BIO 120 2016 11 16

LECTURE 19: AGE-STRUCTURED POPULATIONS LIFE HISTORIES

Typical life history for higher plants & animals

- start at small size
- grow for a period, called resource accumulation, without reproducing
- become mature, start spending resources on reproduction
- need to consider age structure to understand the distribution

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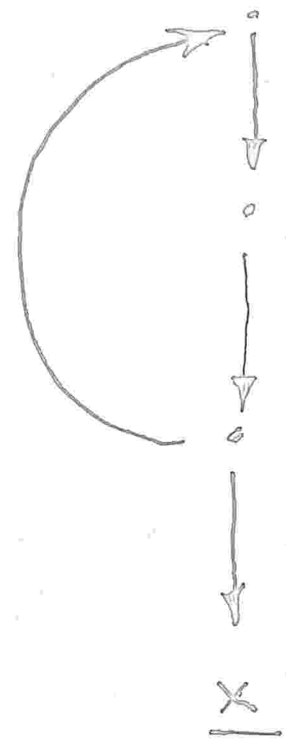
AGE-STRUCTURED POPULATION GROWTH

- a single population

If birth & death rates are constant,

pyramid shape is constant, but human rates are always changing.

AGE STRUCTURE



TIME IS MEASURED IN 5-YEAR-LONG AGE INTERVALS.

LIFE TABLES

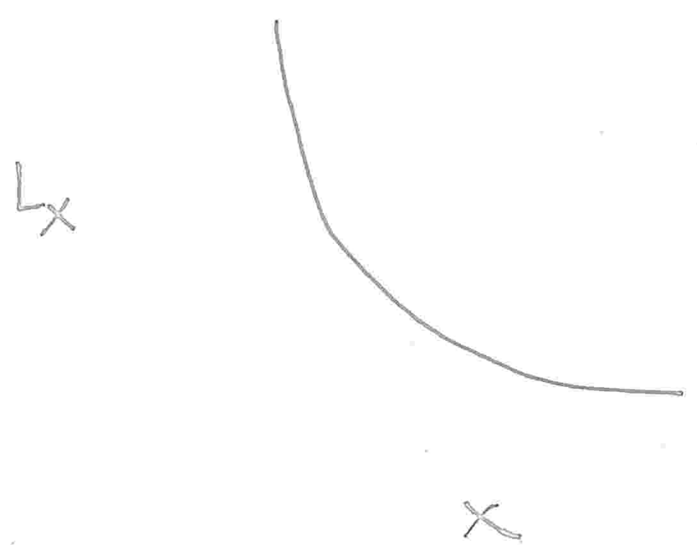
- SUMMARIZE THE LIFE EVENTS THAT ARE STATISTICALLY EXPECTED FOR THE AVERAGE INDIVIDUAL OF A SPECIFIED AGE
- AGE OF DEATH
- AGE AND TIMING OF REPRODUCTION
- FOR MODELLING, THESE VALUES ARE TREATED AS CONSTANT.

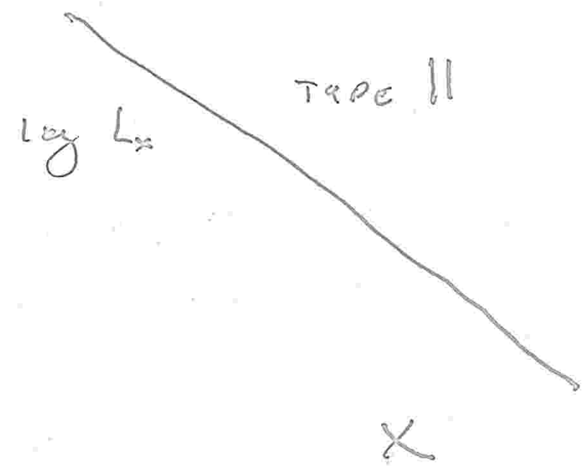
SURVIVORSHIP SCHEDULES

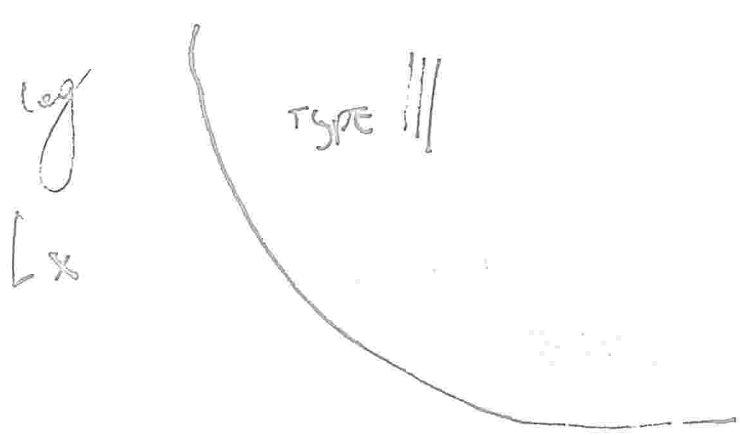
- AGE CLASSES DENOTED BY SUBSCRIPT x
- PROBAB. OF BEING ALIVE AT BIRTH IS TAKEN AS 1.

TYPES OF SURVIVORSHIP:

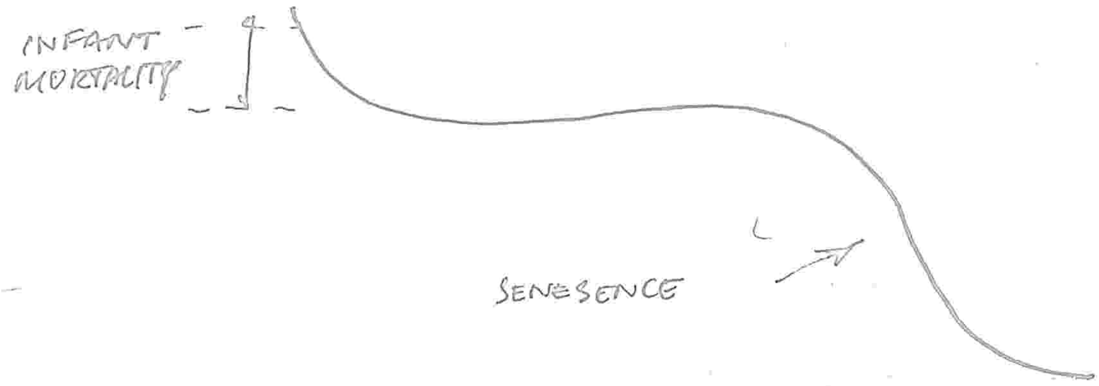
IF MORTALITY IS CONSTANT WITH AGE, THE DECLINE IS EXPONENTIAL.







REAL SHAPES ARE COMPLEX



FECUNDITY SCHEDULES

- AGE CLASSES DENOTED BY SUBSCRIPT X
- b_x = # daughters born to female of age x DURING THE INTERVAL x TO x+1.
- SHAPE OF b_x CURVE CHARACTERISTIC OF SPECIES.
- FECUNDITY – TWO REPRODUCTION STRATEGIES ARE INVOLVED.

POPULATION GROWTH RATES

$$R_0 = \sum L_x b_x$$: NET REPRODUCTIVE RATE

R_0 IS IN TIME UNITS OF ONE GENERATION

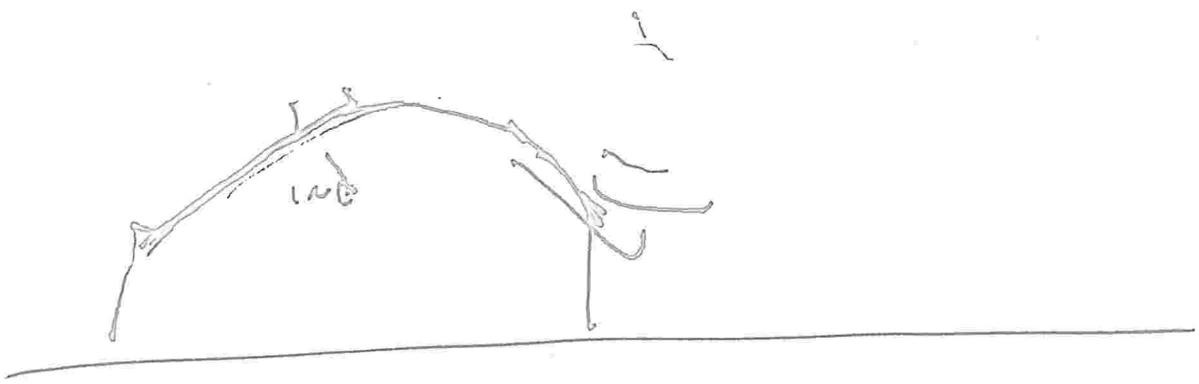
GENERATION TIME.

$$T = \frac{\sum x L_x b_x}{\sum L_x B_x}$$

ROUGHLY RELATED TO THE GEOMETRIC FACTOR λ AS
$\lambda = R_0^{\frac{1}{T}}$.

GENERALLY, ORGANISMS WITH HIGHER λ'S HAVE HIGHER FITNESS.
So why aren't all animals rio?

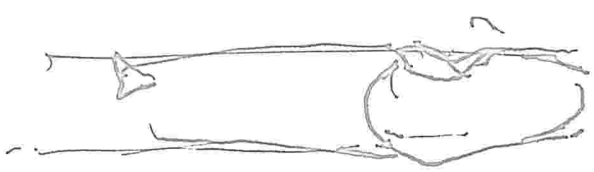
→ A: CONSTRAINT AND

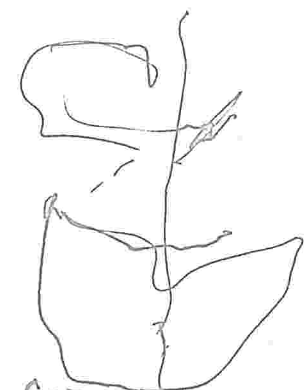


WHAT FACTORS AFFECT THE SEMELPARITY

• WHEN

OBLIGATE SEMELPARITY





SEMELPARITY WOULD BE SELECTED BY POLLINATION

SOME SPECIES USE ITEROPARITY.

ITEROPARITY + LOCAL SYNCHRONY = "MASTING"

→ CAN CALCULATE LIFE EXPECTANCY

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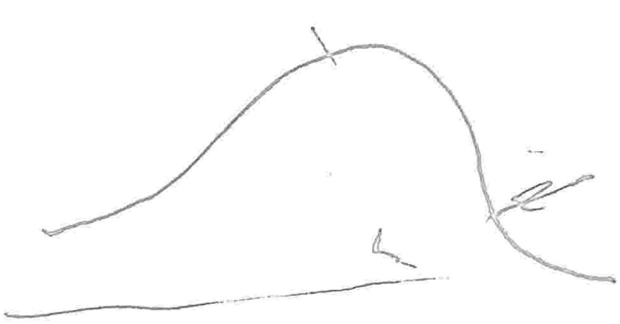


[illegible]

WHAT MIGHT V_x AFFECT?

- SUCCESS OF CAPTIVE BREEDING PROGRAMS:
  THE HIGHER V_x, THE BETTER THE CANDIDATE

V_x; Baby Por & THE ETERNAL TRIANGLE.

ANTAGONISTIC PLEIOTROPY

- PLEIOTROPY: ONE GENE MAY HAVE MULTIPLE DIFFERENT FUNCTIONS

- ANTAGONISTIC PLEIOTROPY: A GENE MAY HAVE OPPOSITE EFFECTS ON SURVIVAL AT DIFFERENT AGES

- A GENE WITH POSITIVE VALUE IN YOUNG ANIMALS BUT NEGATIVE VALUE IN OLD ANIMALS WILL BE FAVOURED BY NATURAL SELECTION

- REPRODUCING EARLY INCREASES FITNESS

PARTIAL CLASSIFICATION OF SPECIES INTERACTIONS

TYPES OF INTERACTIONS ARE CLASSIFIED BASED ON THE BENEF/~~AFFECT~~ACTORS:

- CONSUMER - RESOURCE
  - PREDATOR - PREY
  - PLANT - HERBIVORE
  - HOST - PARASITE
- COMPETITION
- MUTUALISM

FOCI OF STUDY

- POPULATION DYNAMICS (ECOLOGICAL EFFECTS ON N'S, CAN SPECIES COEXIST?)
- EVOLUTIONARY DYNAMICS (ADAPTATION, COEVOLUTION)

INTERSPECIFIC COMPETITION FOR RESOURCES.

- BASIC MODEL: LOTKA - VOLTERRA EQUATIONS

LOGISTIC: $$\frac{dN_1}{dt} = r_1 N_1 \left(\frac{k_1 - N_1}{k_1} \right)$$

LOTKA-VOLT.: $$\frac{dN_1}{dt} = r_1 N_1 \left(\frac{k_1 - N_1 - \alpha_{12} N_2}{k_1} \right)$$

$$\frac{dN_2}{dt} = r_2 N_2 \left(\frac{k_2 - N_2 - \alpha_{21} N_1}{k_2} \right)$$

solution?

- Coexistence requires both species to inhibit their own growth more than they inhibit each other's.

- Can expand to consider n species.

Law of competitive exclusion

- If two species are too similar, they cannot coexist.

- Need a more complex model.

Experiments by Gause (1930)

→ Description of competition by protozoa

→ Predator-preys are unstable

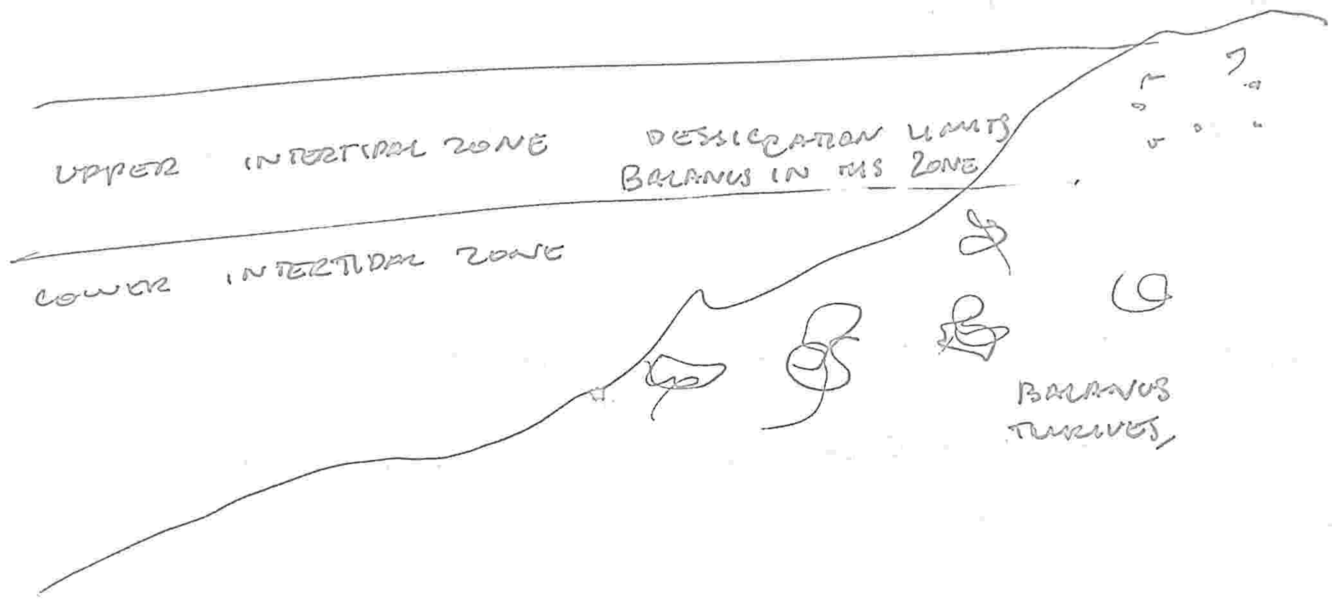
In the wild:

- Competitive exclusion is less likely to go to completion

Tansley, 1917: Garden experiments with two species of Galium

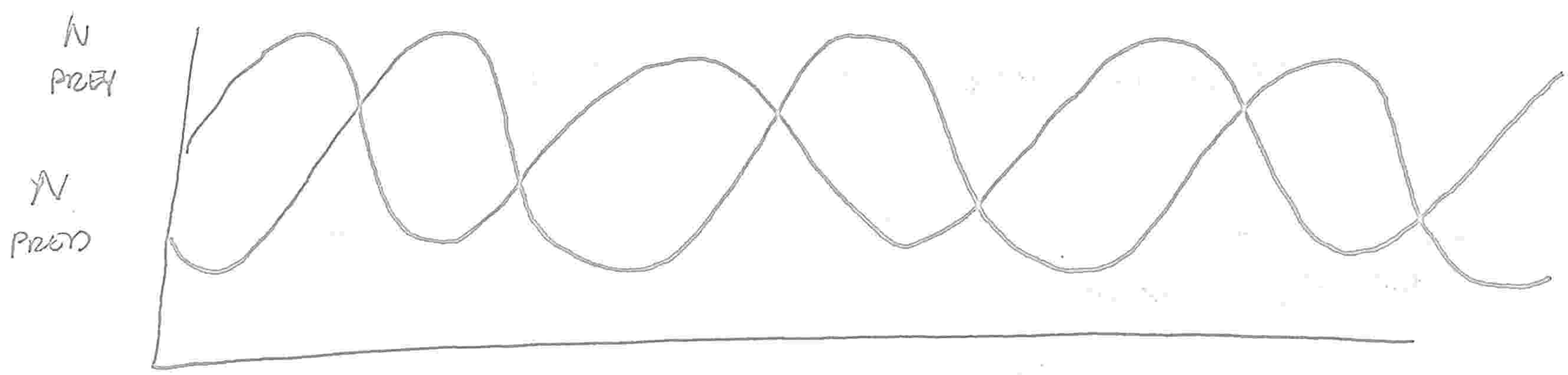
Outcome depends on the environment in which they compete

CONNELL, 1961



L-V MODELS FOR PREDATOR-PREY INTERACTION TEND TO CYCLE

PREDICT COUPLED, LAGGED POPULATION CYCLES



CYCLES IN RL? AND LAB, YES, BUT DIFFICULT TO MAINTAIN

MOST COMMON LAB RESULT: PREDATOR AND PREY DO NOT COEXIST, INTERACTION IS NOT STABLE

NUMBER OF PELTS (IN THOUSANDS)

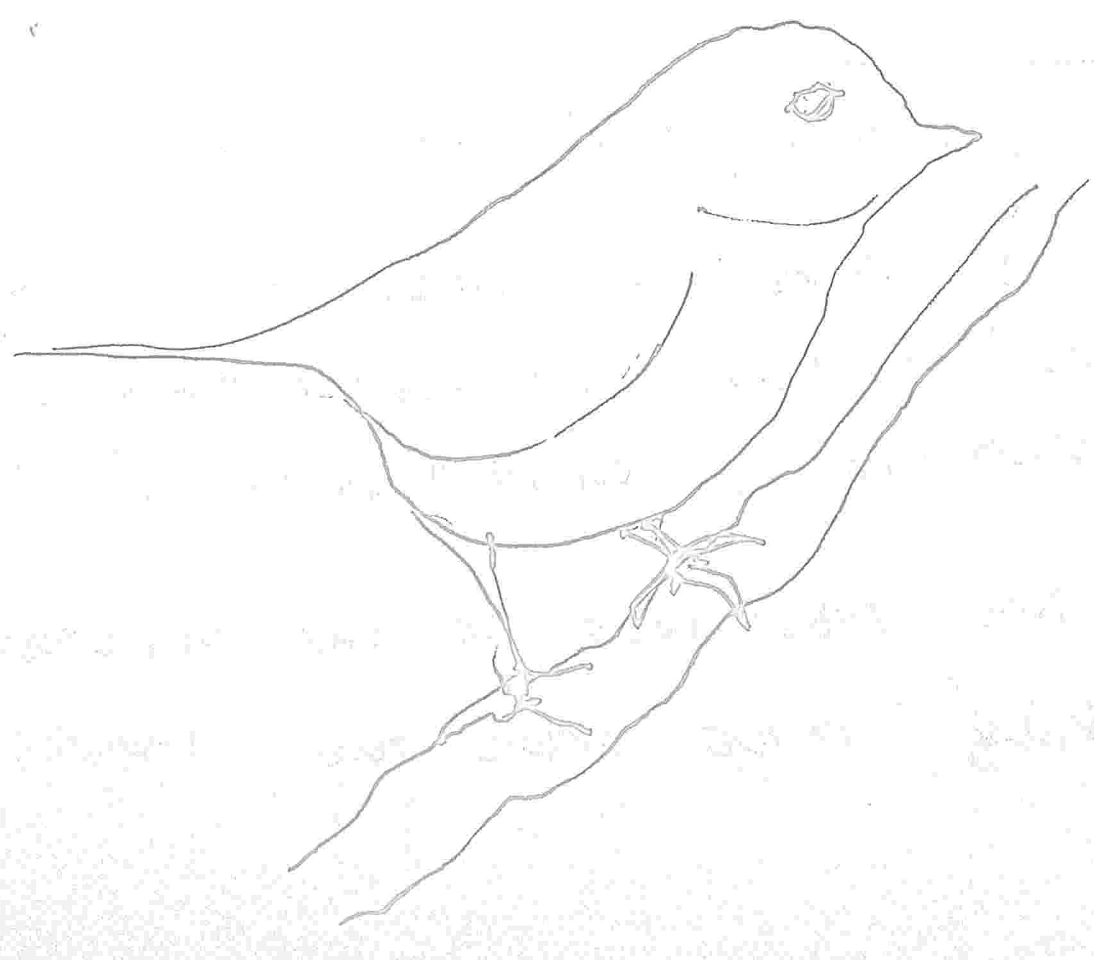
LYNX VS
SNOWSHOE HARE

NICHE PARTITION

INSECTIVOROUS WARBLERS - MANY SIMILAR SPECIES BREED IN CONIFEROUS FOREST.

ALPHAS SHOULD BE HIGH

DIFFERENT SPECIES WERE FEEDING ON THE DIFFERENT PART OF THE TREES.



NICHE DIFFERENTIATION WAS DOMINATING IN 70-80'S

- LIMITING SIMILARITY: NICHES HAD TO BE SUFFICIENTLY DIFFERENT TO ALLOW COEXISTENCE.
- RESOURCE PARTITIONING
- ASSEMBLY RULES (COMPATIBILITY)
- CHARACTER DISPLACEMENT

BUT!

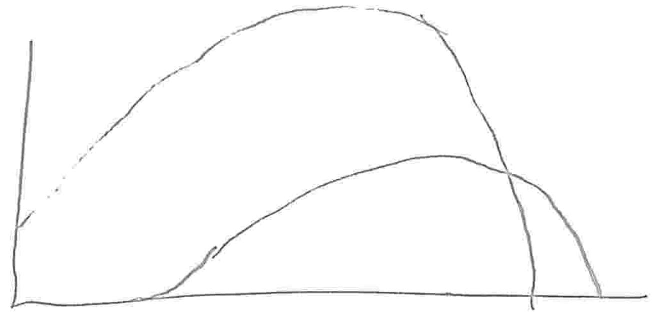
- MOST REAL COMMUNITIES ARE NOT AT A COMPETITIVE EQUILIBRIUM
- REAL POPULATIONS ARE KEPT BELOW CARRYING CAPACITY

PISASTER STARFISH PREDATION PREVENTS MUSSELS FROM COMPETITIVELY EXCLUDING OTHER SPECIES IN ROCKY INTERTIDAL COMMUNITIES, MAINTAINING BIODIVERSITY.

IN THE ABSENCE OF THE STARFISH, MUSSELS TAKE OVER THE ROCKS.

IMAGINE AN UNSTABLE PREDATOR-PREY SYSTEM.

SUPPOSE PREDATORS AND PREY SPECIES ARE ON THE ISOLATED ISLAND.



SUPPOSE NOW PREDATORS AND PREYS ARE LIVING IN AN ARCHIPELAGO OF MANY SUCH ISLANDS $\Rightarrow$ A METAPOPULATION IS SET UP, WHICH HAS SEVERAL STABILITY PROPERTIES.

THUS, METAPOPULATION CAN ALLOW PREDATOR-PREY COEXISTENCE.

GLOBAL COEXISTENCE:

ONE OF THE SPECIES MUST BE A TRANSIENT SPECIES.

K STRATEGY

STRONG COMPETITIVE ABILITY

↓ GROWTH

↑ GEN TIME

SIZE

↑ INVESTMENT IN SOMATIC GROWTH

r STRATEGY

FUGITIVE SPECIES

↑ GROWTH

↓ GEN. TIM

SIZE

↑ INVESTMENT IN GONAD GROWTH