LIFE HISTORIES

Chapter 12

WHO AM I??

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- To major in:

1. **Multivariate statistics**
2. **Mechanics & Fluid dynamics**
3. **Differential equation**

Topics of researches

- **comparative studies of life history** in cetaceans
- **flight kinematics & morphological adaptations in birds**

Introduction

- Redwood forest
- Mayfly
- Fish (salmon)
- Human
- →A Web of ecological relationships,
  with vastly different in life histories.

(All four are palyers in an ecological and evolutionary drama stretching into a vast past and into an unknown future)

What are the selective forces? (for maintain this vast range of biology)

Life history?

- Definition:
  - The significant features of the **life cycle through which an organism passes**, with particular reference to **strategies influencing survival and reproduction**.

    (Lincoln et al.1988, Dictionary..)
- ***Life histories lie at the heart of biology*** *(Stearns 1992)*

  It could unite & explain the complexity & diversity of living things.

What life history can tell us?

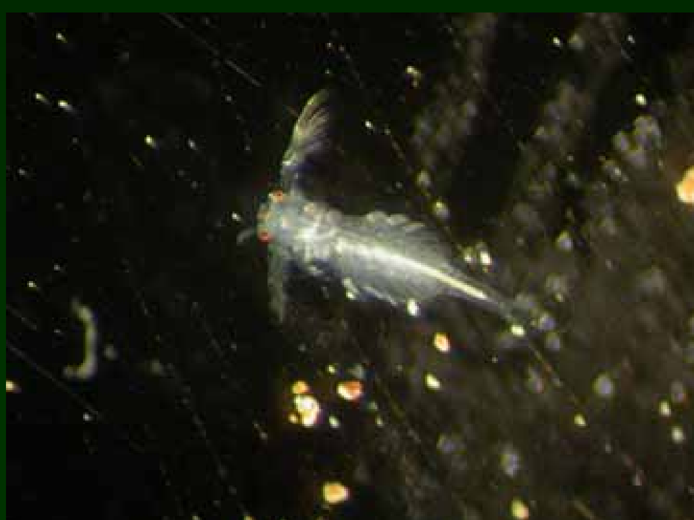
- The history of life
- Life history traits
- Strategy of life

E N D !

History of life

- **BIRTH →** time, gestation period
- **Growth →** growth rate, weaned
- **SM, reproduction →** age, size, fecundity, CI
- Death → mortality, survival, longevity



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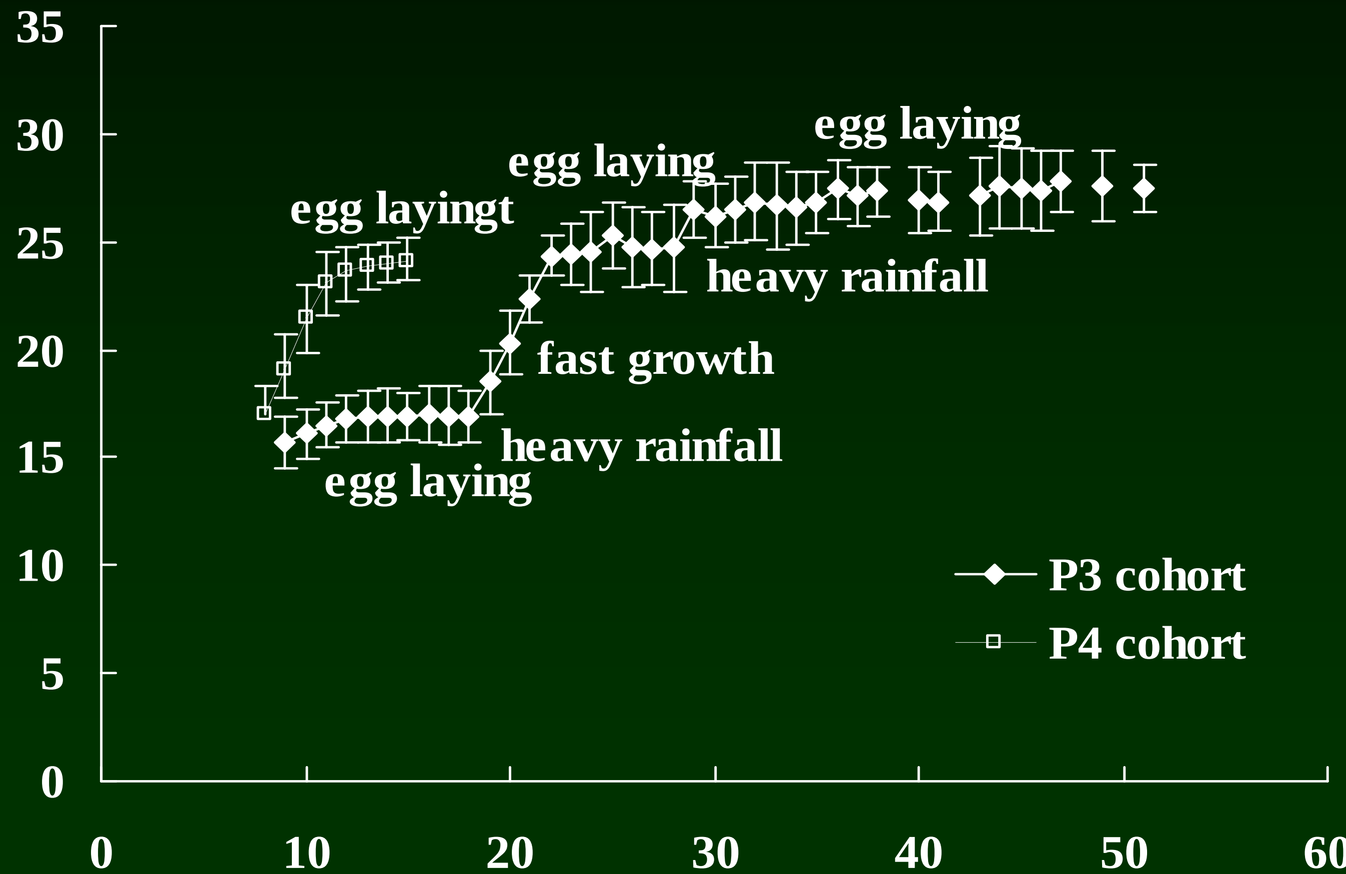
History of Life

- Growth curve



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How to describe organism?

- In **literature**
- In **physics**: D, M, V, S, ….
- In **chemistry**: composition, reaction
- In **mathematics**: shape, curvature
- In **biology**: demographic parameters

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Life History Traits

or demographic parameters

SIZE RELATED

1. size at birth (LB, WB)
2. Size at weaned (mammal, LAW, WAW)
3. Size at sexual maturity (LSM, WSM)
4. Asymptotic size (L_∞, W_∞)
5. Fecundity, clutch size

- TIME RELATED

1. Age at sexual maturity (ASM)
2. Longevity (T_∞)
3. Calving interval (CI)
4. Gestation period (GP)
5. Lactation period (LP)

Other traits

1. no, size, & sex ratio of offspring
2. age- & size-specific reproductive investments
3. age- & size-specific mortality schedules

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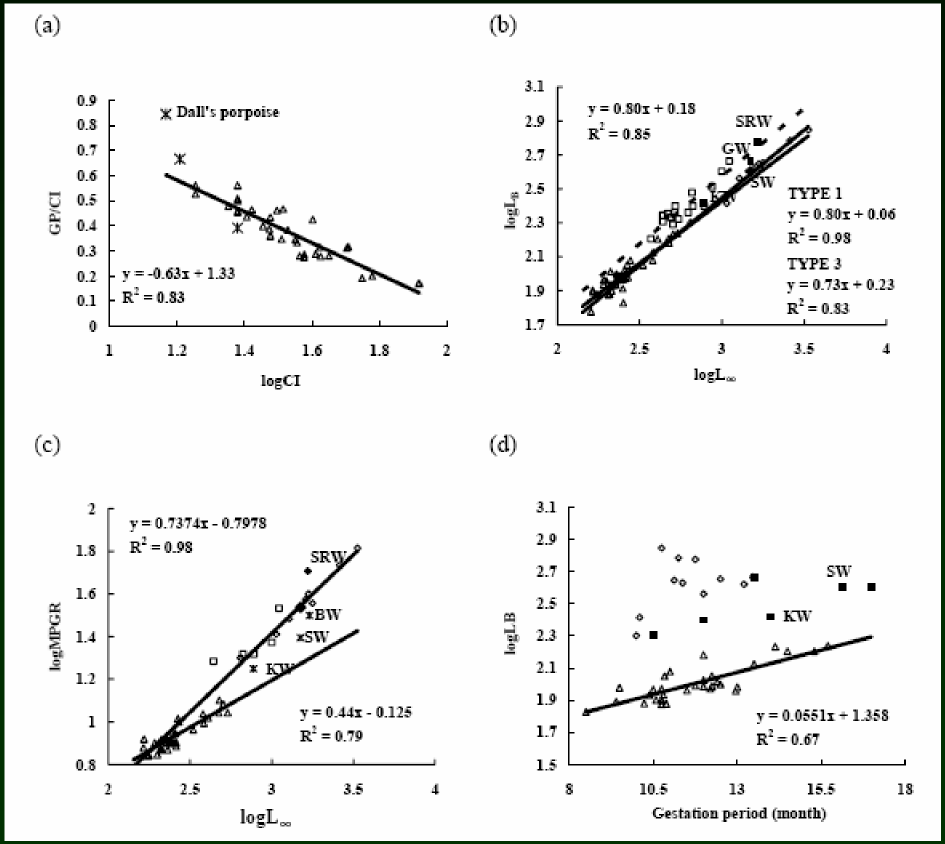
Interaction between life history traits

- **Allometry pattern: $Y = aX^b$**
- **a:ecological** parameters
- **b:ontogenic** parameters
- X, Y: biological parameters
- Ex: Kleiber Law BMR = a $M^{0.75}$
- Size related traits
- Time related traits

Interaction between sized related traits

- L_∞ -- L_B
- L_∞ -- prenatal growth rate
- L_∞ -- LSM
- Offspring size – clutch size



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What life history traits will lead

- Fecundity (f) = clutch size / CI
- R_0 = f × neonatal survival
- Evolution fitness (or reproductive fitness) =
  $R_0\ s^{TM} (s^{T\infty\ -TM} -1)\ /\ln s$
- Maximizing fitness:

1. high R_0

2. high survival

3. short T_M

4. long T_∞

→ Tradeoff between life history traits

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Trade-offs between life history

1. Centra-dogma: **principle of optimal allocation** (Hill 1993, Wells 2003a, b)
2. **parental-offspring conflict**
3. **Longevity-reproduction conflict**

POA-principle of optimal allocation

- **Energy** (or resources) allocated for one purpose, such as reproduction, can not be used for another, such as growth.

Size at birth vs clutch size

- Reproductive investment

  RI = size at birth × clutch size

for limited RI, two strategies

→ large size × small clutch or

→ small size × large clutch

Significance in life history strategy

- Size at birth usually affect the survival and hence
- The evolution fitness

Parental-offspring conflict

- POA: **more energy allocated on reproduction will lead the reduction of growth or survival**, and vice versa
- For offspring: to drain more energy from mother for their growth and survival
- **HOWEVER**
- For mother: to be drained less by offspring to have more available energy for survival, future reproduction

Longevity-reproduction conflict

- Evolution fitness = $\mathbf{R_0\ s^{TM}\ (s^{T\infty\ -TM}\ -1)\ /\ln s}$
- To maximize fitness: **higher R_0, earlier T_M** or **longer longevity** will be need
- BUT
- **Energy allocated on reproduction can not be used for growth and survival**
- **Higher R_0 and earlier T_M usually result in the reduction of longevity**

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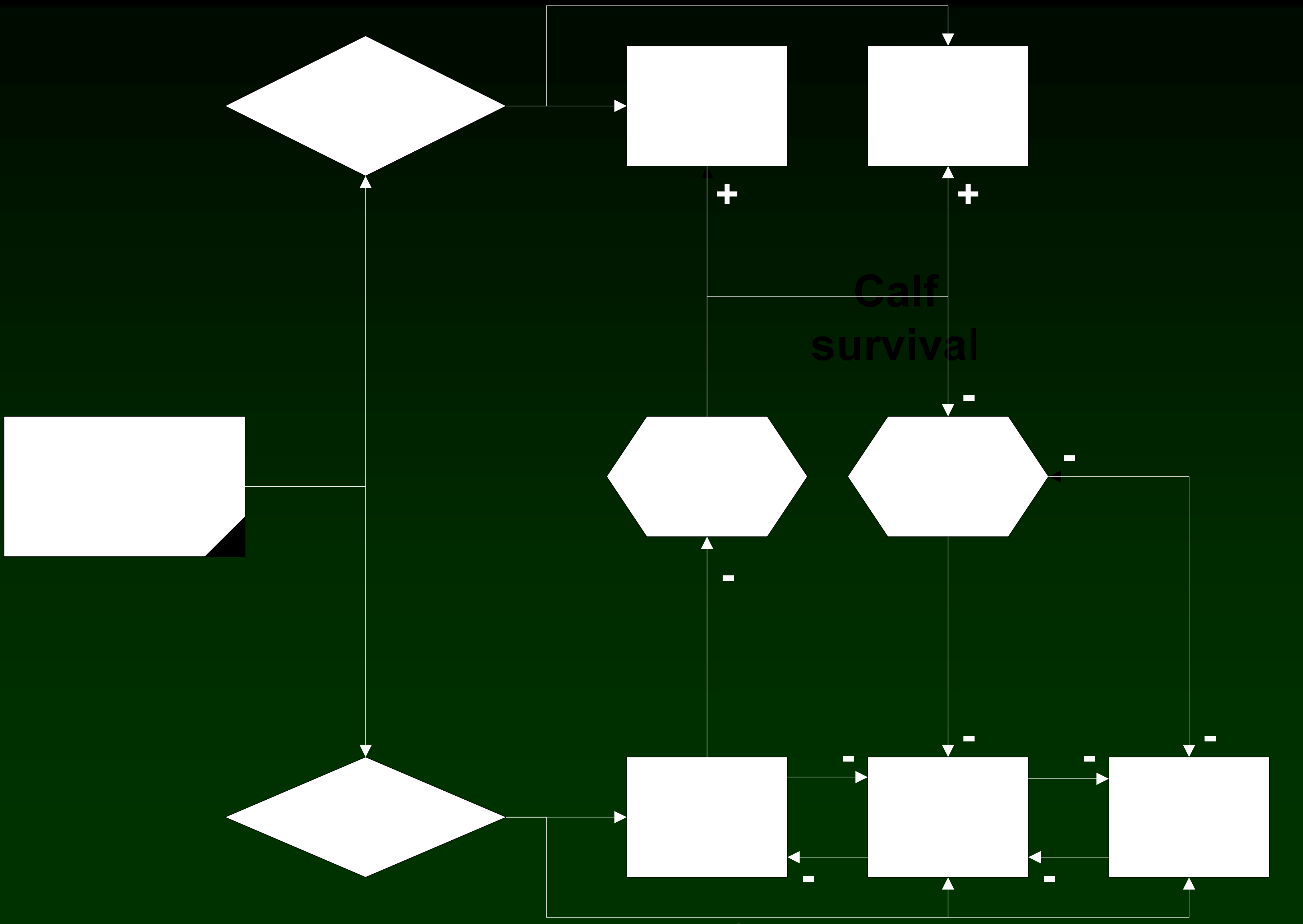
Chapter Concepts

- With low adult survival, organisms begin reproducing earlier and invest more energy into reproduction; when adult survival is higher, organisms defer reproduction to a later age (larger body size) and allocate less energy to reproduction.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Calf
survival
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Two terminals

- **High R_0, earlier T_M but short longevity and low survival**
- OR
- **low R_0, late T_M but long longevity and high survival**
- **→ life history strategy**

Strategy of life history

- *MacArthur and Wilson*
  - r selection: (per capita rate of increase) characteristic high population growth rate.
  - K selection: (carrying capacity) characteristic efficient use of resources.
- *Pianka* : r and K are ends of a continuum. Most organisms are in-between.
  - r selection: unpredictable environments.
  - K selection: predictable environments.

r and K: Fundamental Contrasts

- Intrinsic Rate of Increase:
  - Highest in r selected species.
- Competitive Ability:
  - Highest in K selected species.
- Reproduction:
  - r: numerous individuals rapidly produced.
  - K: fewer larger individuals slowly produced

r: often frontier species, K: often climax species

r & k Selecton- Pianka 1970

Pop chtrs favored	r selection	k selection
r_m	H	L
Compet. Ability	L	H
Development	rapid	slow
Reproduction	early	late
Body size	small	large
Reproduction	semelparity	iteroparity
offspring	Many, small	Few, large

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Different strategies may come from

- Ecological consequence

Or

- Evolutionary consequence

→ By inter- and intraspecific comparative studies

Ecological consequence

- Ex. Plant life histories
- Four Environmental Extremes:
  - ❖ Low Disturbance : Low Stress
  - ❖ Low Disturbance : High Stress
  - ❖ High Disturbance : Low Stress
  - ❖ High Disturbance : High Stress (not exist)

Plant Life History Strategies

- Ruderals (highly disturbed habitats)
  - Grow rapidly and produce seeds quickly.
- Stress Tolerant (high stress – no disturbance)
  - Grow slowly – conserve resources.
- Competitive (low disturbance low stress)
  - Grow well, but eventually compete with others for resources.

Ecological consequence -- intraspecific variations

- *Bertschy & Fox*
- pumpkin seed sunfish, 5 lakes ontario, Canada, 1992-94
- Mark-recapture surveys
- Pop size, Age structure (estimated from bd length)
- Fig 12.15

Evolutionary consequence

- *Shine and Charnov* pointed out vertebrate energy budgets are different before and after sexual maturity.
  - Before: maintenance or growth.
  - After: maintenance, growth, or reproduction.
  - Individuals delaying reproduction will grow faster a reach a larger size.
    - Increased reproduction rate.

4 approaches to classification of LH strategy

- 1. r , k-strategies
- 2. ecological variations: ruderal, stress-tolerant, competitive, :opportunistic, equilibrium, periodic
- 4. compare diff taxa, by
  - Relative offspring size (I/m)
  - Rel reproductive life span (E/ α)
  - Reproduct effort* adult mortality (CE)