

Predation

“Populační ekologie živočichů“

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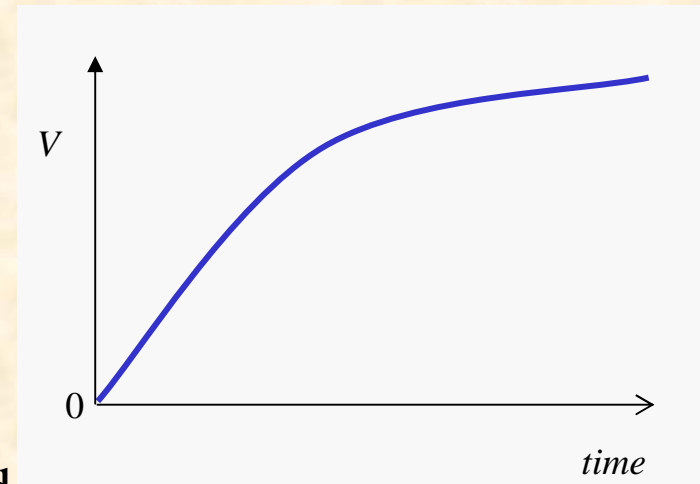
Plant-Herbivore

- ▶ consume small amount of many different plant species
- ▶ consume a lot during life to obtain sufficient amount of N
- ▶ grazers, granivores, frugivores, herbivores
- ▶ plants are not killed only reduced in biomass
- ▶ bottom-up control – herbivore abundance is regulated by quantity and quality of plants
- ▶ top-down control – herbivore abundance is regulated by enemies
- ▶ specialised herbivores (aphids) are alike parasites



Herbivory-regrowth model

- ▶ Turchin (2003)
- ▶ assumptions
 - continuous herbivory (grazing)
 - herbivore is polyphagous
 - plant biomass is homogenous
 - functional response Type II
 - herbivore density may be constant
 - only small quantity of biomass is removed
 - ▶ hyperbolic biomass growth because only small part of aboveground tissues is consumed



V .. plant biomass

H .. herbivore density

r .. intrinsic rate of regrowth

K .. carrying capacity

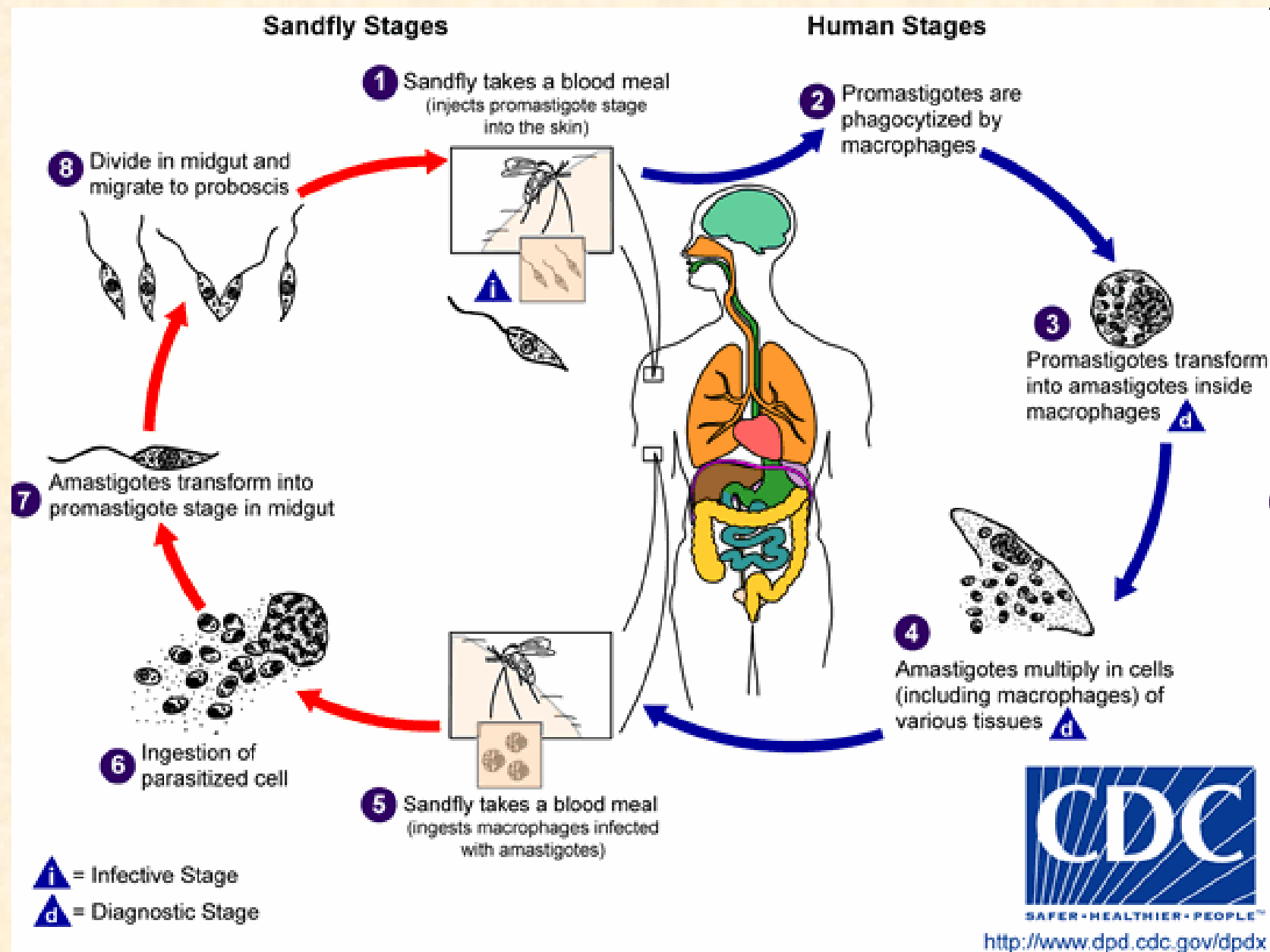
f .. efficiency of removal

T_h .. handling time

$$\frac{dV}{dt} = r \left(1 - \frac{V}{K} \right) - \frac{fHV}{1 + fHT_h}$$

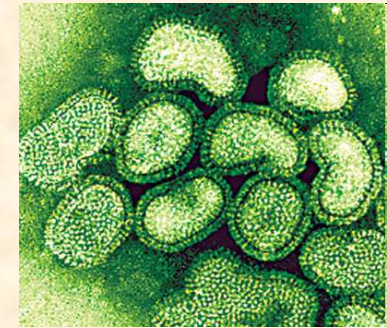
Host-Pathogen

Leishmania



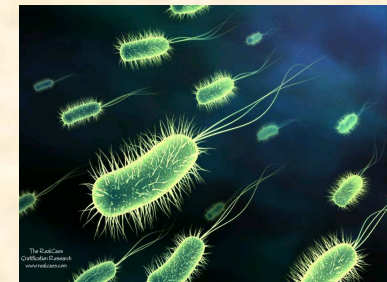
Agents

- ▶ microparasites: viruses, bacteria, protozoans
 - reproduce rapidly in host
 - level of infection depends not on the number of agents but on the host response



swine flu virus

- ▶ macroparasites - helminths
 - reproduce in a vector
 - level of infection depends on the number



E. coli (EHEC)

- ▶ incidence .. number of new infections per unit time
- ▶ prevalence .. proportion of population infected [%]



cercaria



nematode

Epidemiology

- ▶ predicts rates of disease spread
- ▶ predicts occurrence of epidemics
- ▶ predicts expected level of infection

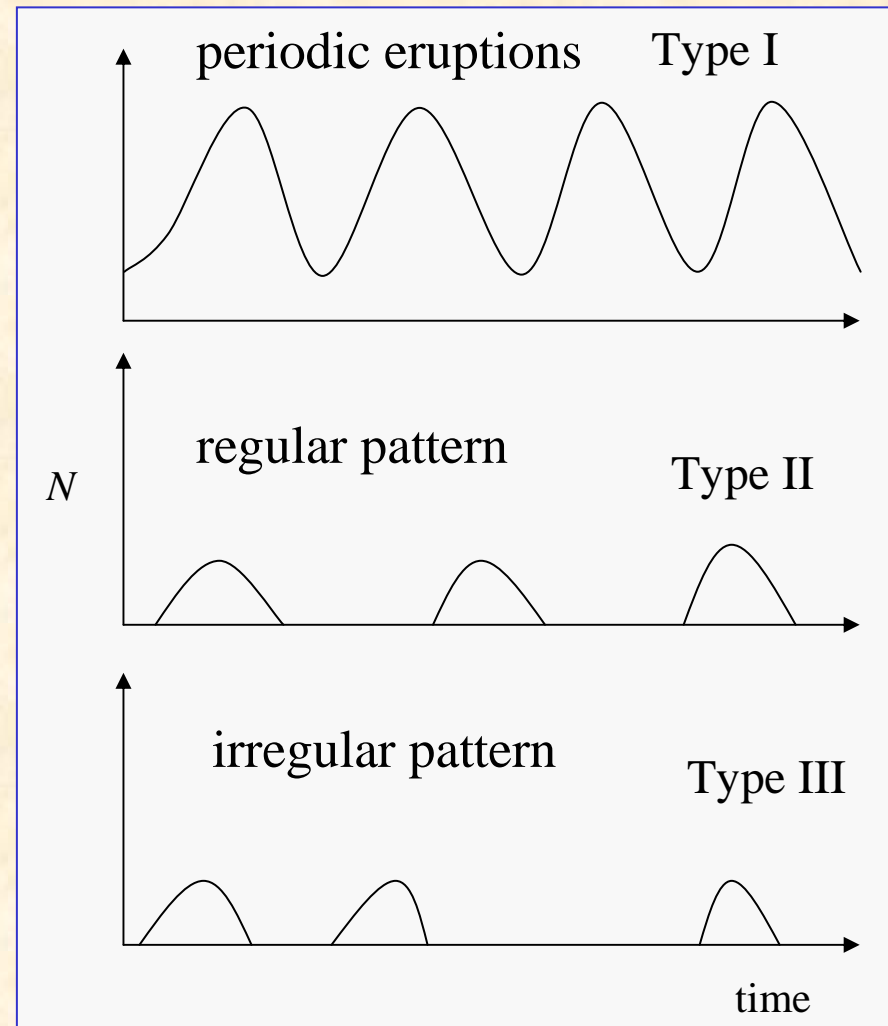
- ▶ number of human deaths caused by diseases exceeds that of all wars

- ▶ affects also animals
 - rinderpest introduced by Zebu cattle to South Africa in 1890
 - 90% buffalo population was wiped out

- ▶ biological control
 - *Cydia pomonella* granulosis virus



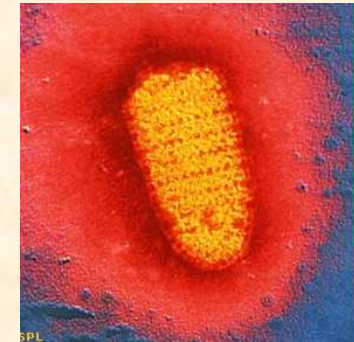
- ▶ epidemics occur in cycles
- ▶ follows 4 stages:
 - establishment - pathogen increases after invasion
 - persistence - pathogen persists within host population
 - spread - spreads to other non-infected regions, reaches peak
 - epidemics terminates



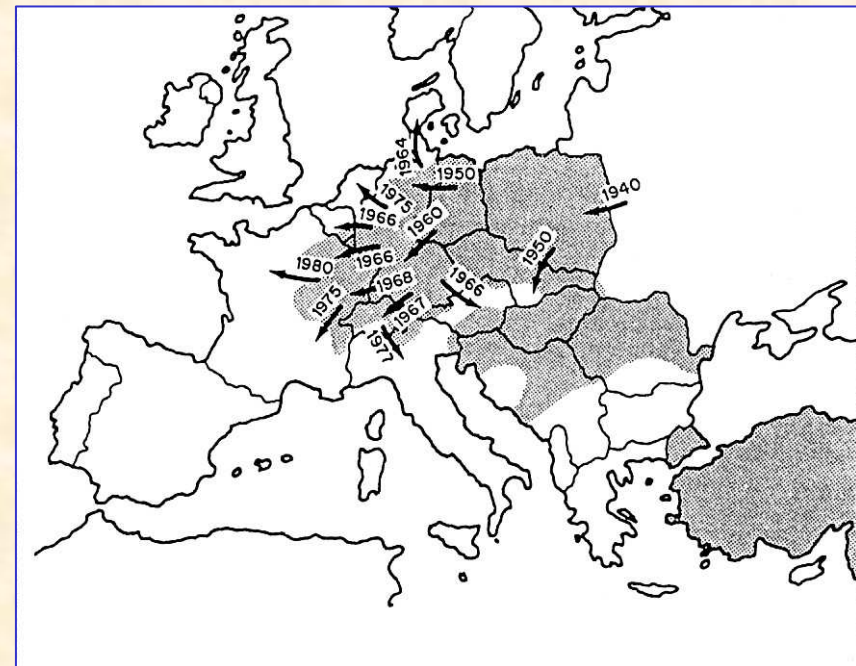
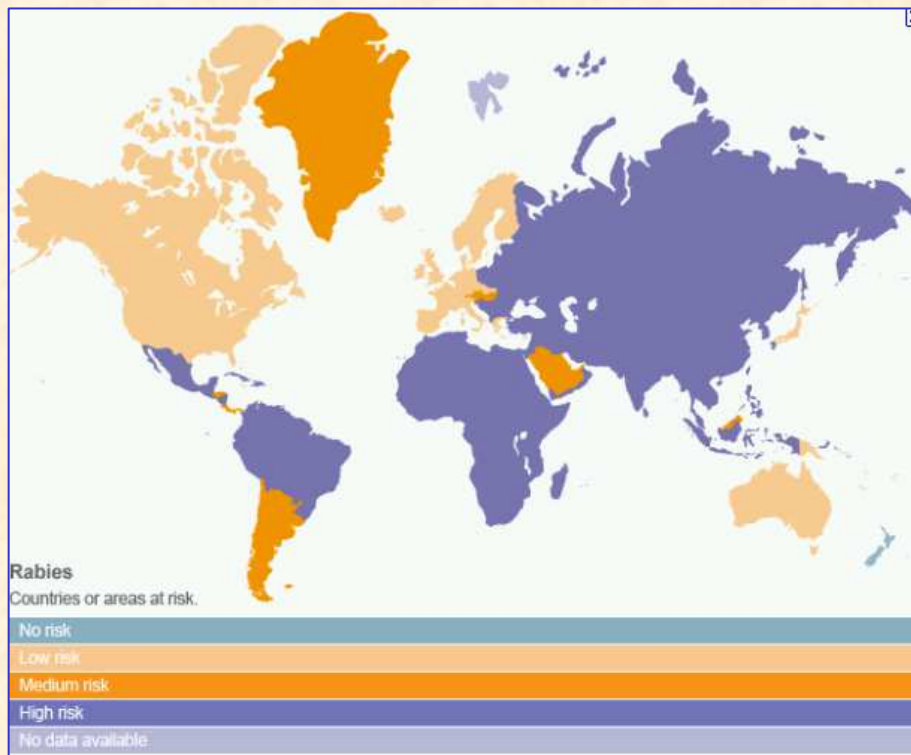
▶ rabies in Europe spread from Poland
1939

- hosts: foxes, badgers, roe-deer

▶ spread rate of 30-60 km/year

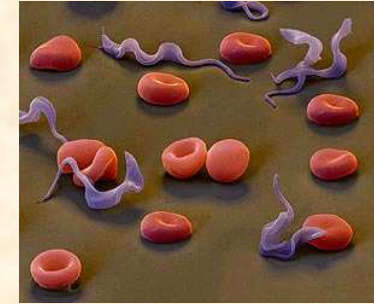


virus



Spread of rabies (Bacon 1985)

Host-pathogen/parasite system



- ▶ used to simulate spread of a disease in the human population or in the pest

- ▶ models:

- Kermack & McKendrick (1927)

- later developed by Anderson & May (1980, 1981)

- ▶ 3 components:

- S .. susceptible

- I .. infected

- R .. resistant/recovered and immune + dead individuals - can not transmit disease

- latent stage - infected but not infectious

- vectors (V) and pathogens (P)

- malaria is transmitted by mosquitoes, hosts become infected only when they have contact with the vector

- the number of vectors carrying the pathogens is important

- such system is further composed of uninfected and infected vectors

Kermack-McKendrick model

- ▶ β .. transmission rate - number of new infections per unit time
 βSI .. density-dependent transmission function (proportional to the number of contacts)
 - mass action
 - analogous to search efficiency in predator-prey model
- $1/\beta$.. average time for encountering infected individual

- ▶ γ .. recovery rate of infected hosts (either die or become immune)
 $\gamma = 1/\text{duration of disease}$

Assumptions:

- $S_0 \gg I_0$
- ignores population change (increase of S)
- incubation period is negligible

SI model

$$\frac{dS}{dt} = -\beta SI$$

$$\frac{dI}{dt} = \beta SI - \gamma I$$

Outbreaks

▶ outbreak (epidemics) will occur if $S_0 > \frac{\gamma}{\beta}$

- i.e. transmission threshold, when density of S is high

▶ making the population size small will halt the spread: $S_0 < \frac{\gamma}{\beta}$

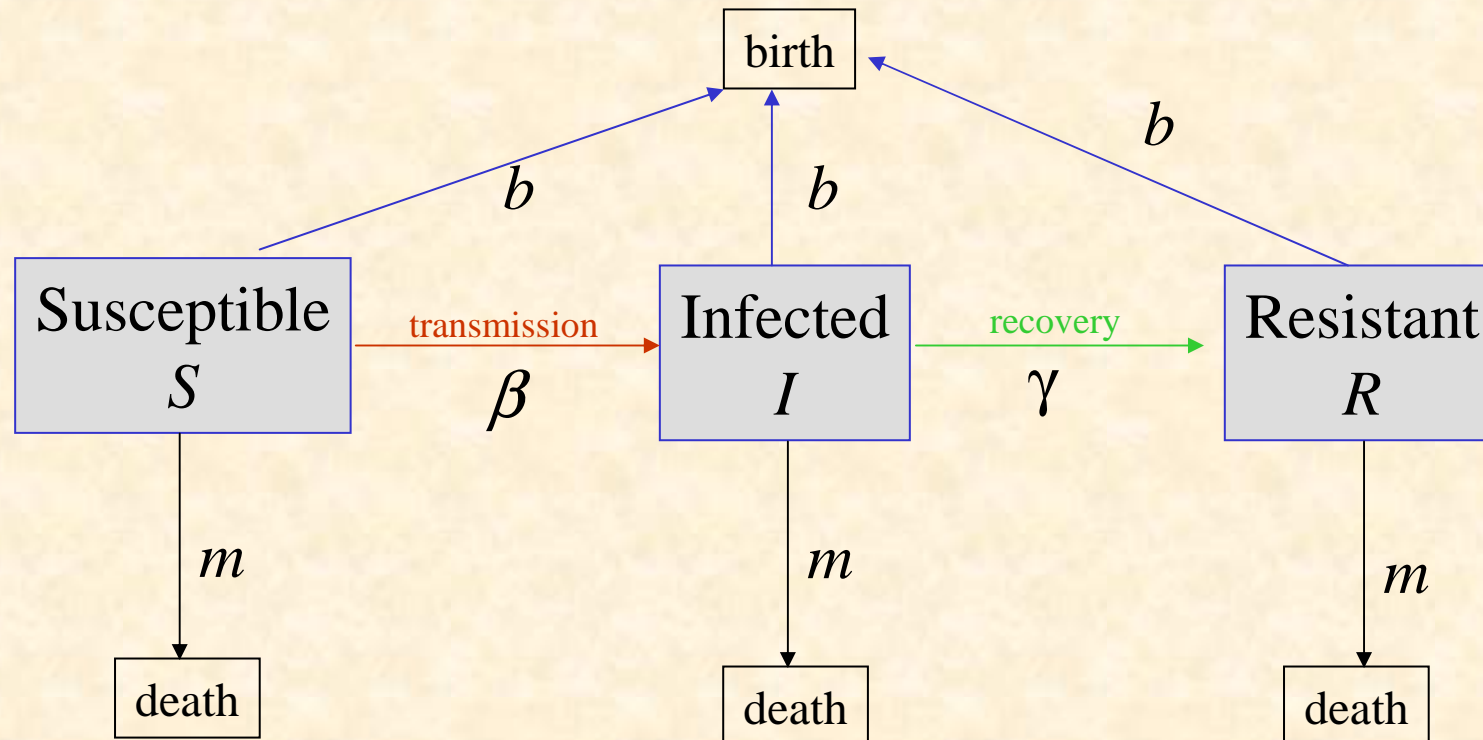
- e.g. by vaccination (not necessary to use for all)

▶ culling or isolation of I will stop disease spread

Anderson-May model

Assumptions:

- host population is dynamic
- newborns are susceptible
- b .. host birth rate
= $1/\text{host life-span}$, given exponential growth and constant population size
- m .. host mortality due to other causes



SIR model

$$\frac{dS}{dt} = b(S + I + R) - \beta SI - mS$$

$$\frac{dI}{dt} = \beta SI - \gamma I - mI$$

$$\frac{dR}{dt} = \gamma I - mR$$

N .. total population of hosts per area: $N = S + I + R$

- ▶ R_0 .. basic reproductive rate of the disease
- number of secondary cases that primary infection produces
- if $R_0 > 1$.. outbreak is plausible

$$R_0 = \frac{\beta N}{b + \gamma + m}$$

Biological control

- ▶ fast biocontrol effect is achieved only with viruses with high β
- ▶ regulation is possible if pest $r \ll$ mortality due to disease
- ▶ low host population is achieved with pathogens with lower β

Population dynamic of a moth and the associated granulosis virus

