Predation

“Populační ekologie živočichů“

Stano Pekár

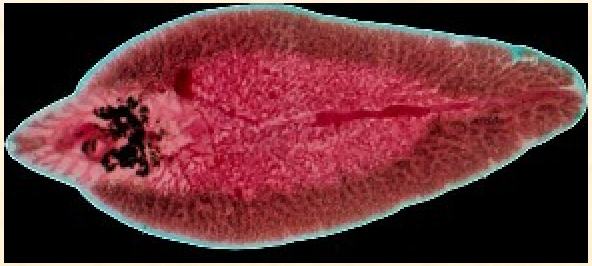
Predator categories

True predators - catch several animals and gain sustenance for their own fitness (spiders, lions)

Parasitoids - consume about single host, free adults but larvae developing on or within a host, consuming it prior to pupation (Hymenoptera, Diptera)

Parasites - live in close association with a host, gain sustenance from the host, but often do not cause mortality (Acari, Trematodes)

Herbivores - feed on plants, may totally consume plants (seed-eaters) or partially (aphids, cows)



Dietary specialisation

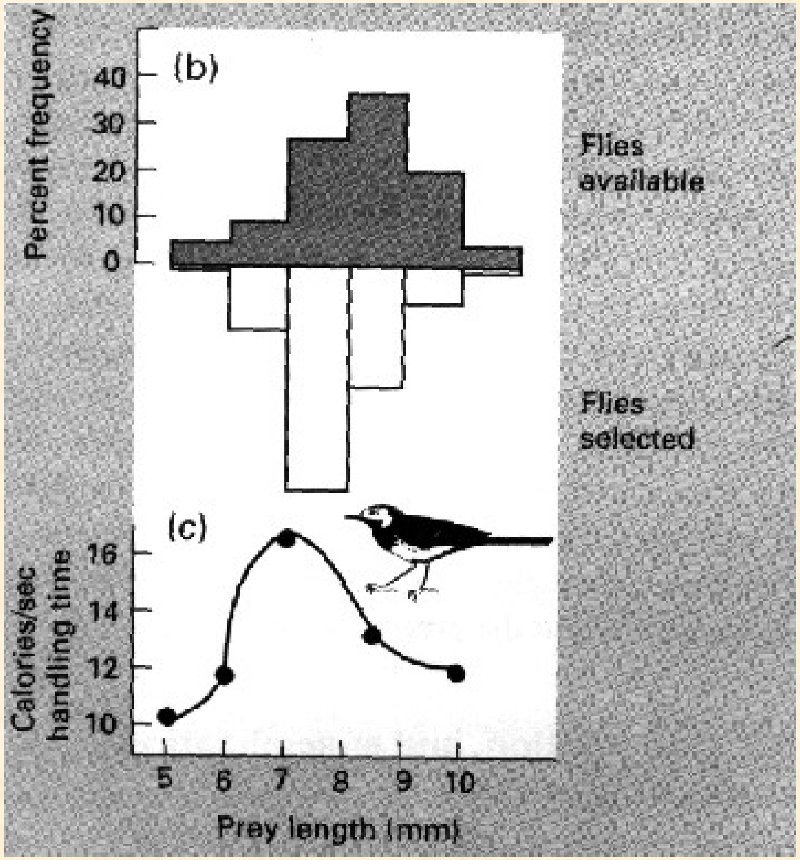
- monophagous (single prey type), stenophagous (few prey types)
- oligophagous (more prey types)
- polyphagous/euryphagous (many prey types)

\- not capable of consuming all prey types

- type can based on taxonomy, size, sex, ontogenetic stage

- predators choose most profitable prey

\- select prey items for which the gain is greatest (energy intake per time spent handling)



Krebs (1978)

- Ecological context – stenophagy vs. euryphagy/polyphagy
- Evolutionary context – generalist vs. specialist

Ecological dimension

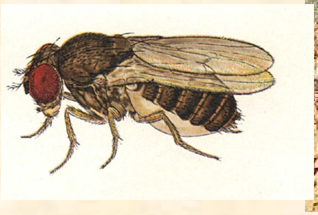
Evolutionary dimension

Euryphagous generalist	**Stenophagous generalist**
Euryphagous specialist	**Stenophagous specialist**

Pekár & Toft (2015)

- predators tend to specialise to a greater or lesser extent during evolution
- monophagy evolved where prey is abundant and exerts pressures which demands adaptations (e.g. morphological, behavioural, metabolic)
- polyphagy evolved where prey was unpredictable

- <u>true predators</u> - majority are polyphagous
- <u>parasites</u> - commonly monophagous due to intimate association with hosts, their life-cycle is tuned to that of their host
- <u>parasitoids</u> - often monophagous but some are polyphagous presumably because adults are free living
- <u>herbivores</u> - rather polyphagous, many insect herbivores are specialised as a result of adaptation to plant secondary metabolites (*Drosophila pachea* consumes rotten tissues of *Senita* cactus which contain poisonous alkaloids)

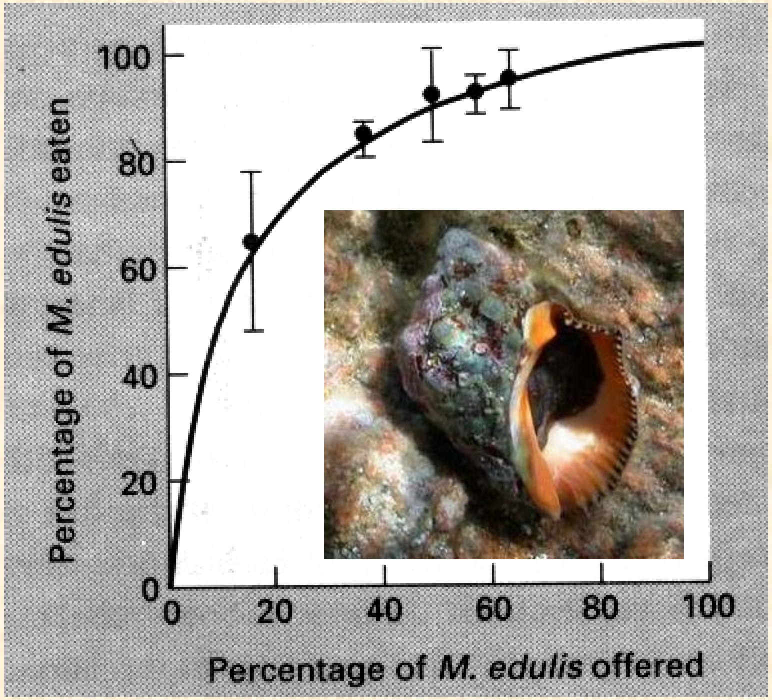


Preference & switching

- even polyphagous predators prefer certain prey

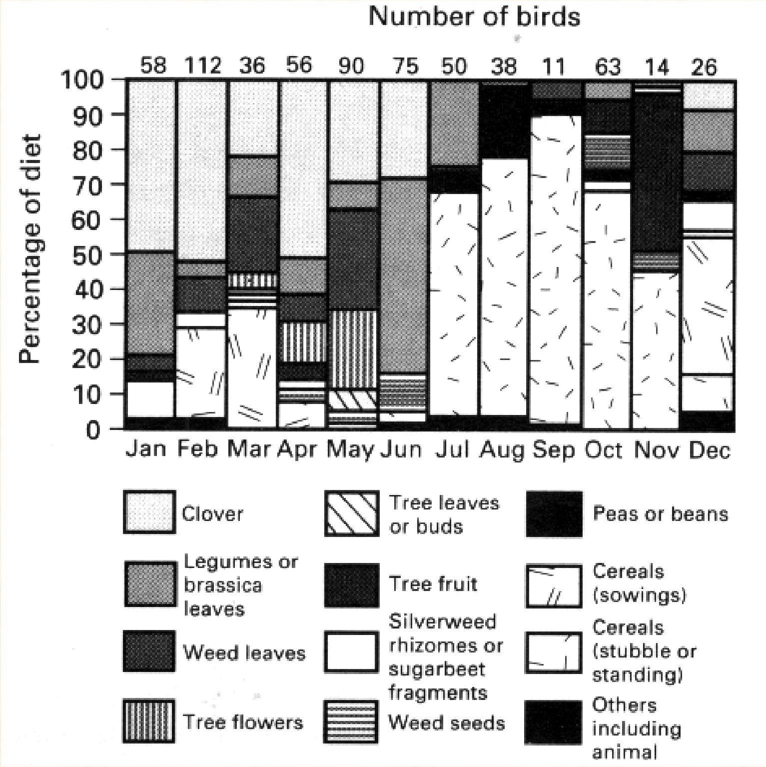
- constant preference irrespective of prey density
- switching to more common prey

Thais preferred *Mytilus edulis* over *M. californianus*



Murdoch & Oaten (1975)

Seasonal shift in *Columba*

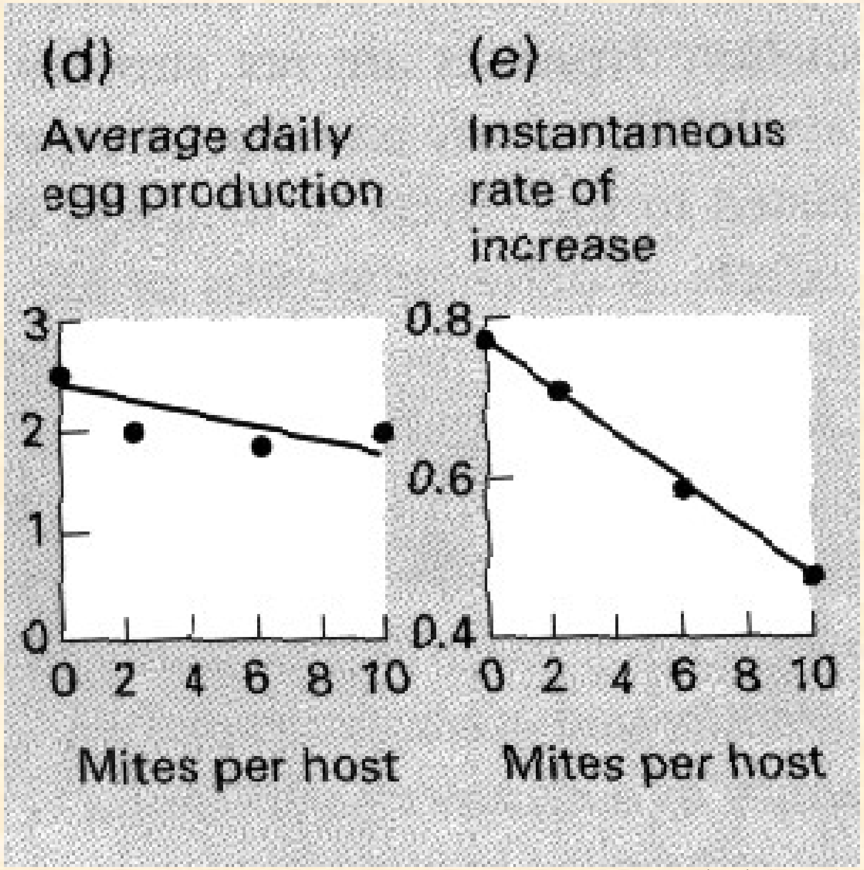


Murton et al. (1964)

Effect on fitness of prey

- predation has positive effect on population of prey because reduce intraspecific competition - stabilise prey population dynamic
- true predators and parasitoids reduce fitness of individual prey to „0“ - *Mustela* consumed mainly solitary and injured individuals, so it has little effect on the *Ondatra* population growth
- caterpillars defoliate partially so that re-growth can occur, but cause reduction in fertility
- parasites - reduce fitness partially, effect is correlated with the burden

Negative effect of mite parasites on *Hydrometra*



Lanciani (1975)

Total response

- mortality of prey increases with the prey density due to predation

- Total response of a predator is composed of:

- individual response to changing prey density → **functional response**

- population response to changing desnity of prey → **numerical response**

- Holling (1959) found that predation rate of individual predator increased with increasing prey density
- defined three types of functional responses
- more types were defined later

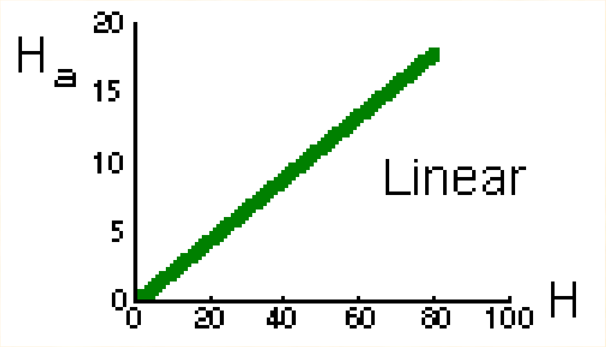
Functional response

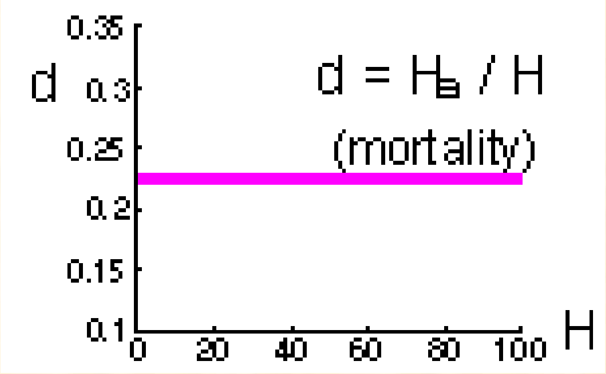
Type I

- number of captured prey is proportional to density

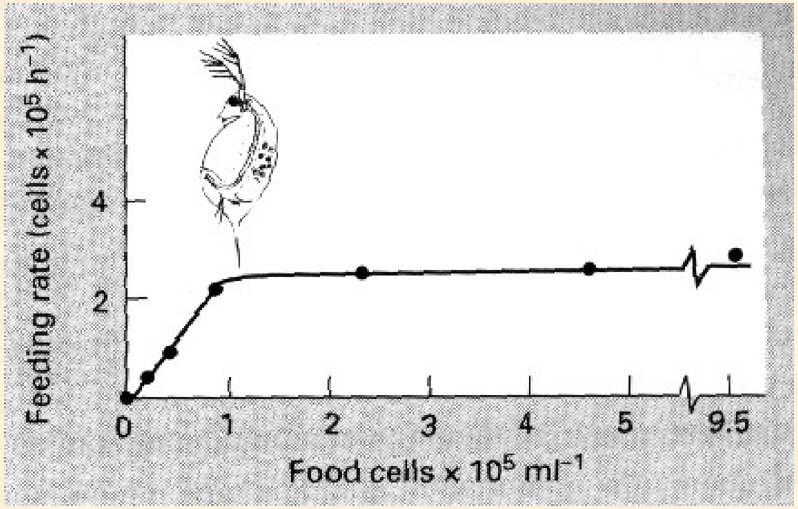
- prey mortality is constant

- less common
- found in passive predators (web-building spiders)
- the handling time exerts its effect suddenly





Daphnia feeding on *Saccharomyces* - above 10^5 cells *Daphnia* is unable to swallow all food

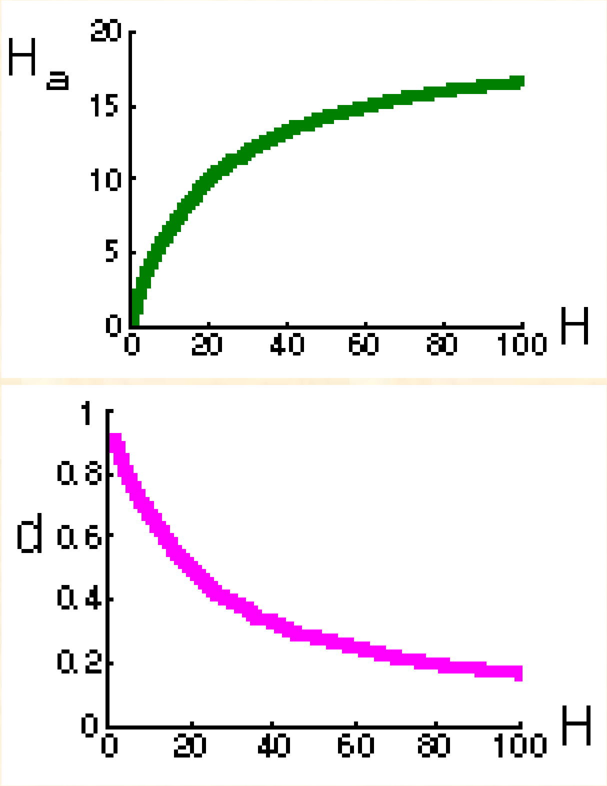


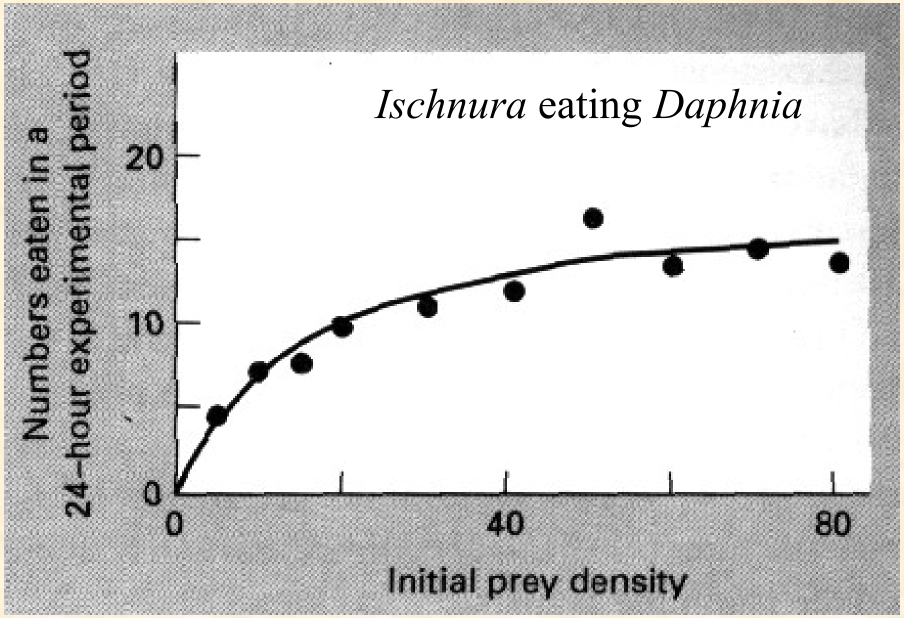
Rigler (1961)

Type II

- predators cause maximum mortality at low prey density
- as prey density increases, search becomes trivial and handling takes up increasing portion of the time
- saturation (due to handling) of predation at high densities

- prey mortality declines with density



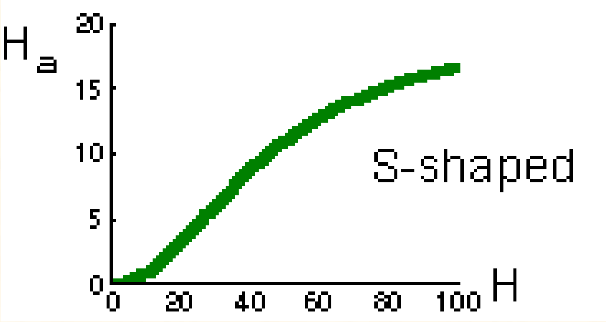


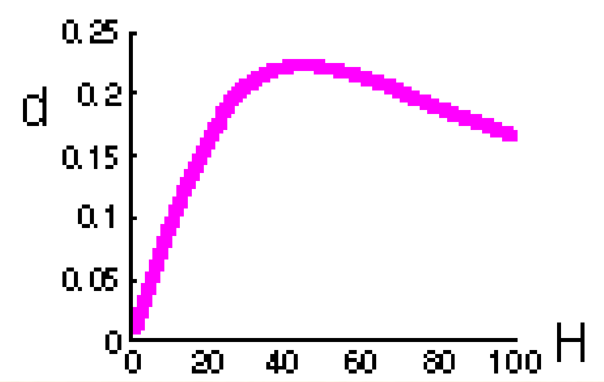
Thompson (1975)

Type III

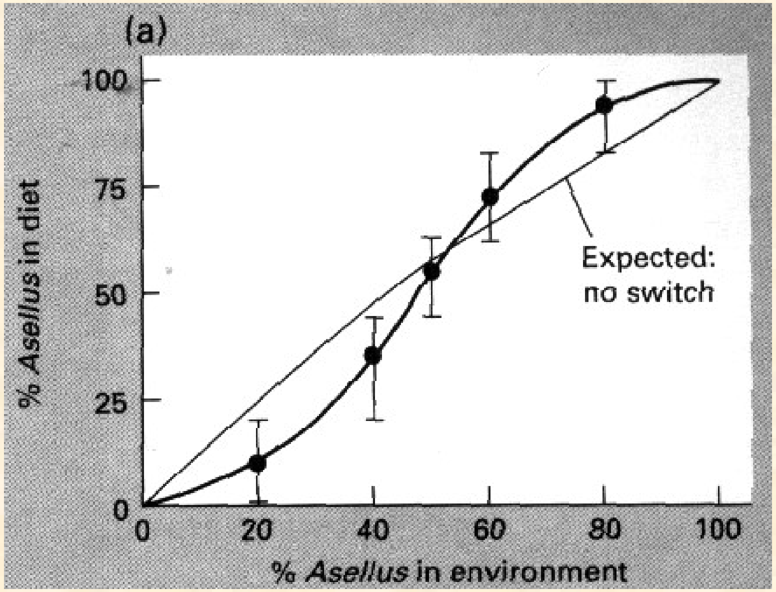
- when attack rate increases or handling time decreases with increasing density
- predators develop search image (e.g. respond to kairomones)
- polyphagous predators switch to the most abundant prey

- prey mortality increases then declines





Notonecta switched from *Cleon* to *Asellus* based on its abundance



Lawton et al. (1974)

Models of response

T .. total time
T_S .. searching time - searching for prey
T_H .. handling time - handling prey (chasing, killing, eating, digesting)

$$T = T_S + T_H$$

H .. prey density
H_a .. number of captured prey
a .. capture efficiency or "search rate"

Type I

- consumption rate of a predator is unlimited
- $T_H = 0$ so $T = T_S$

$$H_a = aHT_S$$

Type II

- consumption rate of a predator is limited because even if no time is needed for search, predator still needs to spend time on prey handling
- $T_H > 0$ so $T = T_S + T_H$
- predator captures H_a prey during T

$$T_H = H_a T_h$$

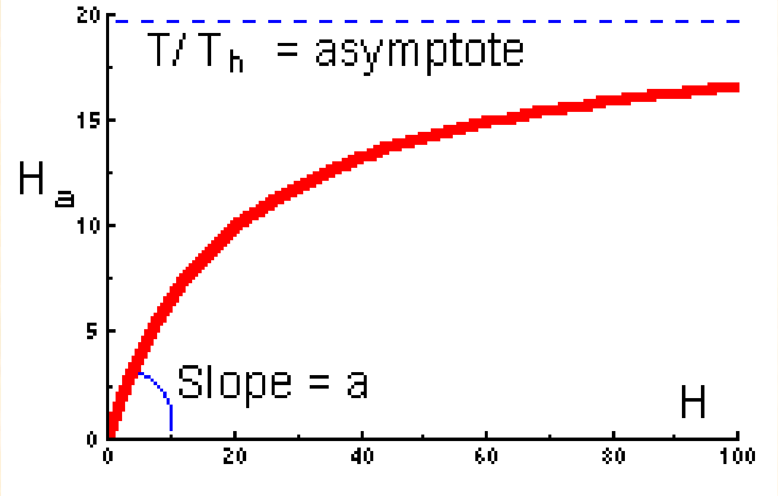
T_h .. time spent on handling 1 prey

$$H_a = aHT_S \rightarrow T_S = \frac{H_a}{aH}$$

- at low density predator spends most of the time searching, at high density on prey handling

$$T = T_H + T_S = H_a T_h + \frac{H_a}{aH}$$

$$H_a = \frac{aHT}{1 + aHT_h}$$



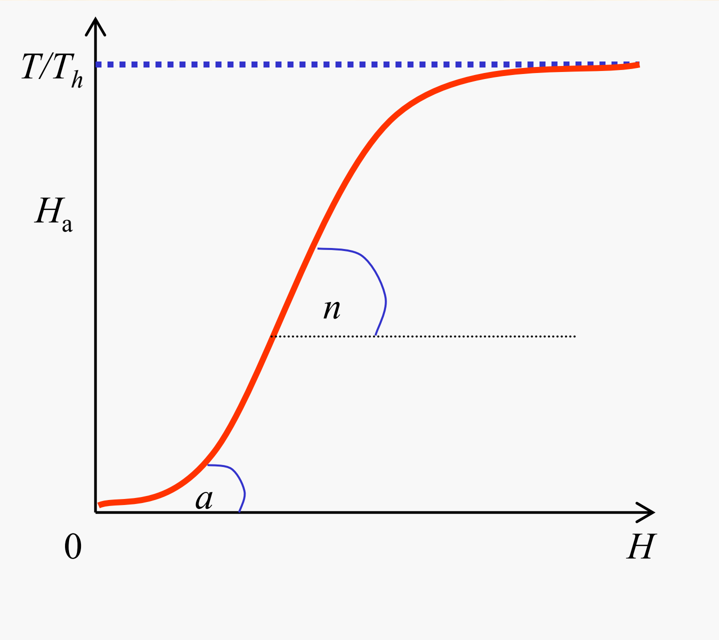
Type III

- consumption increases at low densities and decreases at higher densities

n .. rate of increased consumption at higher densities
if $n = 1 \rightarrow$ Type II

a .. rate of increase at low densities

$$H_a = \frac{aTH^n}{1 + aT_h H^n}$$



Numerical response

Increase of predator population may result from:

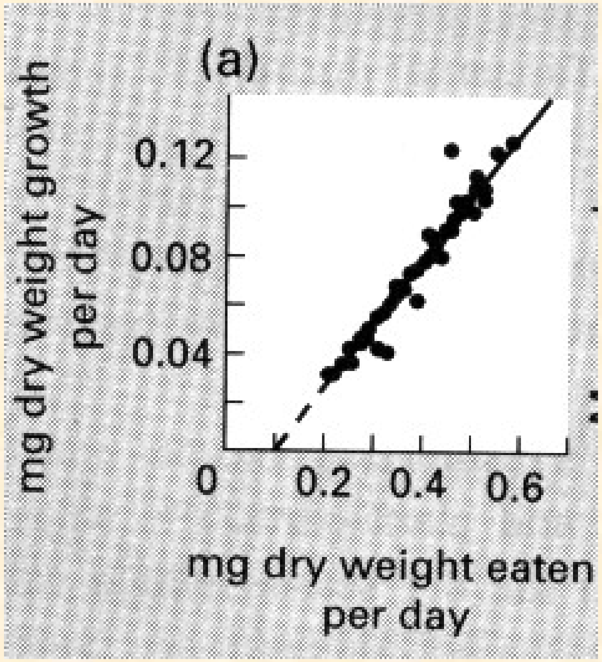
- **increased rate of reproduction**

- the more prey is consumed the more energy can predator allocate to reproduction
- delayed response

- parasitoids - one host is sufficient
- predators, herbivores, parasites

- certain quantity of prey tissue is required for basic maintenance = lower threshold

Growth rate in *Linyphia*



Turnbull (1962)

attraction of predators to prey aggregations

- immediate response
- aggregated distribution makes search of predators more profitable

- conversion of prey into predator numbers (P):

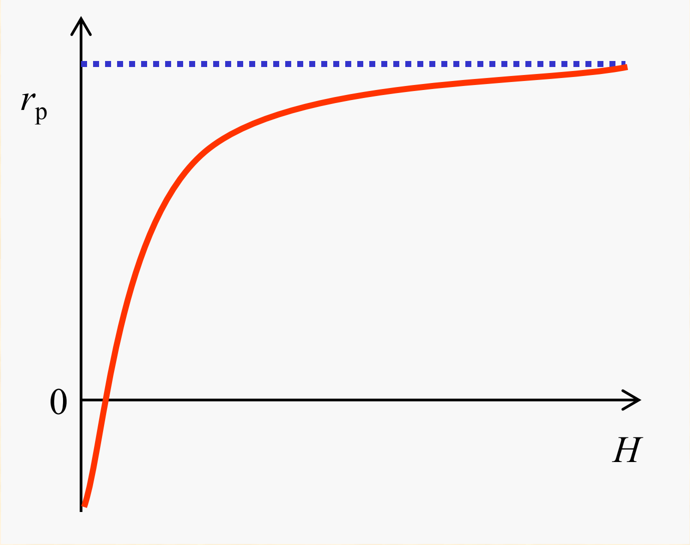
$$\frac{\mathrm{d}P}{\mathrm{d}t} = faHP - dP$$

f .. conversion efficiency
d .. mortality of predators

- Ivlev (1955) model

$$r = a(1 - e^{-fV}) - d$$

V .. amount of prey
a .. search rate
f .. conversion efficiency
d .. mortality of predators

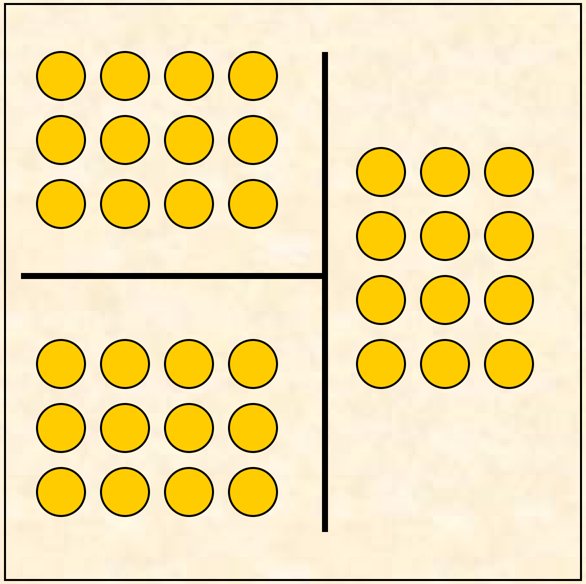


Aggregation

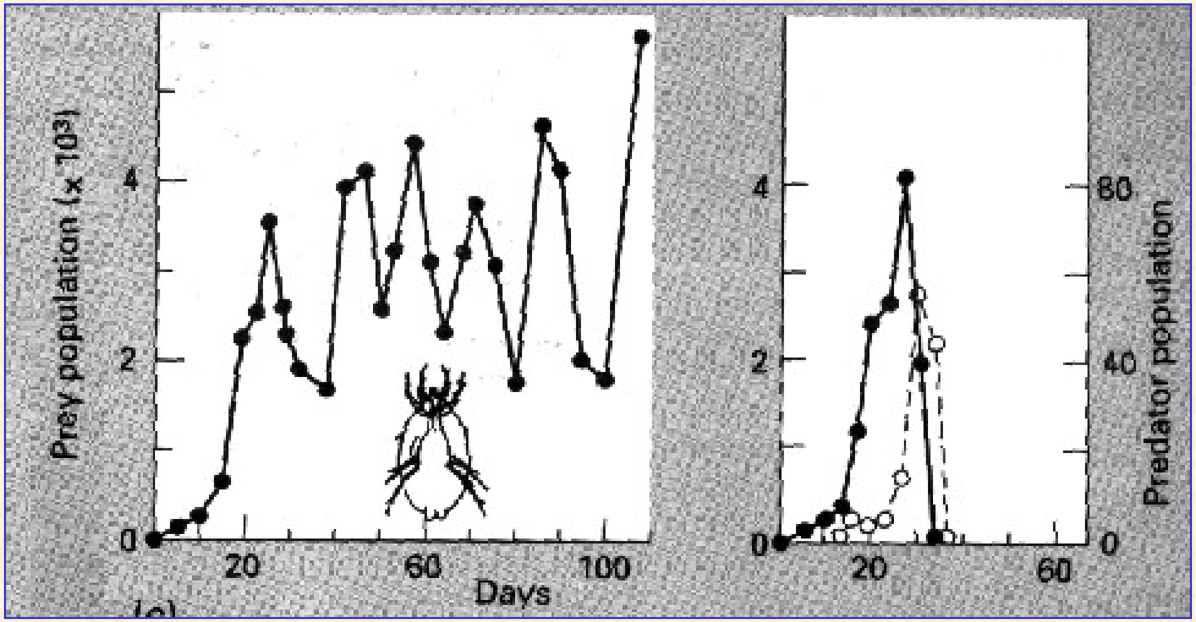
- instead of concentration on profitable patches perspective predators and prey may play "hide-and-seek"

- Huffaker (1958): *Typhlodromus* captured *Eotetranychus* that fed upon oranges
  - *Eotetranychus* maintained fluctuating density
  - addition of *Typhlodromus* led to extinction of both

Experimental setup



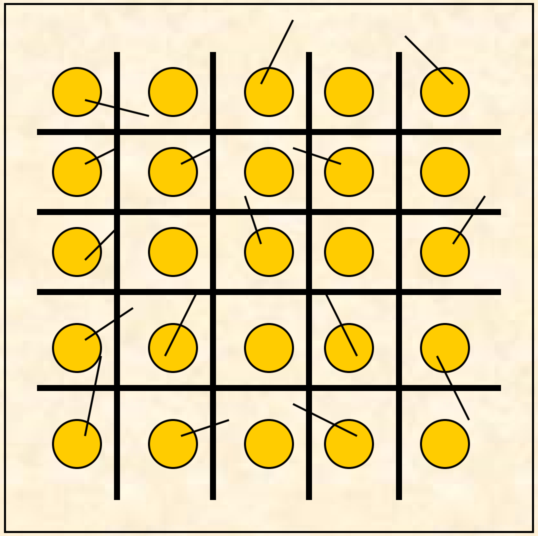
Eotetranychus population dynamic — Predator-prey dynamic



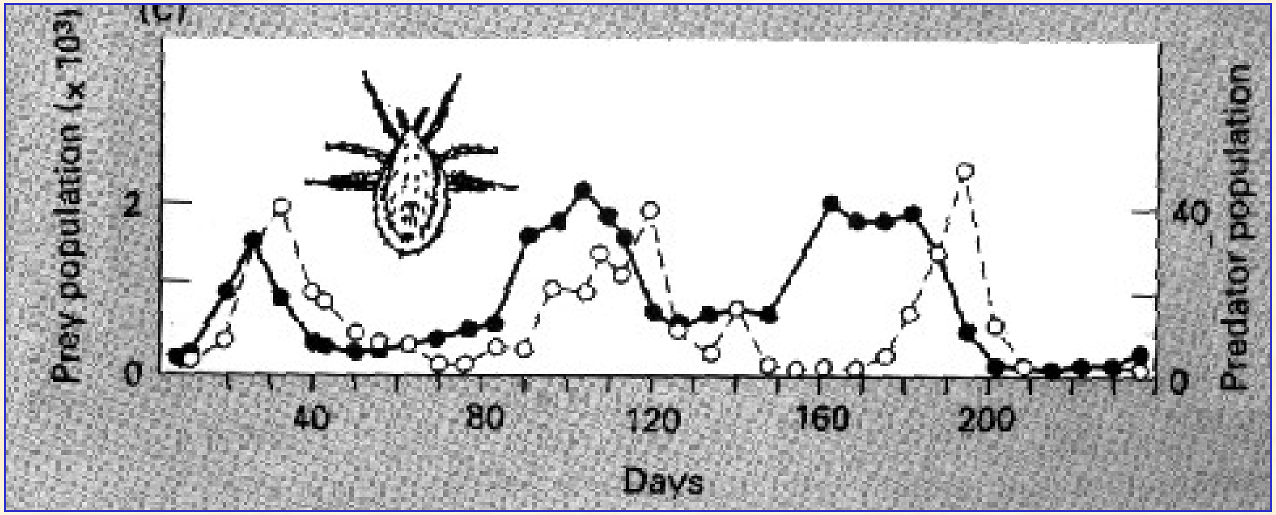
- making environment patchy
- by placing Vaseline barriers
- facilitating dispersal by adding sticks

- each patch was unstable but whole microcosmos was stable
- patch with prey only → rapid increase of prey
- patches with predators only → rapid death of predator
- patches with both → predator consumed prey

Altered experimental setup



Sustained oscillations of the predator-prey system

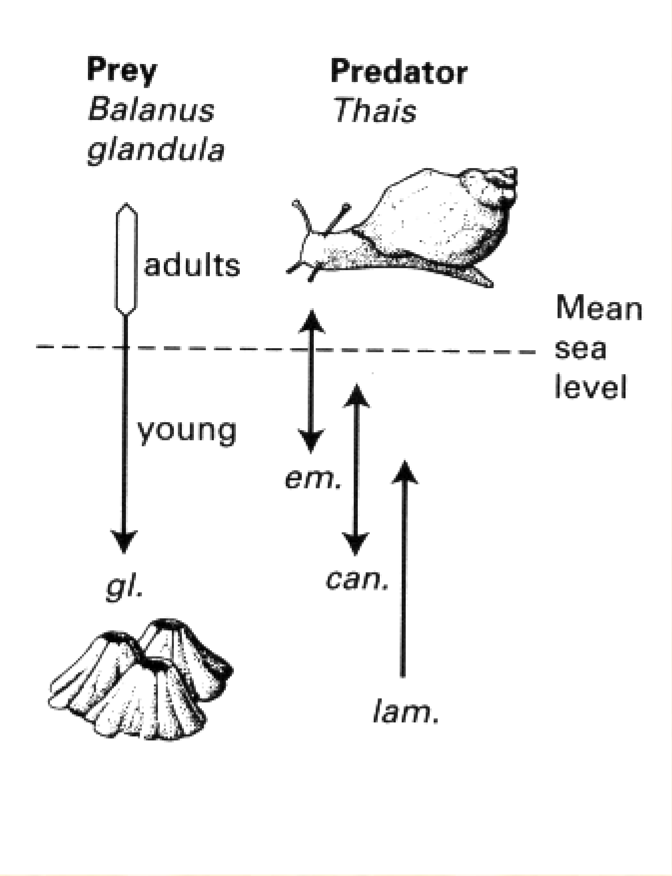


Refuge

- For fixed proportion of prey - certain proportion of *Ephestia* caterpillars buried deep enough in flour are not attacked by *Venturia* with short ovipositors

- For fixed number of prey
- adult *Balanus* occur in the upper zone where *Thais* can not get during short high tide thus consumes only juveniles
- a fixed number of *Balanus* is protected from predation irrespective of *Thais* density

- both refuge types stabilise the interaction



Connell (1970)