Life History Evolution

BIO/BOT 160

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Adapted from Dr. Scott Shaffer's slides

Learning objectives

- Students should be able to
  - Define the term “life history”
  - Explain the relationship between life tables and life history evolution
  - Explain what it means for species to *r* or *K* selected and the weaknesses of this approach
  - Apply the concept of “optimal demography” to life history traits/strategies, such as
    - Optimal clutch size
    - Age at maturity

Life history

- An organism's *life history* is the series of events that relate to its growth, development, reproduction, and survival
- We may characterize life histories at the population level or individual level
- We may suppose that a species' life history is *optimal*, and then ask why these patterns may have evolved

What does natural selection tell us about life history traits?

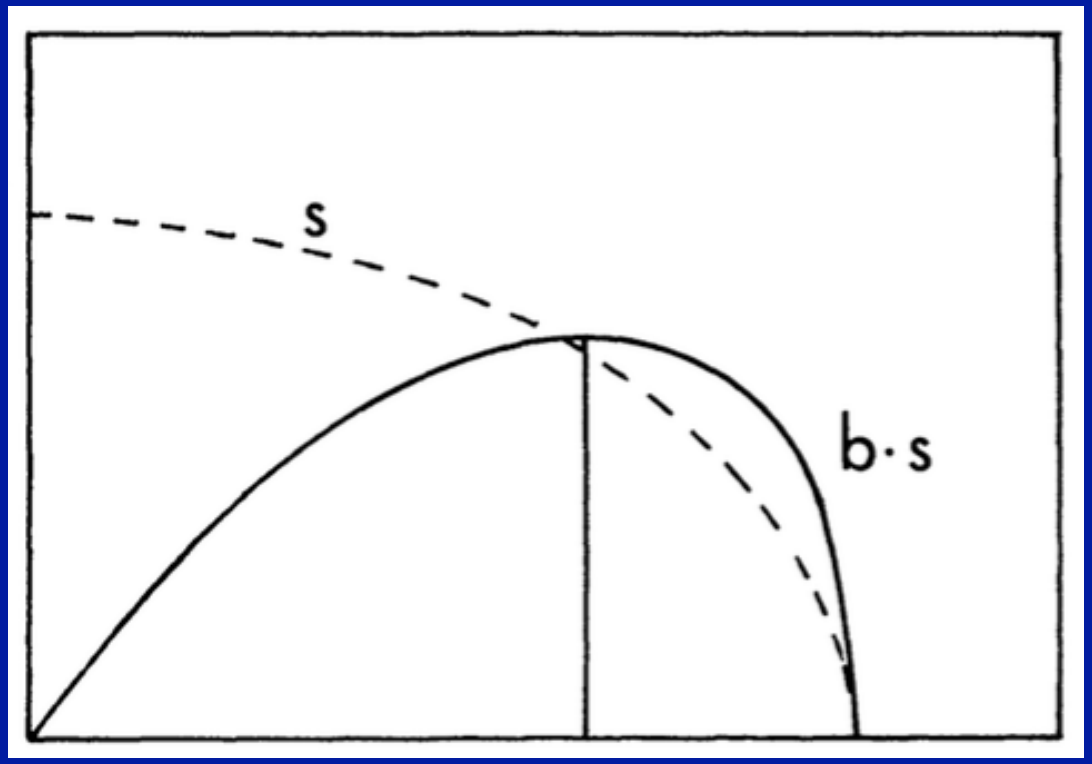
- Genetic traits that maximize fitness should be the most likely to persist

- Over time, species will evolve "strategies" that confer the best possible fitness subject to the constraints

Life history trade-offs – organisms cannot do everything!

Example: how much to invest in reproduction?

Simple model with tradeoffs between clutch size and survival



Stearns 1976

The way that we describe an organism's life history comes from life table data

- The study of life history evolution seeks to understand processes that result in life table

x	N_x	l_x	m_x	$l_x m_x$
0	1000	1.00	0	0
1	900	0.9	0.3	0.27
2	600	0.6	0.5	0.30
3	300	0.3	0.1	0.03
4	100	0.1	0	0
5	0	0	0	0

The study of life history evolution asks questions such as:

- Why do some organisms have very long lives while others have very short lives?

slow life cycle

fast life cycle

The study of life history evolution asks questions such as:

- Why do some organisms mature rapidly while others take longer to mature?

mature in one year

mature in 8-10 years

The study of life history evolution asks questions such as:

- Why do some organisms have many offspring while others have only a few?

Ganets lay 1 egg

Some birds lay many eggs

The study of life history evolution asks questions such as:

- Why do some organisms have precocial offspring while others have altricial offspring?

Precocial plover chicks are ready to walk as soon as they hatch

B. Lyon

Altricial robin chicks needs lots of parental care before they hatch

B. Lyon

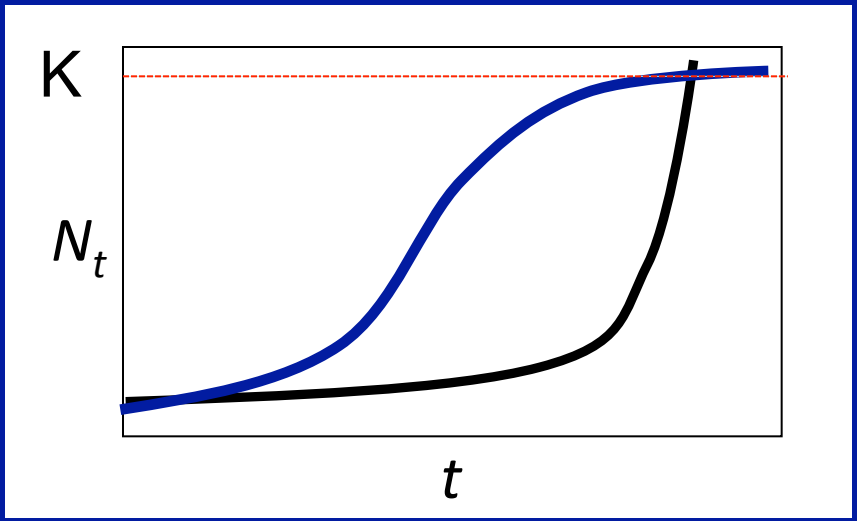
Approaches to studying life histories: r and K selection

r-environment

- Unstable environment
- Well below K
- No density-dependence
- Selection for traits that give rapid population growth

K-environment

- Stable environment
- High density, near K
- Density-dependence
- Traits favored that are good for dealing with crowding



r and K selection approach to life history evolution

Expected traits of r and K strategies:

	r - selected	K - selected
# Kids	high	low
Time to maturity	early	late
Offspring size	little	big
Interspecific Competition	weak	strong
Efficiency of resource use	low	high

r and K selection approach to life history evolution

Problems with r and K selection:

1. Most species do not fit completely into either r or K types for all traits

2. No relation to life tables, population growth, or fitness

3. Little evidence for density-dependent selection has been found in any studies in nature

Approaches to studying life histories: optimality

- Assumes that life history traits evolve to maximize lifetime fitness

- Thus, optimal life history is the one that maximizes fitness (i.e. highest population growth rate for individuals with that strategy)

Optimality approach to life history evolution

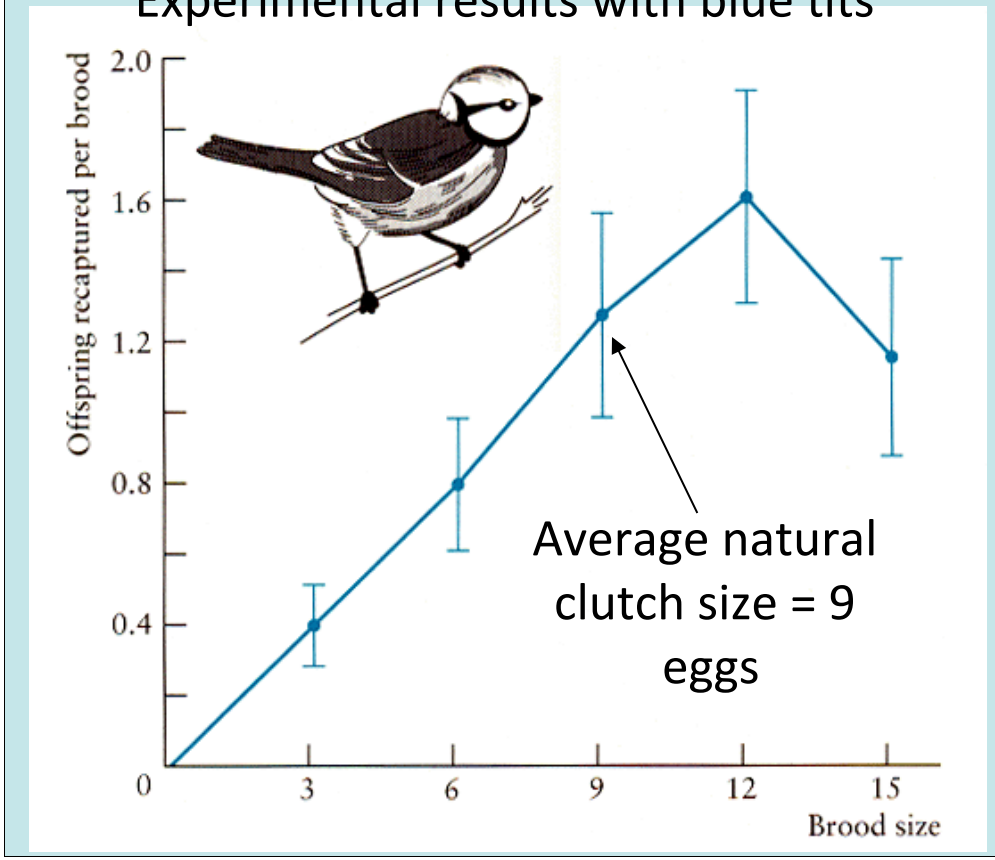
- Two critical things determine what the best life history strategy is for an organism:
  1. Extrinsic mortality rate (fitness that organisms cannot control)
  2. Trade-offs: organisms must allocate limited resources between competing demands (fitness organisms can influence)

- Natural selection adjusts the life history traits of an organism (i.e. the trade-offs) to optimize fitness given the level of extrinsic mortality

Optimality approach to life history evolution

- Lack's clutch size model

Experimental results with blue tits



Researchers actually found that birds can often raise more chicks than the average number of eggs that they lay

Why? They overlooked other factors that can influence fitness

Trade-offs!!

Optimality approach to life history evolution

Trade-off #1: Current vs. future reproduction

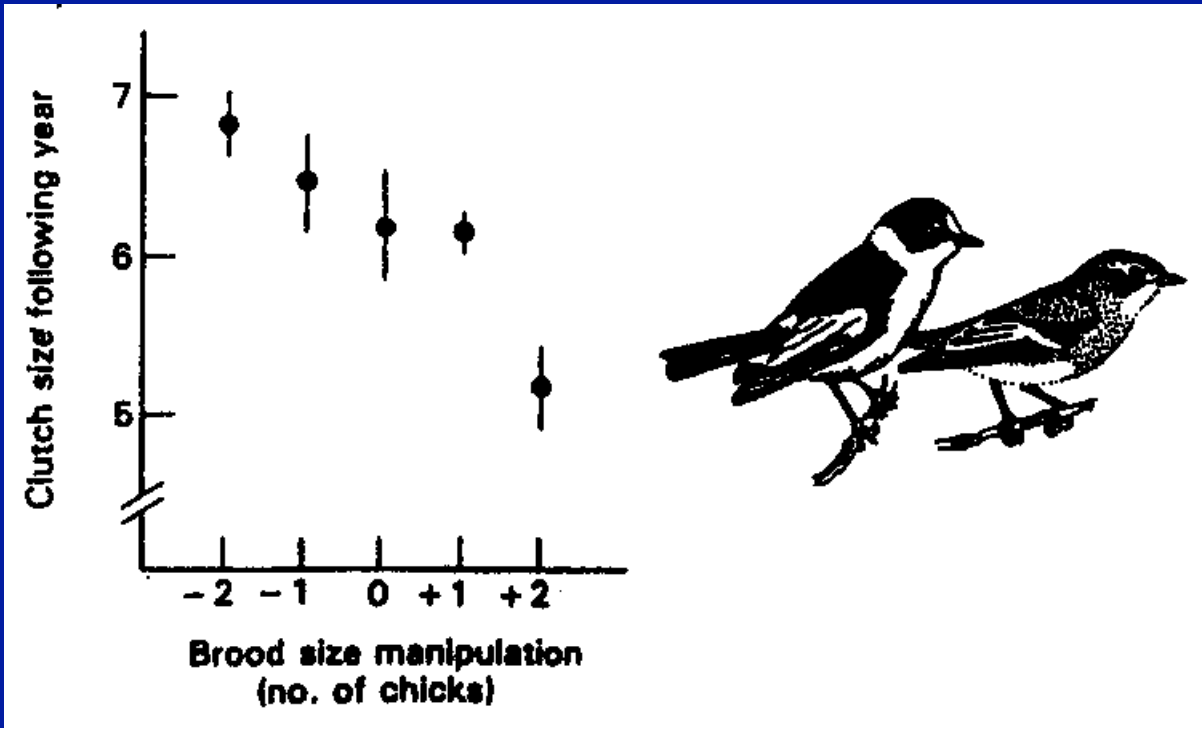
- "Cost of reproduction"
- Assay: parents survival to future or reproduction in the future

Results of experimental studies when parents raised more than optimal number of chicks:

- 36% found reduced parental survival
- 57% found lower future reproduction

Optimality approach to life history evolution

- Trade-off #1: Current vs. future reproduction
  - Example from clutch-size manipulation experiments on collared flycatchers



Optimality approach to life history evolution

- Trade-off #2: Quality vs. quantity of offspring
  - If parents raise too many offspring then each offspring may be lower quality (i.e. have poor survival to future stages)

Results of experimental studies when parents raised more than optimal number of chicks:

- 68% found small chicks with bigger clutches
- 57% found reduced chick survival

When to mature

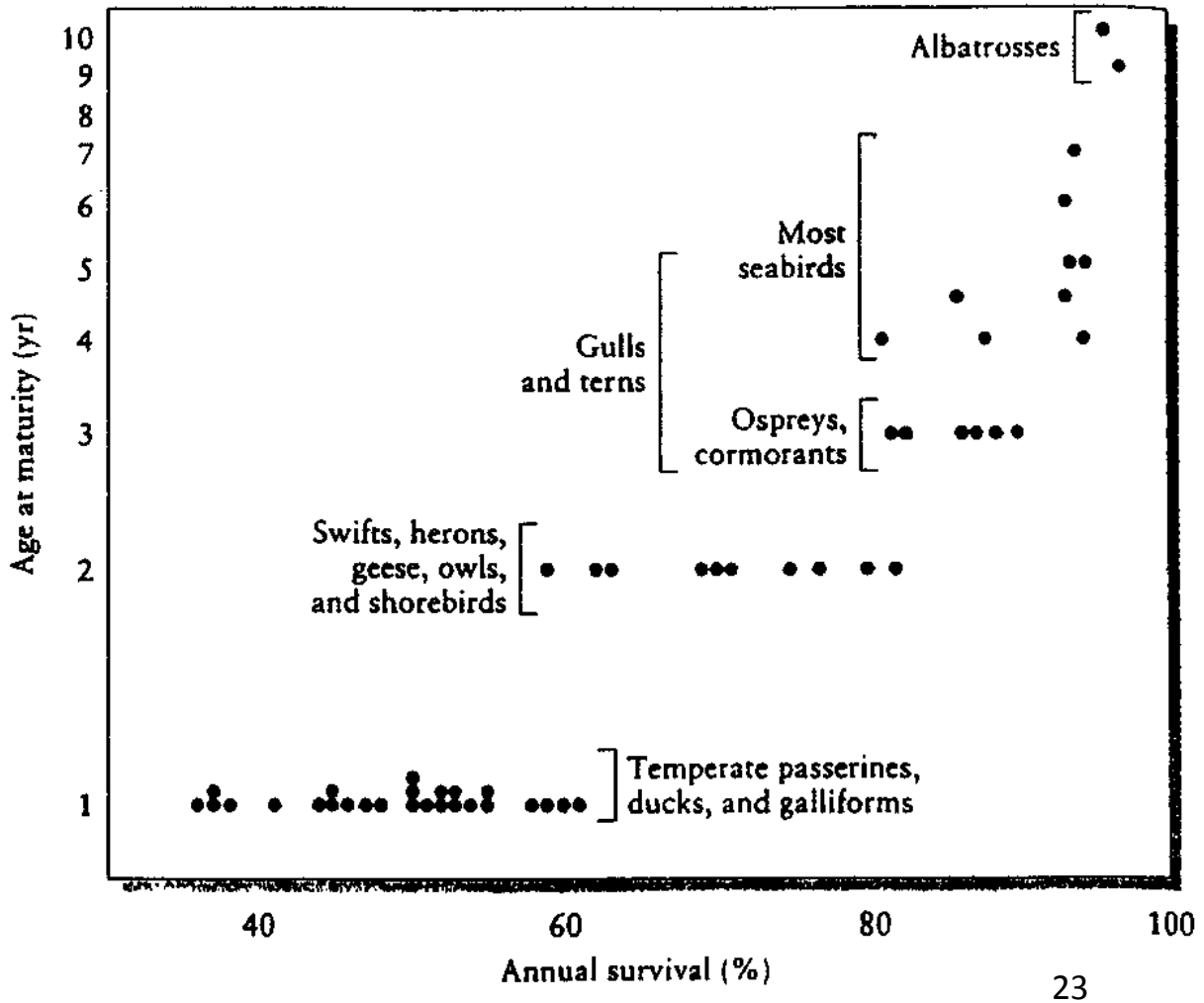
- In nature there is huge variation in the age at maturity (when things begin to reproduce)
  - E.g. some species breed at 1 year of age, some wait 10-20 years before reproducing
- How do we explain this variation?
- Costs and benefits of delaying maturation:
  - Benefits: grow larger, increase fecundity realized at maturation, get wiser
  - Costs: longer wait to reproduction, lower probability of reaching age at maturation

When to mature

- Interactions between costs and benefits shape maturation time:
  - Individuals of species with higher annual survival pay a lower cost of waiting
  - Prediction: species with higher annual survival rates should show later ages of maturation
- Studies have found that there is a positive relationship between survival and age at maturity
  - e.g. songbirds: low survival + early maturity, albatross: higher survival + later maturity

When to mature

Relationship between average survival and age at maturity: example in birds



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