

Predation

“Populační ekologie živočichů“

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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)

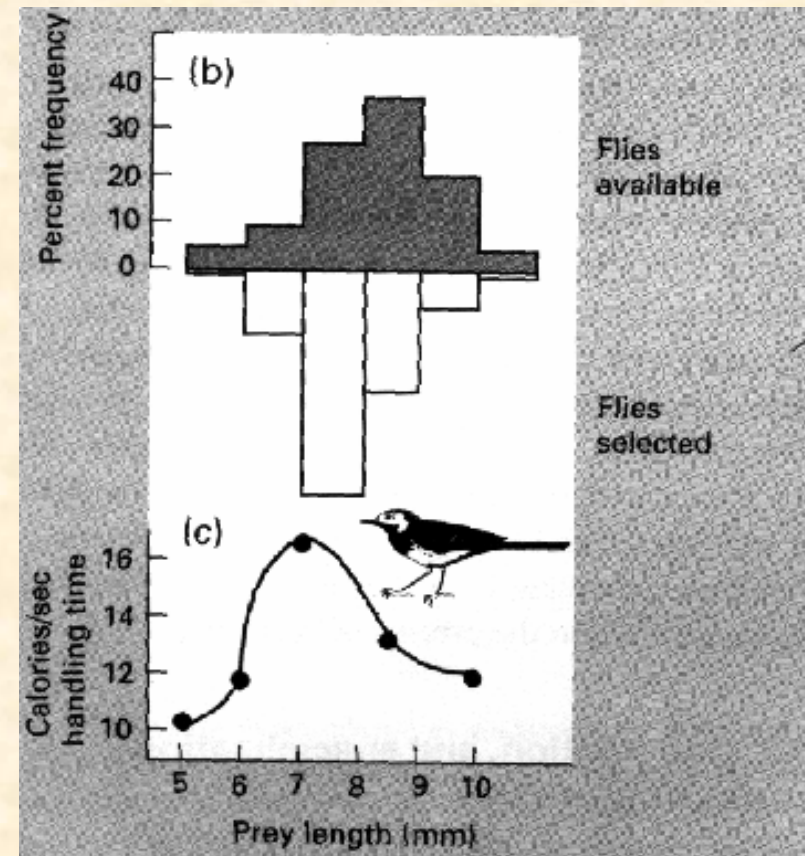
Parasites - live in close association with a host, gain sustenance from the host, but often do not cause mortality (Acari, Trematodes)

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

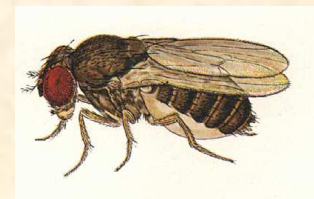


Dietary specialisation

- ▶ monophagous (single prey type)
 - ▶ oligophagous (few prey types)
 - ▶ polyphagous/euryphagous (many prey types)
- not capable of consuming all prey types
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- ▶ predators choose most profitable prey
 - select prey items for which the gain is greatest (energy intake per time spent handling)



- ▶ 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)
 - polyphagy evolved where prey was unpredictable
- ▶ true predators - majority are polyphagous
- ▶ parasites - commonly monophagous due to intimate association with hosts, their life-cycle is tuned to that of their host
- ▶ parasitoids - often monophagous but some are polyphagous presumably because adults are free living
- ▶ herbivores - 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)

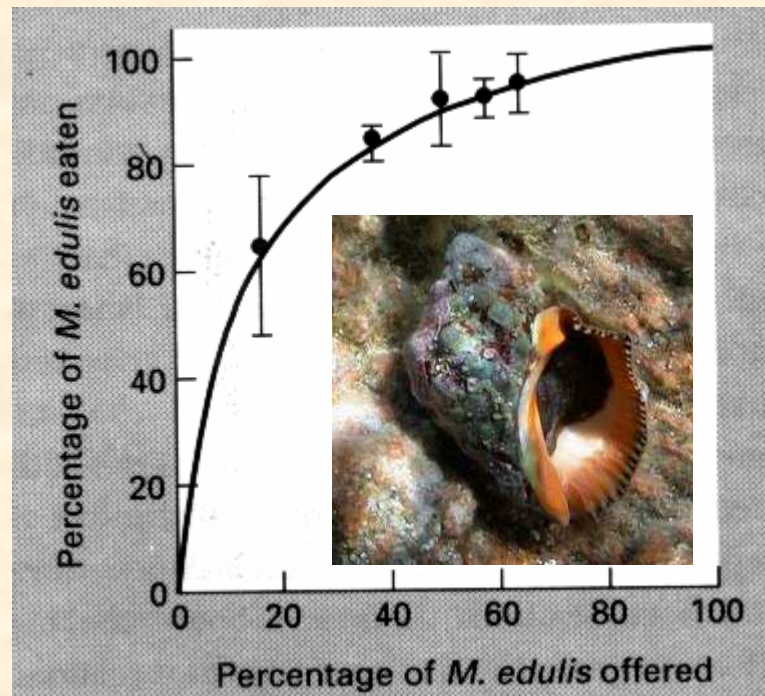


Preference & switching

- ▶ even polyphagous predators prefer certain prey
- constant preference irrespective of prey density
- switching to more common prey

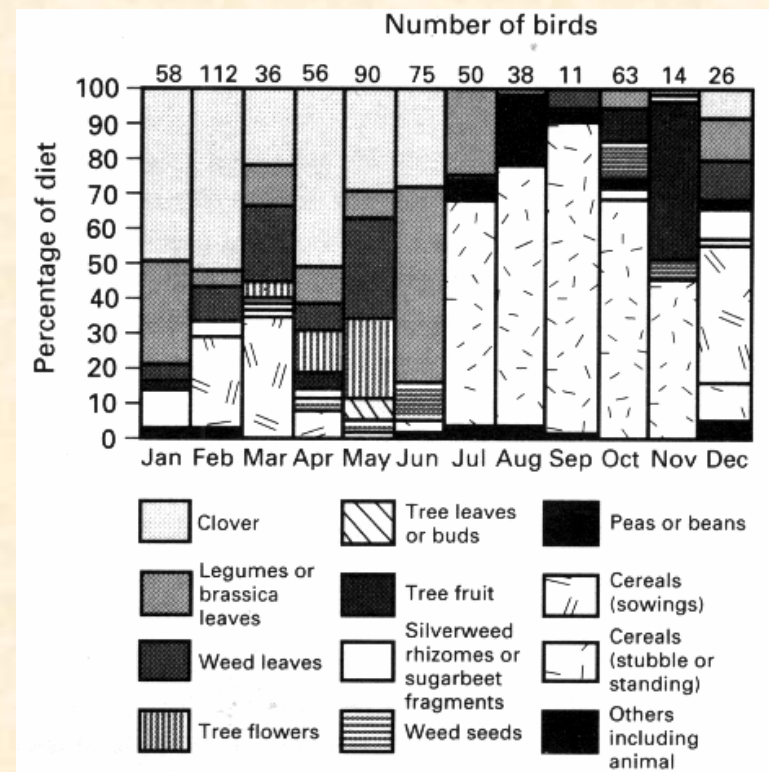


Thais preferred *Mytilus edulis* over *M. californianus*



Murdoch & Oaten (1975)

Seasonal shift in *Columba*

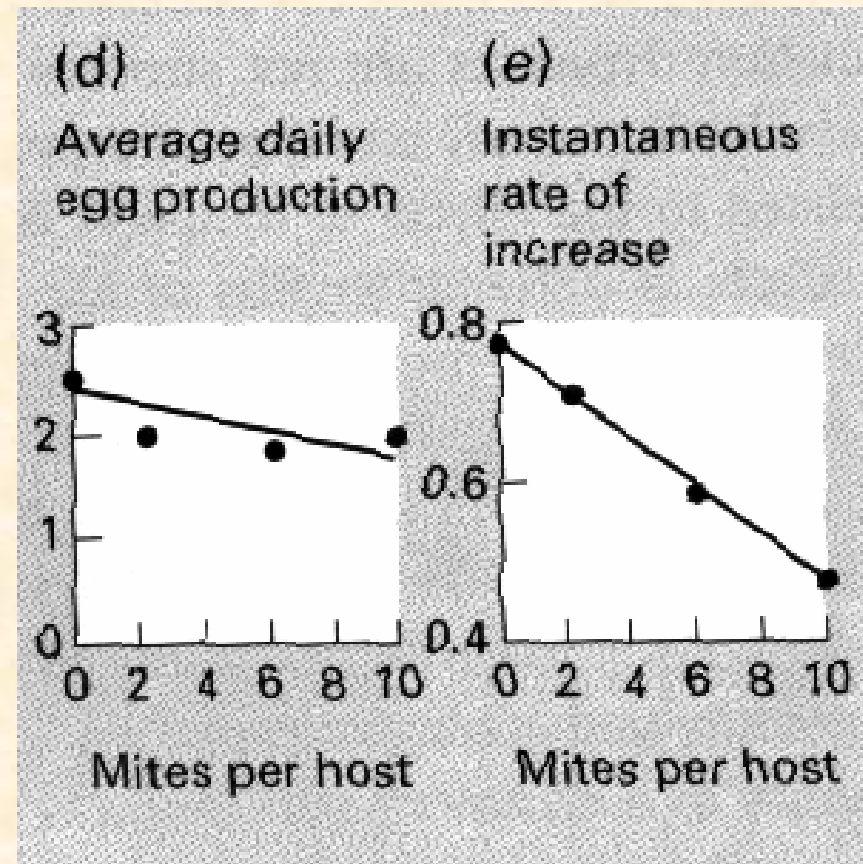


Murton et al. (1964)

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)

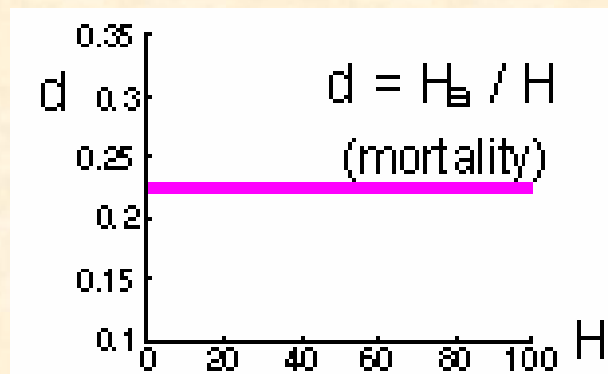
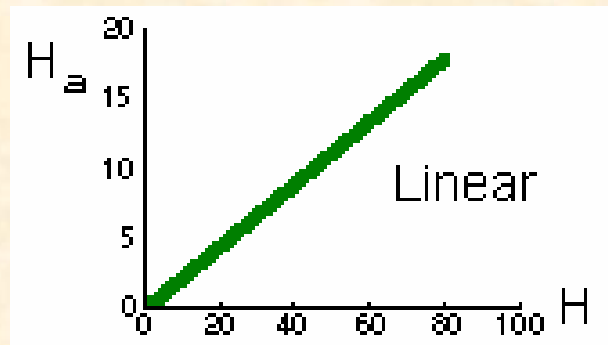
Total response

- ▶ 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 density 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

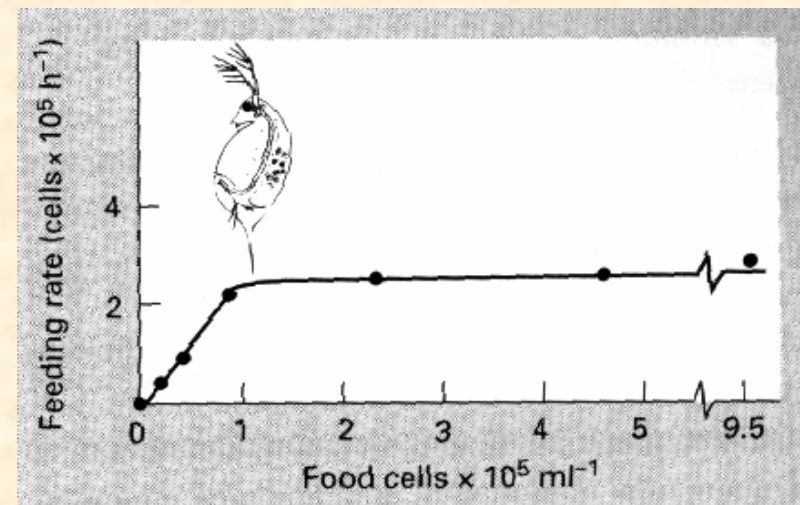
Functional response

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



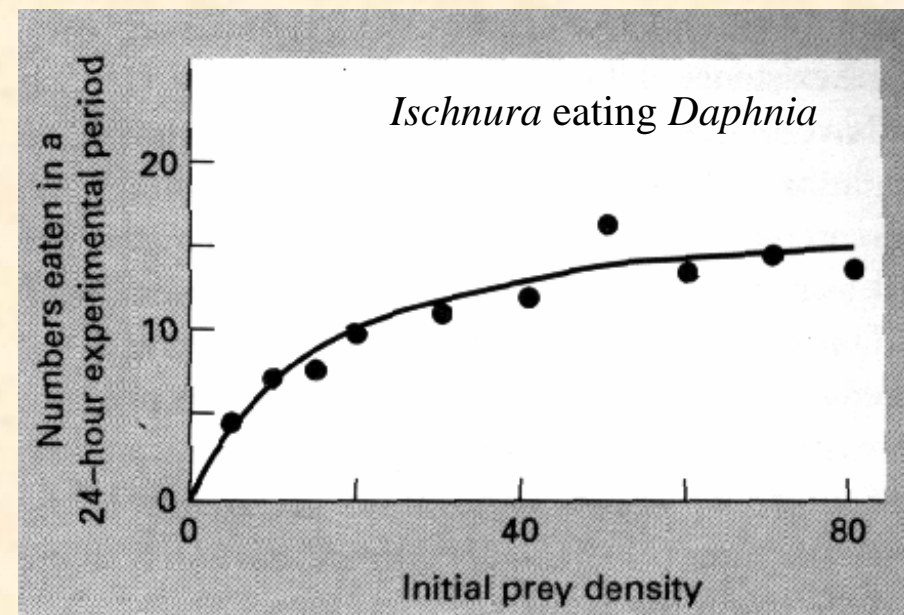
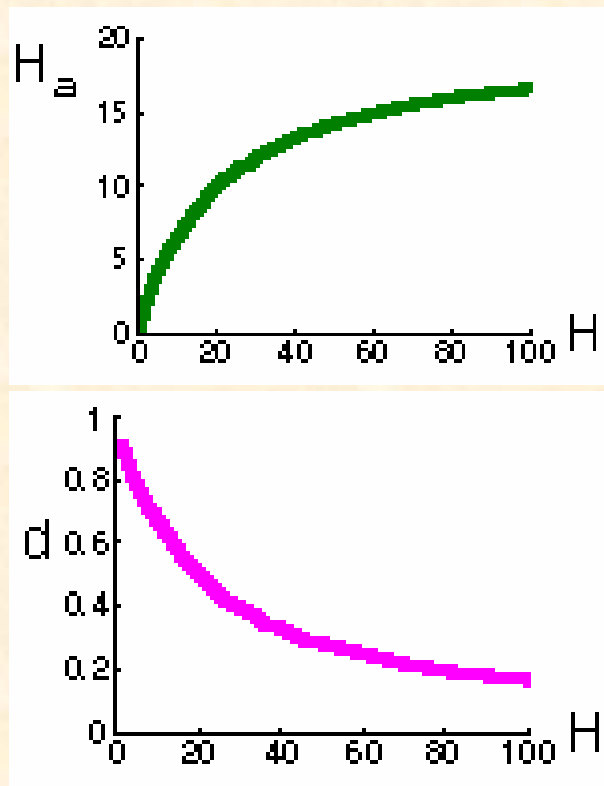
Daphnia feeding on *Saccharomyces* - above 10^5 cells
Daphnia is unable to swallow all food



Rigler (1961)

Type II

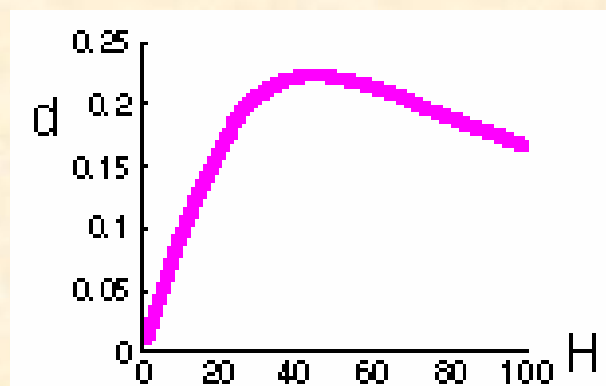
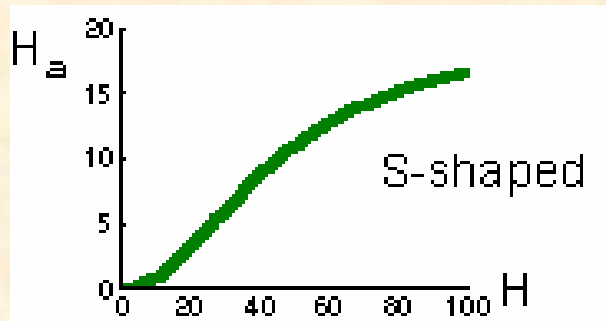
- ▶ predators cause maximum mortality at low prey density
 - ▶ as prey density increases, search becomes trivial and handling takes up increasing portion of the time
 - ▶ saturation (due to handling) of predation at high densities
- prey mortality declines with density



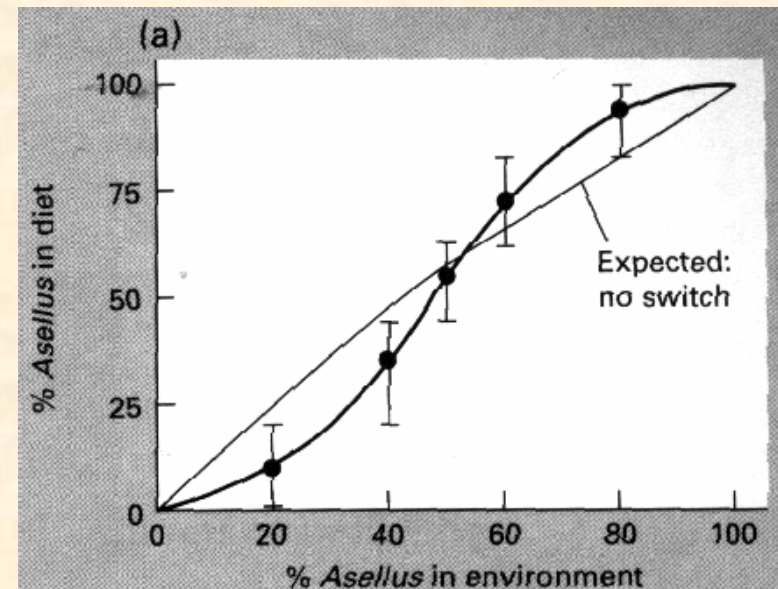
Thompson (1975)

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

$$T_H = H_a T_h$$

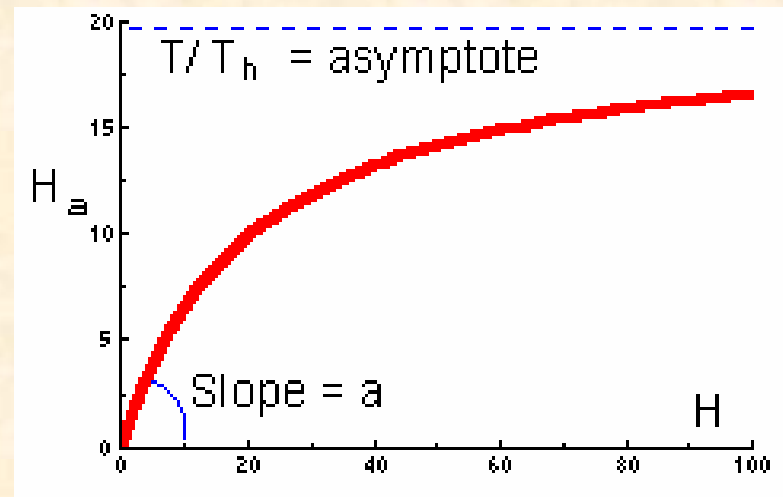
T_h .. time spent on handling 1 prey

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

▶ 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

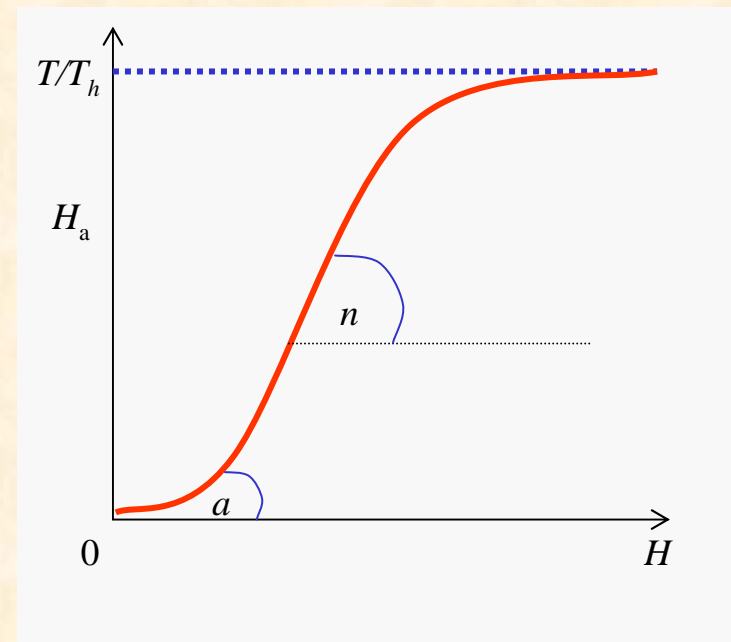
► consumption increases at low densities and decreases at higher densities

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

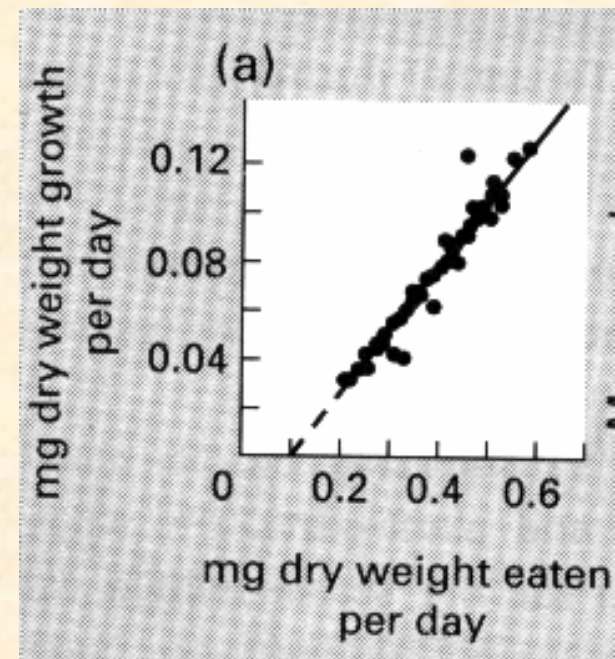
- ▶ parasitoids - one host is sufficient

- ▶ 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):

$$\frac{dP}{dt} = faHP - dP$$

f .. conversion efficiency

d .. mortality of predators

▶ Ivlev (1955) model

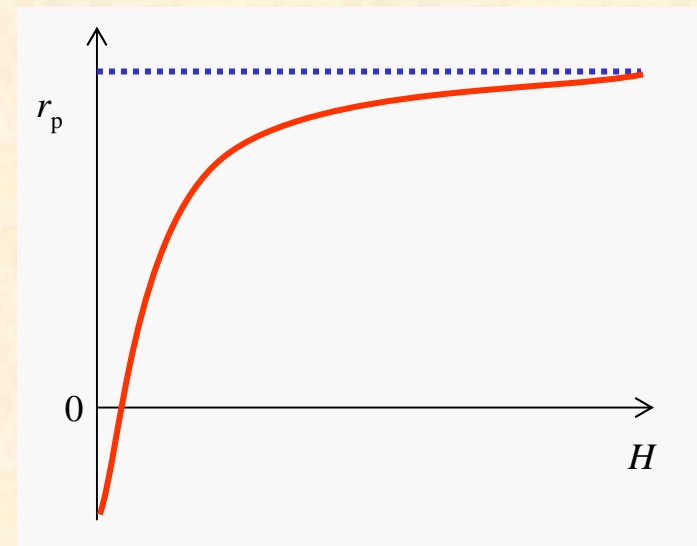
$$r = a(1 - e^{-fV}) - d$$

V .. amount of prey

a .. search rate

f .. conversion efficiency

d .. mortality of predators

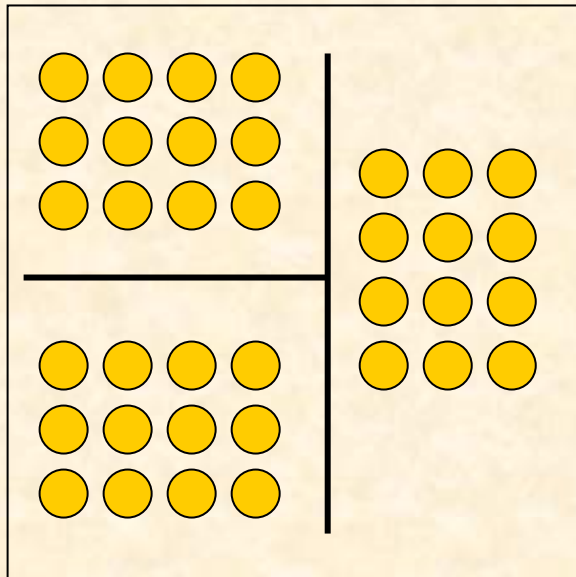


Aggregation

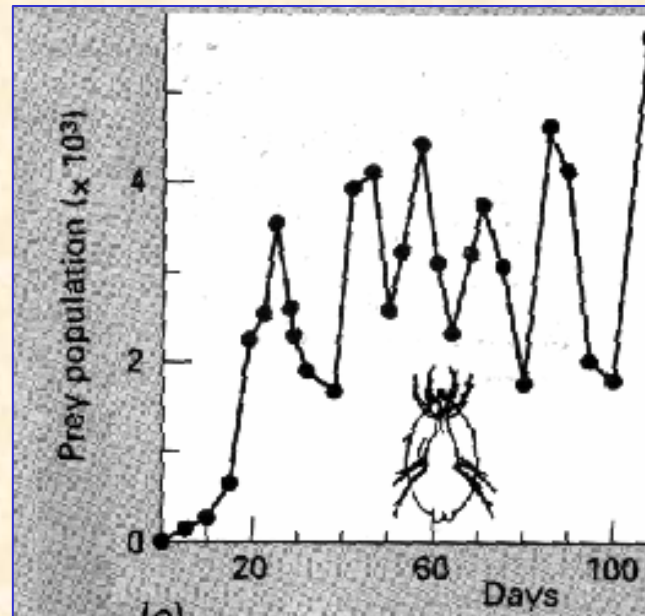
- ▶ instead of concentration on profitable patches perspective predators and prey may play “hide-and-seek”
- ▶ Huffaker (1958): *Typhlodromus* captured *Eotetranychus* that fed upon oranges
 - *Eotetranychus* maintained fluctuating density
 - addition of *Typhlodromus* led to extinction of both



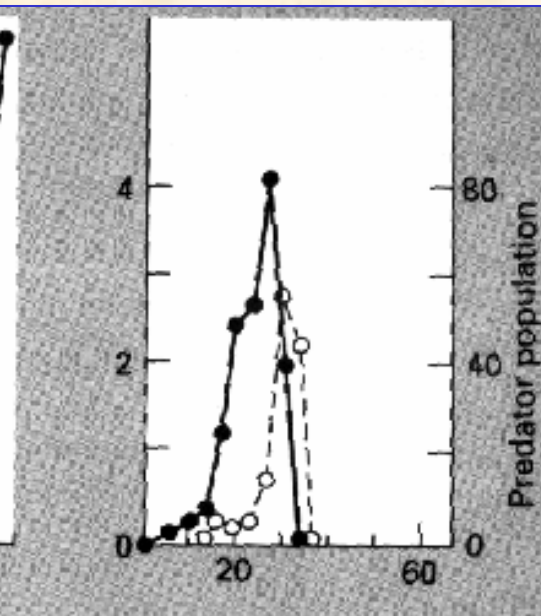
Experimental setup



Eotetranychus population dynamic



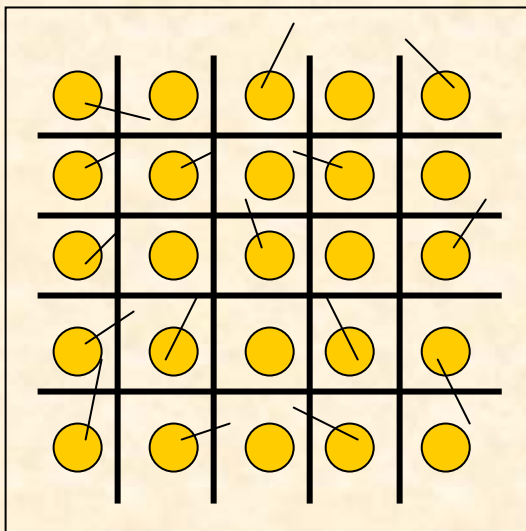
Predator-prey dynamic



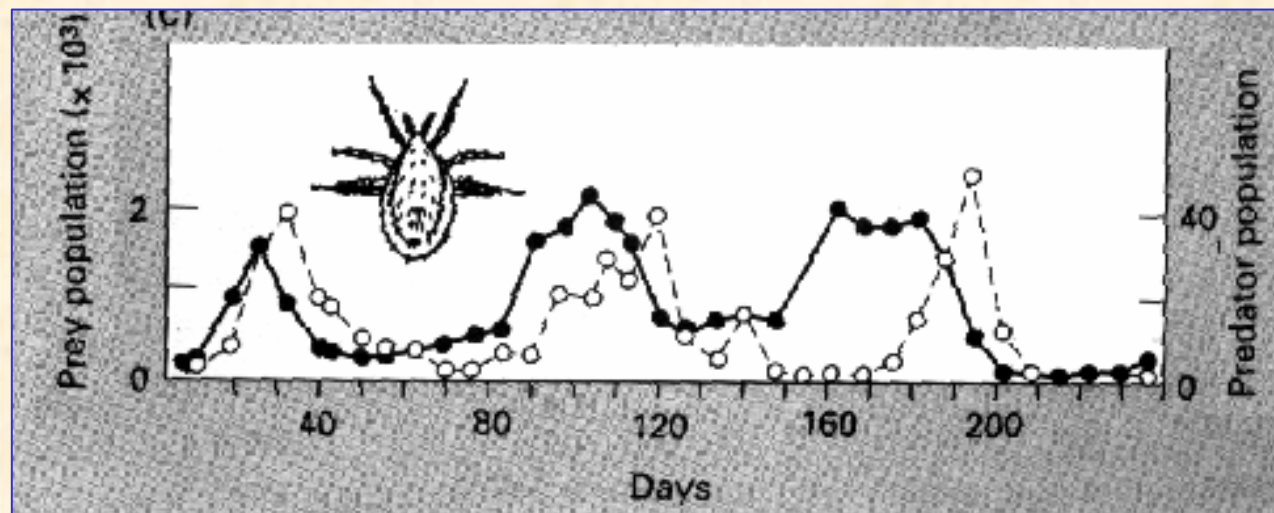
- ▶ making environment patchy
 - by placing Vaseline barriers
 - facilitating dispersal by adding sticks

- ▶ 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

