a good indication of which parts of those readings to focus on. These readings serve to supplement lectures. Also, if it was a reading that you discussed in section, you should be quite comfortable with its general content.

2) research articles---we've read quite a few of these. It's good to read these to get a sense of how research in evolutionary ecology is done and how its results are transmitted. Some of the articles were not discussed in lecture. Nonetheless for each article you should be able to tell me:

- (a) which of the general topics we have covered it is relevant to
- (b) the hypotheses that the authors were trying to test
- (c) the general methods---for example whether it was an observational study or a manipulation, what animals were studied, and what variables were observed
- (d) the general results; especially how the results relate to the general theory that the study is relevant to

You should pay particular attention to those articles about which I talked at length in lecture.

Mutation Accumulation

Basic Premise: new, deleterious mutations build up in the genome. Such early-acting mutations are weeded out by selection, but late-acting ones basically fill a "genomic garbage can" that never really gets emptied.

Experimental Evidence: Difficult to come by. Some *Drosophila* selection studies show accumulation of deleterious alleles without a concomitant change in early life reproductive fitness.

Overall, it is very difficult to distinguish between antagonistic pleiotropy and accumulation of late-acting, deleterious mutations.

Much research directed in the area of evolution of senescence, however, due in part to the medical interest in the subject.

Phylogenetic relations between adult mortality rate and life-span under "ideal conditions"

Regarding the lecture notes:

- A good resource for studying
- Note: some of the titles and the bottoms of the slides might get chopped off by some printers. You may want to add those back in pen (everything appears correctly on screen in Acrobat Reader)
- The lectures often contain material that won't be found in the required readings

- One study strategy: be able to tell the story behind each of the pictures in the lecture notes. The examples make the theory come alive a bit more. Have fun while studying---tell your friends about the natural history items you've learned; tell your significant other about the American burying beetle, etc.