

## Lecture 9 Life-history (continued)

Last week we addressed question of how often should an organism breed.

Extreme case: once only (semelparous) or more than once (iteroparous)

Noted that all else being equal both strategies are equal when a semelparous organism produces only one more offspring than an iteroparous form.

BUT, all else is not likely be equal. Cole conclusion inaccurate if there is adult or juvenile mortality.

Concluded that one needs to consider adult mortality of iteroparous form and juvenile mortality of both forms:

$$B_a (\text{semel}) = B_p (\text{itero}) + P (\text{adult surv})/C (\text{juv surv})$$

Not all adults of itero form survive nor do all offspring of either form.

So, for example if we set juvenile survivorship constant for both forms and fecundity of a semelparous form twice that of an iteroparous species with 100% adult survivorship and juvenile survivorship of both at 10%.

$20 = 10 + 1/0.1$ ; then juvenile survivorship need only be greater than 10% for iteroparity to be favored.

**Let's consider the question of how many times should an organism breed?**

or

**How much reproduction should be invested and when should it be invested?**

Obviously when  $l_{(x)}$  is low (or  $q$  high), RE should go up. But what about when survivorship is high.

Remember

always obvious.

Consider: allocation of energy is divided into three activities:

- maintenance/survivorship (P)
- fecundity (reproduction)
- growth (where we assume that larger size is better for survivorship and yields higher fecundity).

Sort of like investment analogy – need to keep some funds safe (maintenance), need some to be making money (growth) that yields fortune (reproduction).

$$\lambda (\text{finite rate of increase of population}) = m (\text{births}) + p(g)$$

To maintain a given  $\lambda$ , if more energy goes to  $m$  then less goes to  $p(g)$ , and vice versa.

All this assumes trade off – i.e. cost to reproduction in the proximate sense (physiological)

Let's look at possible relationships between fecundity and survivorship/growth relative to reproduction.

$$\lambda (E) = b(E) + pg (E) , \text{ what is optimal } E \text{ to get maximum } \lambda ?$$

When convex:

See fig1

To get optimum E need to add curves

See fig 2

When concave:

See fig 3

Now that we have established **how much** – i.e. whether it should be a portion of the RE available or, all or none, the question remains as to how much should it be at a specific age.

The will depend on how much current reproduction will affect future reproduction.

Because reproduction is costly, fecundity at all ages cannot simultaneously be maximized by natural selection.

Our equation:  $\lambda = m + p(g)$ , attempts to solve the optimum, but it should be noted that if the curve changes with age the solution will be difficult to determine. (makes it difficult to empirically evaluate the theory).

We can view  $\lambda$  as describing both the finite rate of increase of an individual's genes **and**, at any single time interval, as the reproductive value.

$$\lambda_{(i)} = m_{(i)} \text{ (current repro)} + p_{(i)} g_{(i)} \text{ (future repro)}$$

Where,  $p_{(i)}$  and  $g_{(i)}$  = future reproduction (RRV), which is weighted by  $e^r$

$$\lambda_{(i)} = m_i + p_i (V_{i+1}/V_o)$$

So, the amount of current reproduction is expected to increase as RRV decreases for an iteroparous (see figs 4&5) and semelparous see figs 6&7) organisms.

### Summarize

- 1) age-specific RE will evolve to maximize  $\lambda$  which will represent a tradeoff between  $m$  (current reproduction) and  $p(g)$  (future reproduction).
- 2) For semelparous organism where trade off between  $m$  and  $p(g)$  is concave, RE will be all or none.
- 3) For iteroparous organism tradeoff between  $m$  and  $p(g)$  is convex, RE will be intermediate. As RRV decreases, RE will increase.

Next question: **What determines clutch size?**

How many offspring should be in a clutch?

Let

$I_p$  = parental investment  $\rightarrow$  two components

$I_y \rightarrow$  offspring size

$N_y \rightarrow$  number of offspring

$$I_y \times N_y = I_p$$

What is best strategy to maximize  $I_p$  in terms of fitness?

Define:  $W_p$  (parental fitness) a the product of

$(N_y)$  (number of offspring)  $\times$   $(W_y)$  (fitness of offspring).

Assume:  $I_p$  is constant and relationship between  $W_y$  and  $N_y$  is linear and proportional with slope = 1.

See fig 8

$$W_p = (N_y) (W_y)$$

Parental fitness = (number of young) (fitness of young)

$$10 = (0.1) (100)$$

$$10 = (0.2) (50)$$

We could generate a series of different fitness curves.

(See fig 9)

$W_y$                        $I_y$                        $N_y$

(see fig 10, 11 and 12)

$W_y$

by superimposing the adult fitness function on the graph.

Thus far we've talked about the demographic consequences determining life-history traits – i.e. maximizing  $r$  ( $\lambda$ ), or fitness in a demographic sense only. To understand how history traits evolve they must be considered in

Relating size of offspring, let's consider:

Stationary resources →

contest competition (territoriality) →

non-linear relationship between  $W_y$  versus  $I_y$ , where slight increase in  $I_y$  may lead to high  $W_y$

→ high  $I_y$  (low  $N_y$ )

→ low birth rates (independent of potential for population increase).

Resources transient or dispersed → exploitative competition → Linear relationship between  $W_y$  vs  $I_y$  →

Low  $I_y$  (high  $N_y$ ) →

High birth rate where dispersal important in

Fast growing population.