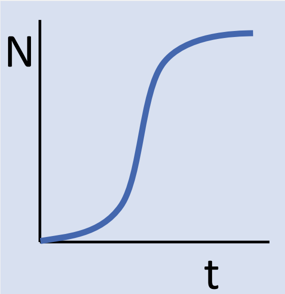


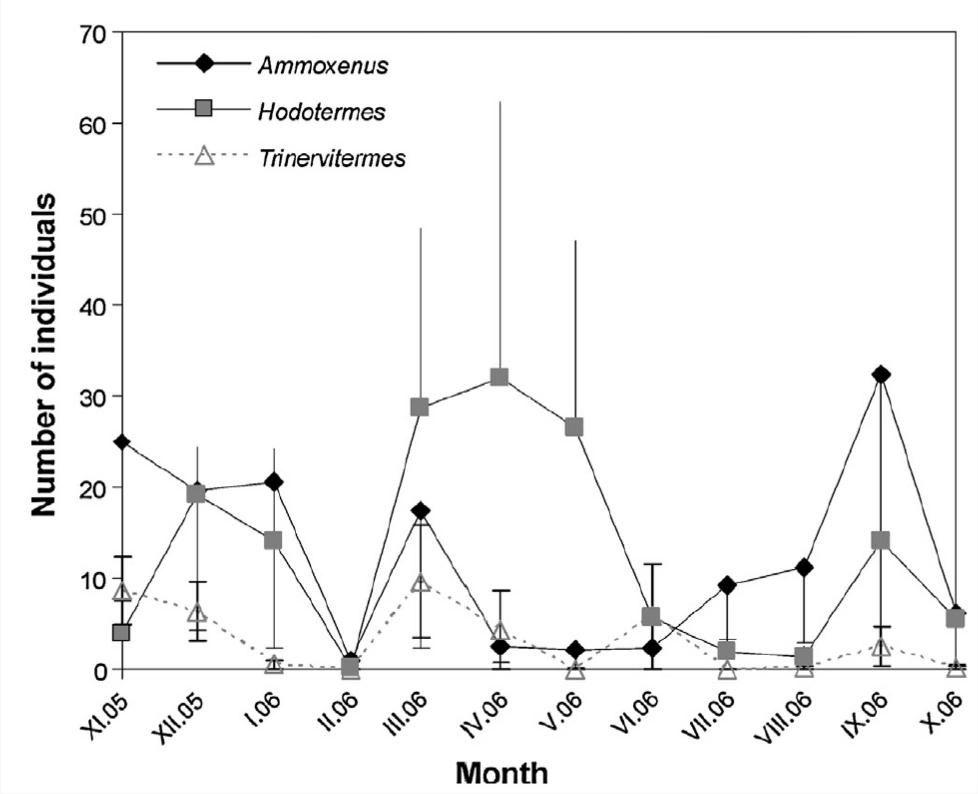
Stano Pekár

Population size

„Population Ecology of Animals“

Motivation example

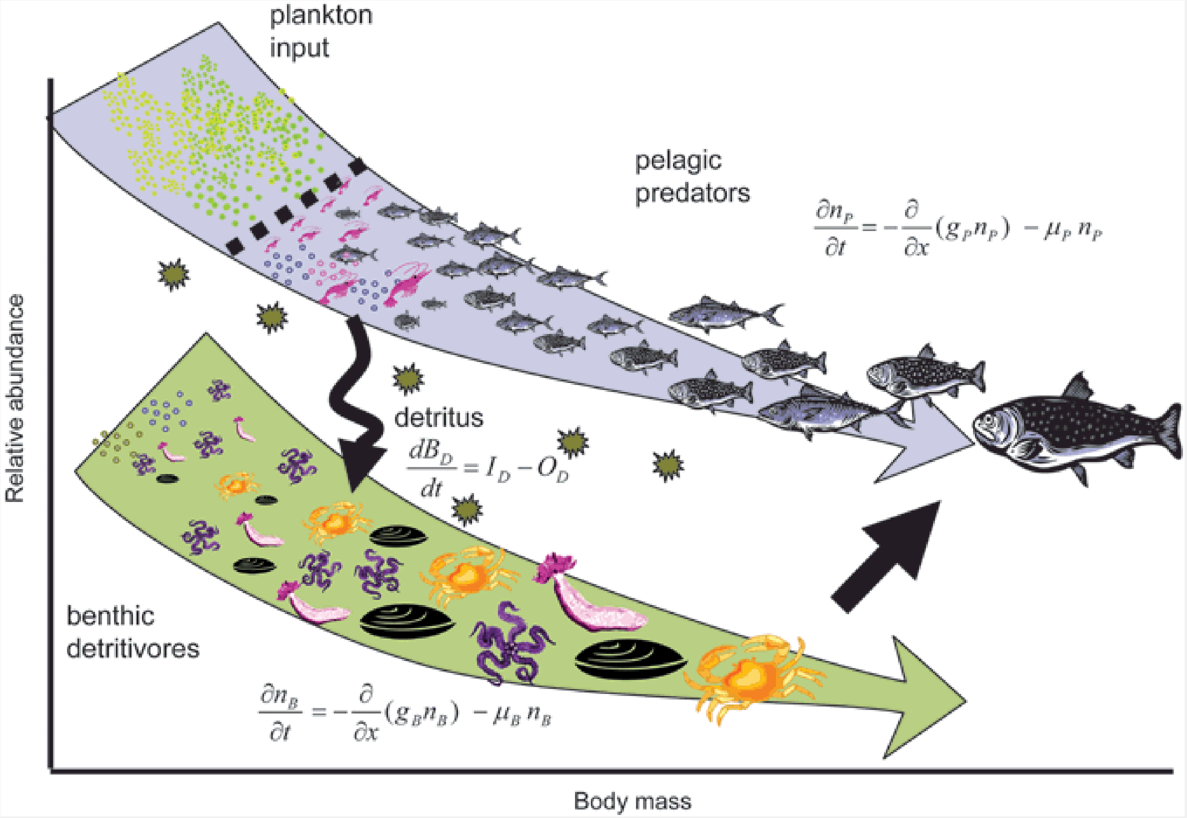
- **Haddad et al. (2016)**: The activity density of *Ammoxenus amphalodes* was tightly coupled to the activity density of *Hodotermes*, but not to that of *Trinervitermes*



Ecological density

- number of individuals is related to their body mass (M_i)

$$N_i \propto M_i^{3/4}$$



Blanchard et al. 2008

Population size

- changing in time and space – fluctuation
- smaller species have higher fluctuations than larger species
- may show oscillations (regular change) – regular cycles
- population size is based on census or sampling

- variance (*Var*) increases with mean (*E*) (Poisson distribution)

$$E_i = Var_i$$

- Coefficient of variation (*CV*) is useful measure:

$$CV = \frac{s}{\overline{N}}$$

  s .. standard deviation
- 95% confidence interval assuming normality:

$$\overline{N} \pm 1.96\sqrt{Var}$$

Population Estimates

- Absolute population density
- Relative population density

Absolute population density

- number of individuals (N_i) per unit area or unit of habitat (leaf, plant, host)
- p_i .. detection probability, C_i .. count

$$N_i = \frac{C_i}{p_i}$$

- Methods: capture-recapture, quadrats, distance, sampling (sieving, sweeping, extraction, etc.)

Relative population density

- number of individuals per effort
- **Effort** is a standardized unit (e.g., 10 traps, 1 observer in 1 day, 1 fishing boat with a net)
- population indices
- Methods: Sampling (trapping, fishing, pooting)

- Variation = population variability + sampling error
- may also include a temporal trend

Capture-recapture method

- effective for highly mobile individuals
- based on capture-mark-release-recapture
- Assumptions:
  - marked individuals are not affected and marks will not be lost
  - marked animals become mixed in the population
  - all individuals have same probability of capture
  - capture time must be short
- capture history is recorded using binary coding for every individual

Closed populations

- population does not change over sampling period - no death, birth, immigration, emigration

<u>Petersen-Lincoln estimator</u>:

$$\hat{N}_i = \frac{n_{i-1} . n_i}{r_{i(i-1)}}$$

N … number of individuals in population

n … number of released marked individuals

r … number of recaptured marked individuals

i … day of capture

$$\mathrm{SE} = \sqrt{\frac{n_{i-1}^2 . n_i . (n_i - r_{i(i-1)})}{r_{i(i-1)}^3}}$$

- For small populations (Chapman 1951)

$$\hat{N}_i = \frac{(n_{i-1} + 1).(n_i + 1)}{r_{i(i-1)} + 1} - 1$$

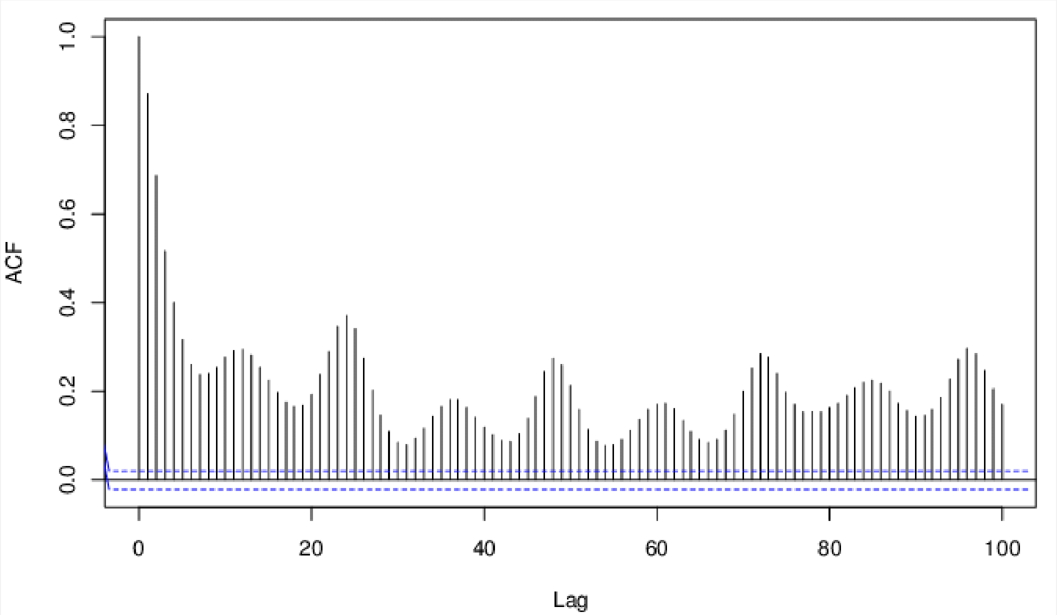
$$\mathrm{SE} = \sqrt{\frac{(n_{i-1} + 1).(n_i + 1).\left(n_{i-1} - r_{i(i-1)}\right).(n_i - r_{i(i-1)})}{\left(r_{i(i-1)} + 2\right).(r_{i(i-1)} + 1)^2}}$$

Open populations

- changes due to death, births, immigration, emigration
- Estimators: Jolly-Seber, Cormack-Jolly-Seber
- Assumptions:
  - all individuals have similar survival during capture dates
  - individuals are immediately released
  - emigration is complete
  - probabilities of capture and survival are independent of each other
- at least 3 sampling periods
- number of marked and re-captured individuals should be > 10

Population cycles

- regular changes in population size
- stable periodic oscillations
- cycles of the 1st (intraspecific competition - overcompensation) and 2nd (time-lag) order
- Time-series analysis – autocorrelogram is used to estimate period



Ecological models

- Aim: **to simulate (predict) what can happen**
- Model is tested by comparison with observed data

Realistic (practical) models - complex (many parameters), realistic, used to **simulate real situations**

Strategic (education) models - simple (few parameters), unrealistic, used for **understanding the model behaviour**

A model should be:

1. a satisfactory description of diverse systems
2. an aid to enlighten aspects of population dynamics
3. a system that can be incorporated into more complex models

Ecological models

Deterministic models - everything is predictable

Stochastic models - including random events

- Educational models are often deterministic, practical models are stochastic
- All biological processes are stochastic
- Deterministic models represent average state of stochastic processes
- Stochastic processes implemented in cellular automata
- Discrete models:
  - time is composed of discrete intervals or measured in generations
  - used for populations with synchronised reproduction (annual species)
  - modelled by difference equations

Ecological models

- Continuous models:
  - time is continual (very short intervals) thus change is instantaneous
  - used for populations with asynchronous and continuous overlapping reproduction
  - modelled by differential equations

Stability & Equilibrium

- how population changes in time
- stable equilibrium is a state (population density) to which a population will move after a perturbation