

### Lecture 6: Reproduction

#### I. Introduction – reproduction is fundamental feature of life history

##### A. Objectives

1. Introduce diversity of reproductive adaptations, from the individual's point-of-view
2. Discuss some of the tradeoffs that go into reproductive strategies and tactics
3. Set the stage for understanding population-level implications of reproductive strategies

##### B. Significance

1. crucial link to an individual's fitness
2. major use of consumed energy (along with homeostasis, growth)
3. resources are limited
  - a. limitations from: spawning sites, mates, energy, time,
  - b. selective pressure to optimize use of available resources
4. specialized adaptations => reproductive isolation => speciation

Note: reproductive habits, needs are poorly known for most species

#### II. Fecundity

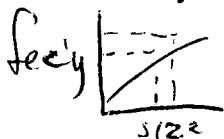
##### A. Definition

Number of eggs spawned per year

presence of immature eggs in body problematic for estimating fecundity

##### B. Ecological determinants

1. body size or age



trade off betw. time to grow vs fecundity

700-900 mm  
Am. eel in Potomac R.  
- if delay spawning 2 yrs  
gain 135 mm in length,  
2.7 M → 5.2 M eggs

2. food availability

short-term fx on egg size, number  
long-term fx on growth (egg capacity)

other metabolic constraints: parasites, toxins, temperature, etc.

##### C. Egg number vs. egg size

1. trade-off for individual female

a given ovary has limited capacity to produce eggs  
egg size = strong determinant of juv. survival

log eggs → caves, springs  
sm. eggs → ocean

2. range of strategies

a given river, lake, ocean supports range of egg-size strategies  
- catfishes and carp in New R

##### D. Spawning frequency

1. iteroparity vs semelparity -- lifetime trade-off

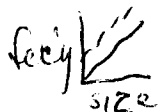
allows bet-hedging

2. single vs batch (fractional) spawning -- intra-annual trade-off

allows bet-hedging on mates, spawning sites  
→ avoids body-cavity limit for egg storage

repeat spawners must weigh future fecundity against prob. of surviving to future 1

OH2



E. Geographic and phylogenetic patterns

1. marine vs freshwater

OH 3

sm eggs. ↙ converse

big bodies  
hi fecundity  
single spawn

but much overlap

2. latitudinal gradient

more parental care @ low latitudes (tropics)

III. Spawning synchronicity -- mates must find each other in reproductive state

A. What has to happen (physiology and behavior)

1. males and females develop their gonads - maturation of gonads sex-specific
2. individuals perceive the spawning season
3. gametes mature
4. males and females gather and choose mates (more about this later)
5. spawning occurs until eggs are gone or environmental conditions change

repeat spawners often resorb un-laid eggs

B. Seasonal stimuli

1. temperate fishes

OH 4, 5

mostly spawn in spring or autumn  
respond to  $\Delta$ s in temperature, day length

2. tropical and desert freshwater fishes

mostly spawn in wet season  
cues easily disrupted by large dams (reduce flood spikes)

3. role of hormones: pituitary => gonadotropins => gonad development

IV. Reproductive guilds (or at least a subset of them)

Handout

see for details Eugene Balon (1970s) -- 33 guilds

disparate taxonomy but similar use of resources

A. Non-guarders

little investment in eggs/young; hi fecundity

1. Broadcast spawners -- many pelagic species

a. marine species: herrings, ocean sunfish, striped bass  
eggs drift on currents or sink to bottom

b. walleye (freshwater) -- eggs adhere to rocks

c. pikes (freshwater) -- eggs adhere to vegetation

2. Brood hiders

- a. grunnions -- spawn on beaches *above* water line
- b. *Cyprinella* shiners (North America) -- crevice spawners
- c. pirate perch (North America) -- tunnel into root wads along bank

B. Guardians

1. Substrate choosers -- selective but use substrate "as is"

- a. many darters and minnows -- deposit eggs in gravel or vegetation

2. Nesters -- find or build nest, then defend it

- a. cavity nesters -- No. Am. catfishes, sticklebacks (vegetation)
- b. depression (or saucer) excavators (use fins to fan) -- sunfishes
- c. mound builders -- trouts build redds  
chubs (minnows) build mounds/ridges -- also used by other species

C. Bearers -- retain eggs or young in/on body (largest parental investment)

1. External bearers -- mostly tropical

- a. mouth brooders -- cichlids, reef fishes
- b. pouch brooders -- seahorses (males)
- c. gill brooders -- cavefishes

2. Internal bearers

- a. ovovivipary -- eggs grow internally on yolk (no placental connection to mom)  
- guppies, most sharks
- b. vivipary (~1000 species) -- eggs grow via placental connection to mom  
- some sharks, *Gambusia*, coelacanth

V. Life on the spawning grounds -- getting mates together

A. Meeting a mate - 2 basic ways, many variations

- or aggregation

- 1. Social schooling -- many marine species, minnows
  - typically preceded by mass migration
  - attracted to same structure or each other

2. Territoriality

♂♂ interactions determine spacing  
 - some males may break "rules" (sucubers)

♀ selects ♂ or site

B. Male - female interactions

- 1. Cheap sperm, expensive eggs => males are mate-limited, females are egg-limited (fitness)  
 inter-sex tension induces sex-specific behaviors, tactics

2. Enticement and inducement

a. quickness if ♀♀ not especially selective, quickest ♂ wins or nearest

b. coloration -- reef fishes, darters

♂ usually attracts ♀

some color patterns occur only during gamete release

c. nest site quality

many ♀♀ choose sites rather than ♂♂  
 - egg presence as criterion

→ ornamental egg mimics on ♂♂ (see plate in J&B book)

d. mating rituals

many subtle, species-specific behaviors

3. Mating systems

a. monogamy -- No. Am. catfishes, butterfly fishes, cichlids, gobies

b. polyandry -- uncommon, anemonefishes

c. polygyny -- damselfishes, sculpins, darters

territorial ♂♂ care for young

} most potential spawners do not spawn in a given season

4. Mate and nest swapping in darters

a. parentage analysis

Brady Porter work based on new genetics technology (striped darters)

Do guarding ♂♂ guard their own offspring?  
 - guards sired 0-100% of offspring being guarded

b. location, location, location...

at some sites, both ♂♂ and ♀♀ spawned at multiple sites, w/ multiple mates

perhaps seeking "best" site under varying environmental cond's ...

see plates in J&B  
 see fantail plate