Predation

"Populační ekologie živočichů"

Stano Pekár

Total response

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

- Total response of a predator

- increasing consumption rate of individual predators → **functional response**
- increasing density of predators → **numerical response**

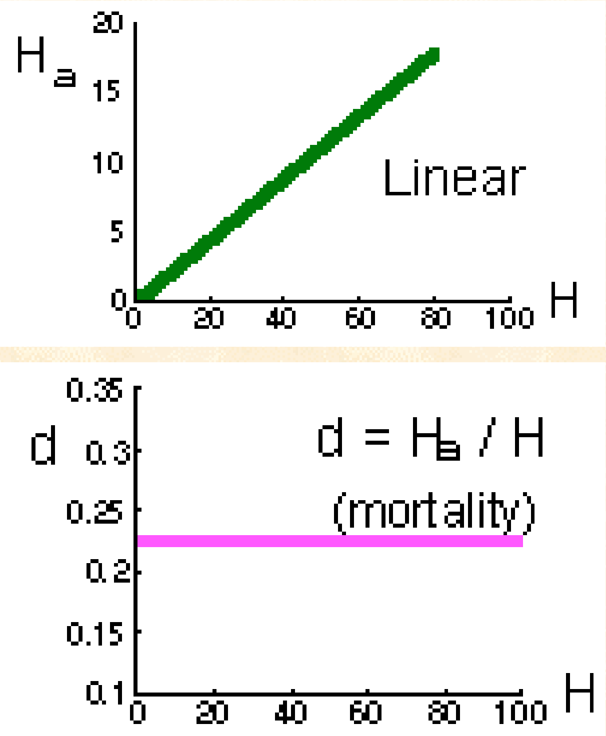
- Holling (1959) found that predation rate increased with increasing prey population density

- defined three types of functional responses

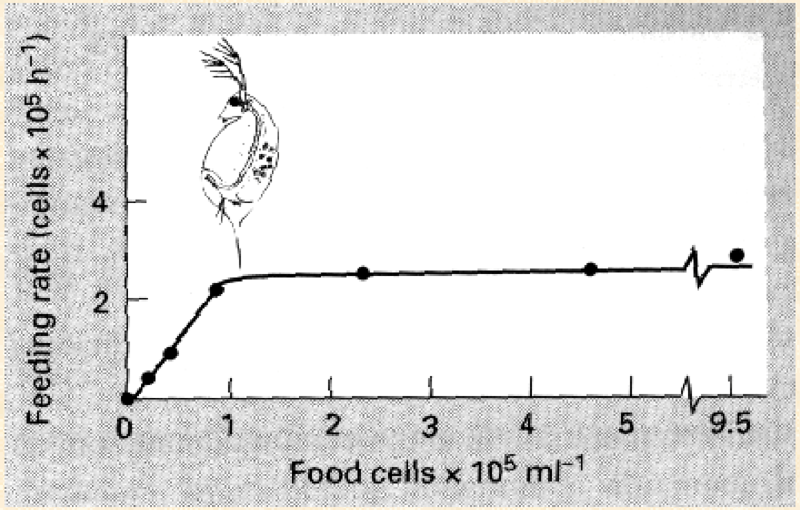
Functional response

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)

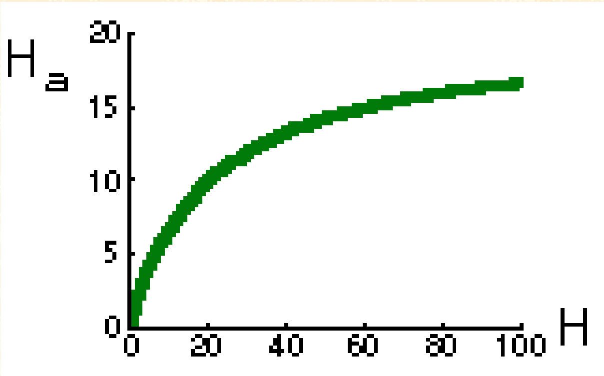
Type II

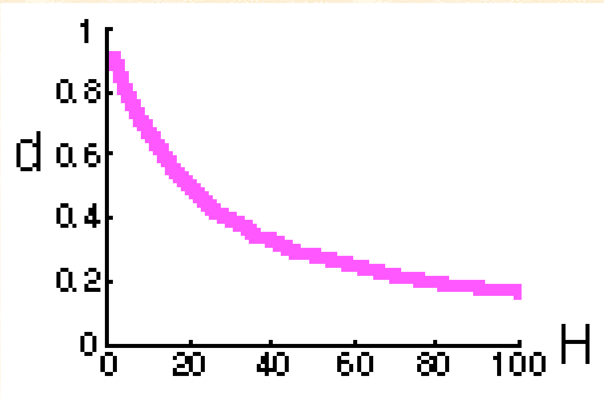
‣ predators cause maximum mortality at low prey density

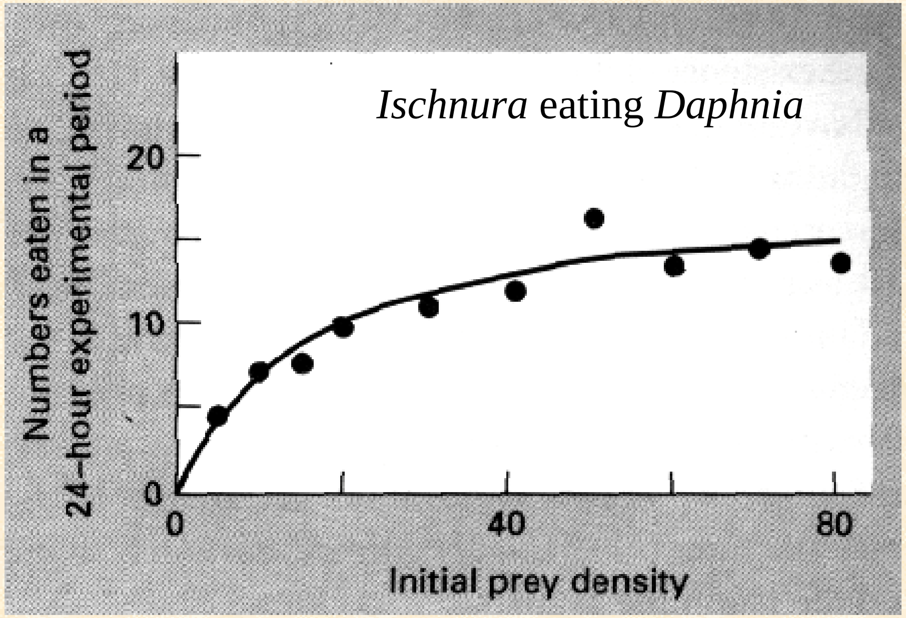
‣ as prey density increases, search becomes trivial and handling takes up increasing portion of the time

‣ saturation of predation at high densities

- prey mortality declines with density





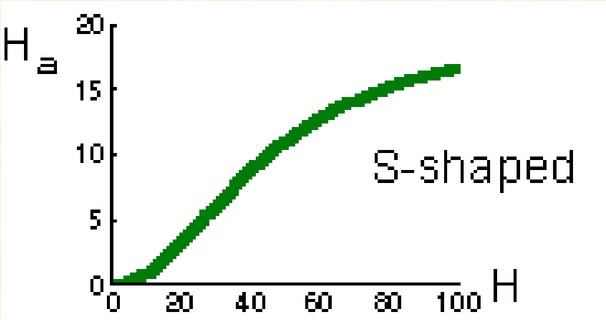


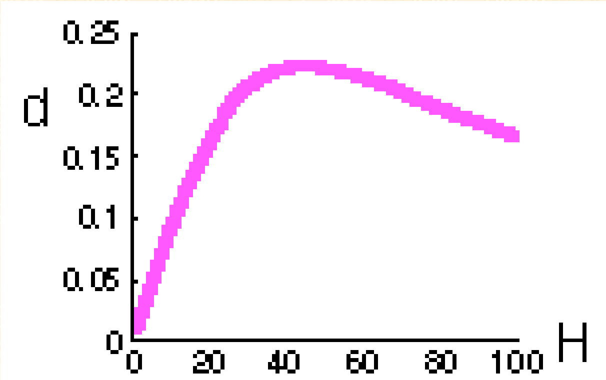
Thompson (1975)

Type III

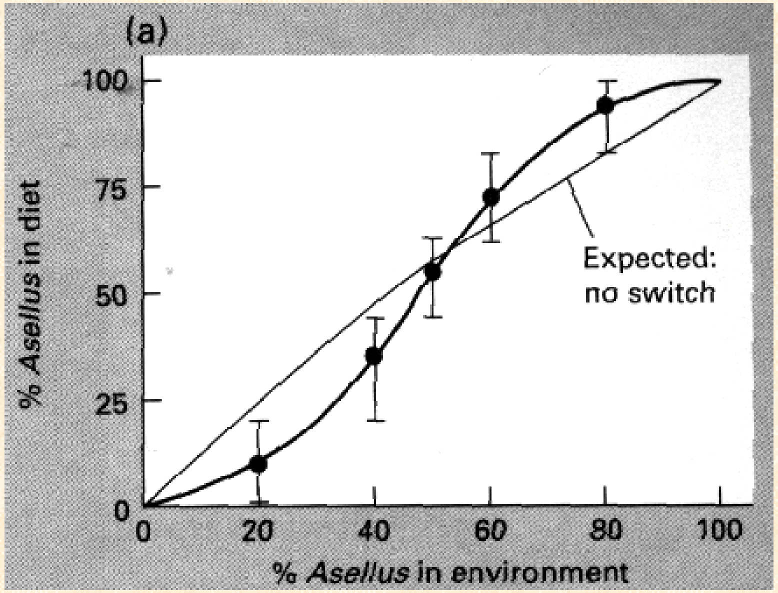
- when attack rate increases or handling time decreases with increasing density
- predators respond to kairomones
- predators develop search image
- polyphagous predators switch to the most abundant prey

\- 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, “area of discovery”, or “search rate”

Type I

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

$$\boxed{H_a = aHT_S}$$

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
- $T_H > 0$
- predator captures H_a prey during T

$$T_H = H_a T_h$$

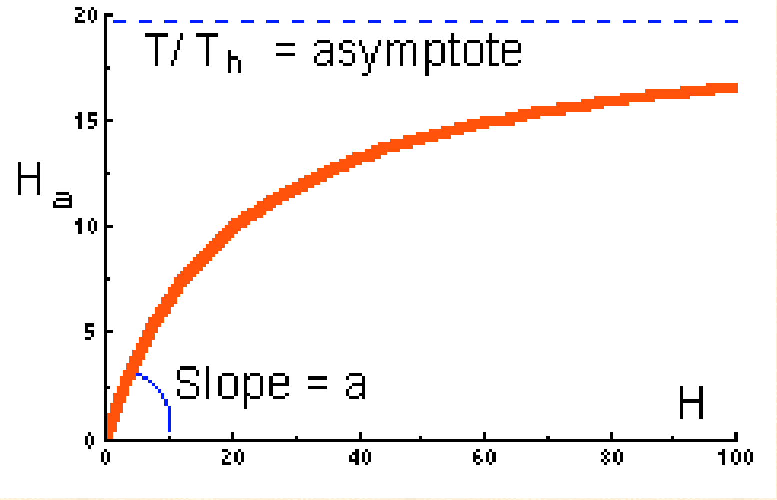
T_h .. time spent on handling 1 prey

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

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

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

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



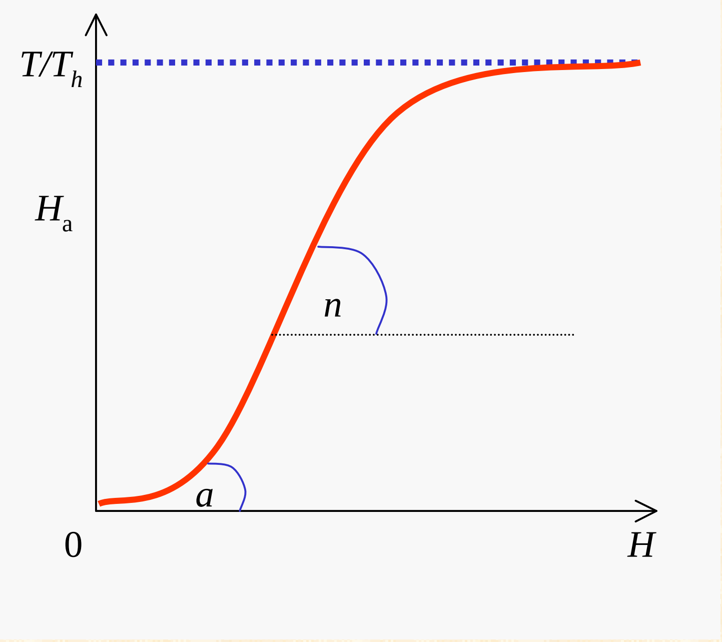
Type III

- 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:

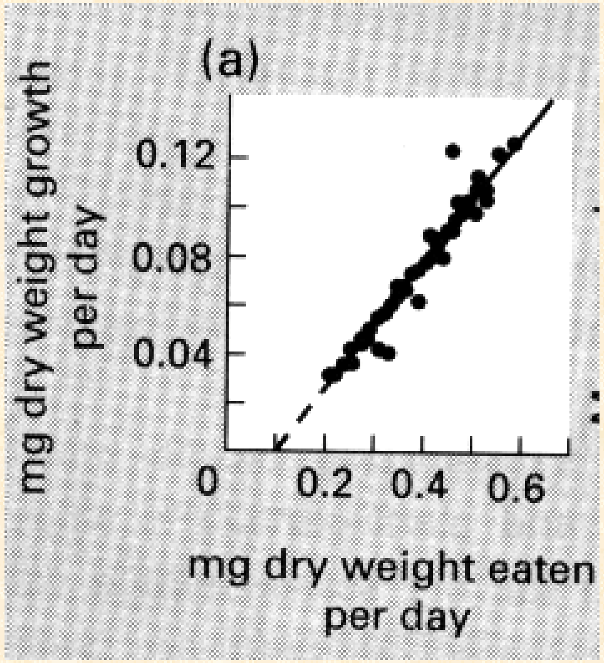
- **increased rate of reproduction**

- 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 predators

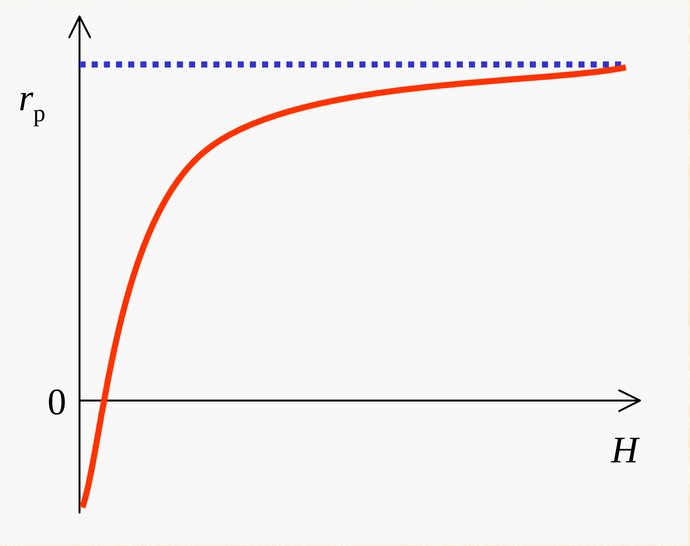
$$r = caHP - dP$$

c .. conversion efficiency
d .. mortality of predators

- Ivlev (1955) model

$$r = c(1 - e^{-dV}) - a$$

V .. amount of prey
c .. conversion efficiency
a .. mortality of predators

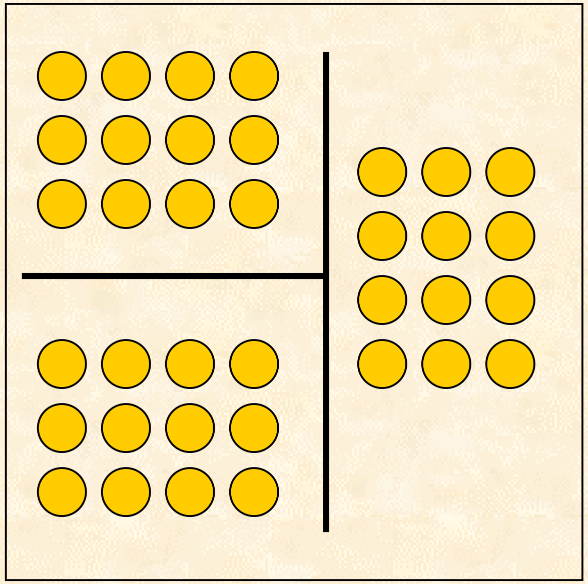


Aggregation

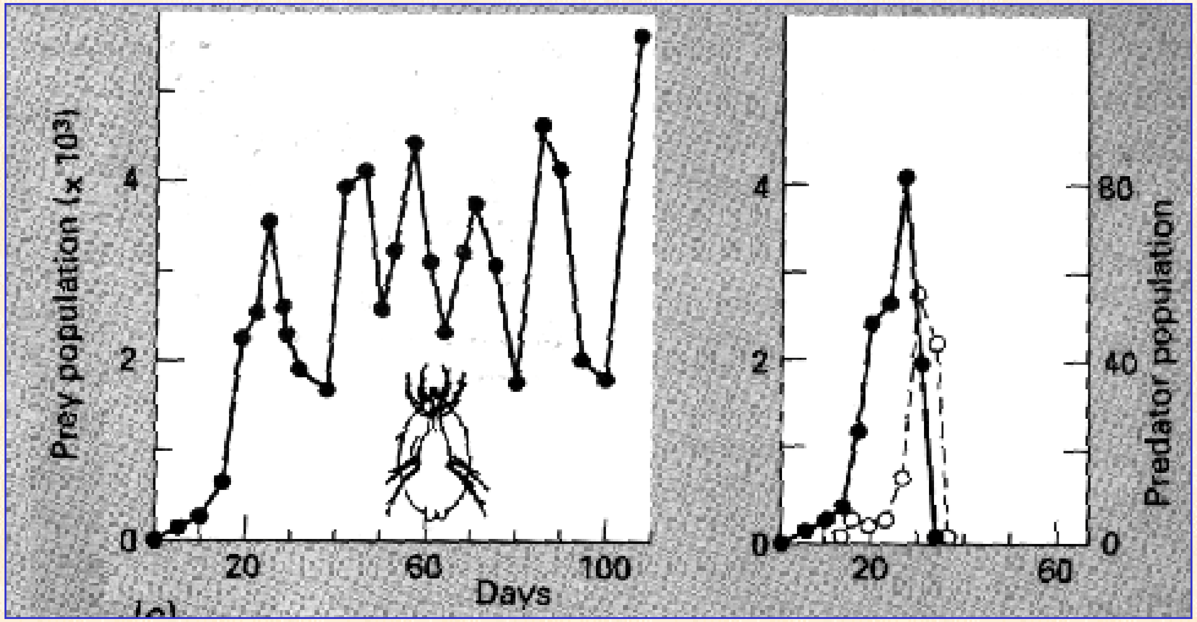
- instead of concentration on profitable patches perspective predators and prey may play “ hide-and-seek”

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

Experimental setup



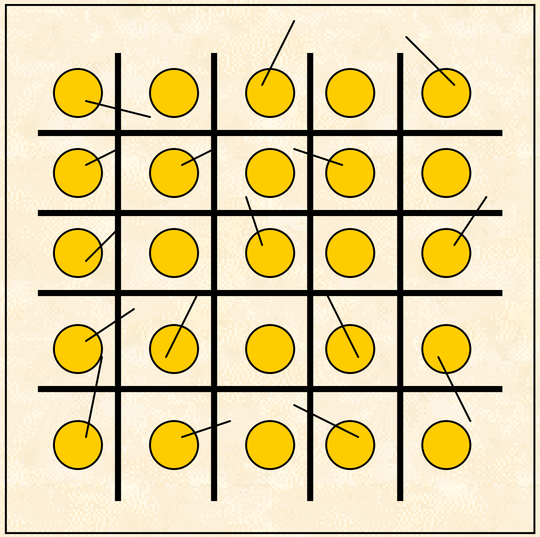
Eotetranychus population dynamic   Predator-prey dynamic



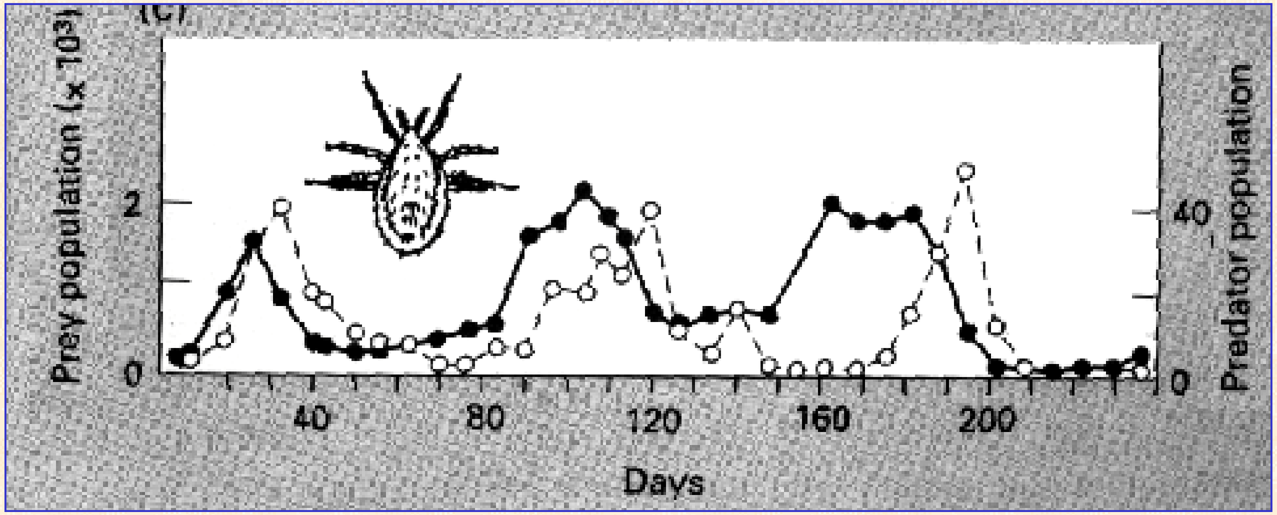
‣ making environment patchy
- by placing Vaseline barriers
- facilitating dispersal by adding sticks

‣ each patch was unstable but whole cosmos 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

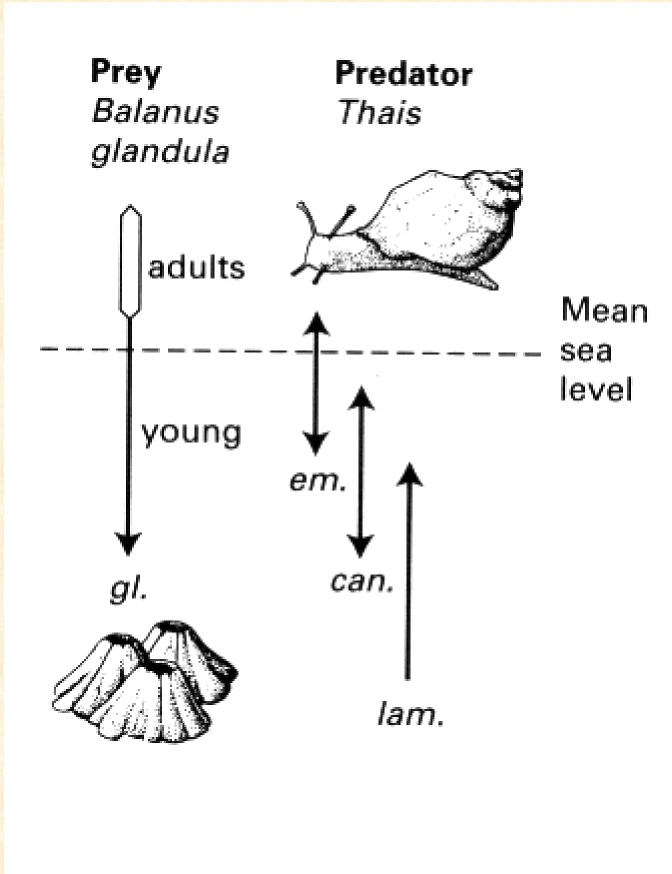


Total refuge

- 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 refuges stabilise the interaction



Connell (1970)

Excercise 19

Carabids are kept in dishes (10 cm^2) individually, with a different number of seeds (*H*). The seeds are kept at constant density. After 6 hours (*T*) consumed seeds were counted.

1. What type of functional response carabids have?

2. Estimate search efficiency (*a*) [cm^2/h] and handling time (T_h) [h].

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

$$\frac{1}{H_a} = \frac{1}{a}\frac{1}{HT} + \frac{T_h}{T}$$

$$y = \alpha + \beta x$$

$$T_h = \alpha T$$

$$a = \frac{1}{\beta}$$

H	Ha
1	2.5
5	6.1
10	7.9
20	10.5
40	12.3
50	11.8

```
H<-c(1,5,10,20,40,50)
Ha<-c(2.5,6.1,7.9,10.5,12.3,11.8)
plot(H,Ha)
y<-1/Ha
x<-1/(H*6)
plot(x,y)

m1<-lm(y~x)
abline(m1)
coef(m1)
1/1.91424538
0.08445655*6
```

Excercise 20

Grasshoppers were reared individually from egg to adulthood and the amount of food consumed (*V*) was determined. The fecundity was observed for each. From these data the intrinsic rate of increase ® was estimated.

množství	***r***
0.5	–1.0
1	–0.6
2	–0.1
5	0.3
10	0.5
20	0.7
40	1

1. Find relationship between *r* and *V*.
2. Estimate parameters of Ivlev model and the minimal amount of prey needed for reproduction.

```
v<-c(0.5,1,2,5,10,20,50)
r<-c(-1,-0.6,-0.1,0.3,0.5,0.7,1)
plot(v,r)
m1<-nls(r~c*(1-exp(-d*v))-a,start=list(a=1,c=2,d=1))
summary(m1)
x<-seq(0,50,1)
lines(x,predict(m1,list(v=x)))

library(rootSolve)
null<-uniroot(function(x) 1.9*(1-exp(-0.3*x))-
1.2,lower=0,upper=10);null
```