Natural-enemy victim interactions I

4/12/2021

Natural Enemy-Victim Interactions

Also known as consumer-resources interaction

Ecologists have described many different interactions

Predator/Prey

Herbivory

Parasitoid/Host

Parasite/Host

Pathogen/Host

Mycobacterium tuberculosis

Generally…

	Enemy: Victim	Kills victim?	Relative body size Victim is:	Lifespan- victim lives
Predator/ Prey	One: Many	Yes	Smaller	Shorter
Grazer/ Herbivore	Many: Many	No	Smaller or larger	Shorter or longer
Parasitoid	One: One	Yes	Similar	Similar
Parasite	Many: One	No	Larger	Longer
Pathogen	Many: One	No	Larger	Much Longer

Previously,

You have seen the consumer-resource system.

The resource supply rate was **INDEPENDENT** of the consumer.

Consumer and resources generally affect each other!

Consumer-resource

$$\frac{dR}{dt} = f(R) - Cg(R)$$

Growth rate of the resources

Consumption Rate

$$\frac{dC}{dt} = eCg(R) - mC$$

Conversion efficiency

Background mortality

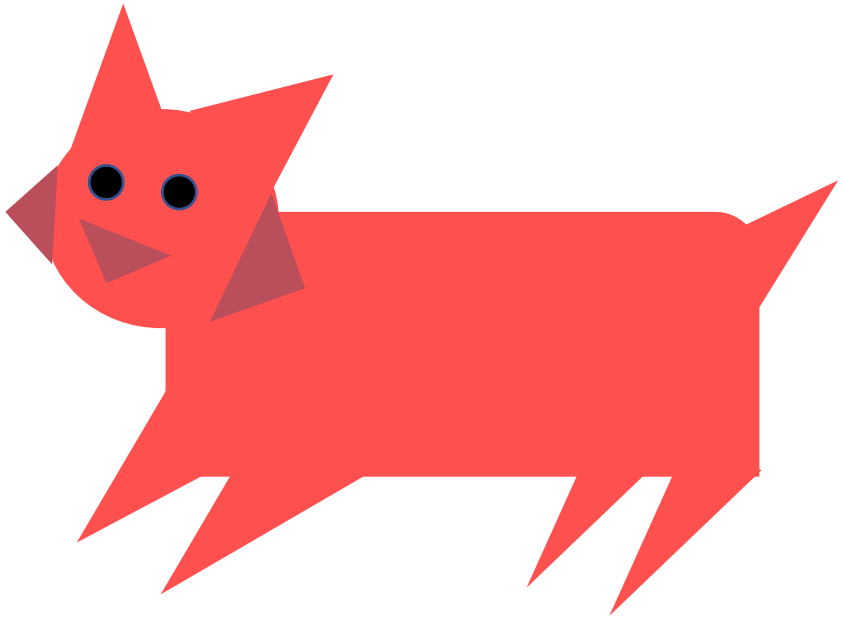
Lotka-Volterra Predator Prey Model

Aha, I want to write a model
where there are two species.

One eats, the other is eaten!
One influences the other!

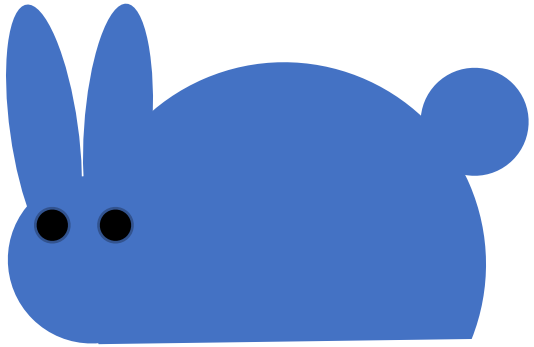
What a marvelous model it would be to
describe my fish problem!*

Predator



dP

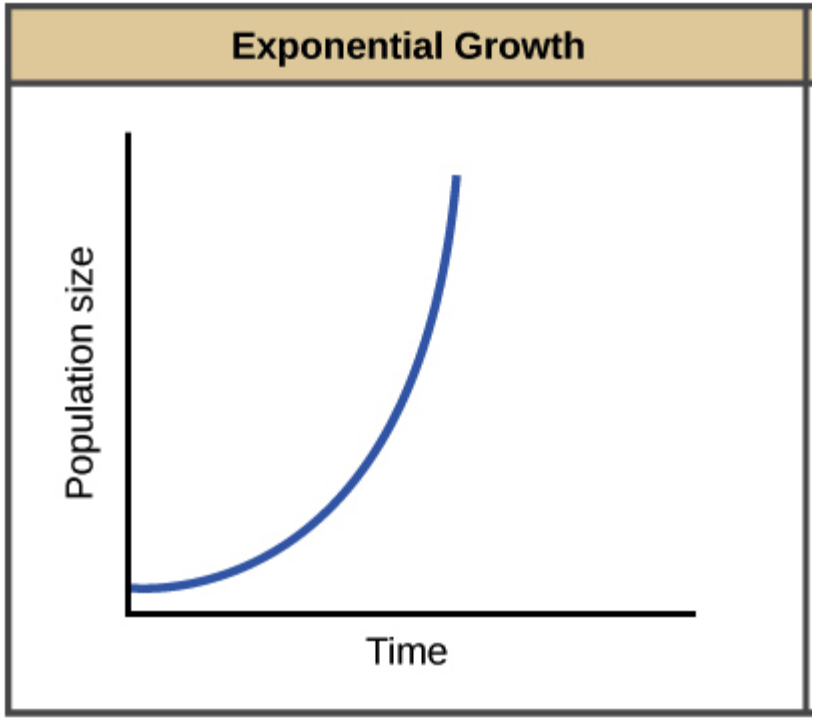
Prey (Victim)



dV

Exponential growth in the absence of predators!

$$\frac{dV}{dt} = rV$$



Death rate due to predators

$$\frac{dV}{dt} = rV - aVP$$

- The more predators there are the more prey is lost
- The more prey there is, there is more prey to be lost
- The higher the attack rate the more prey is lost

Growth due to the prey

$$\frac{dV}{dt} = rV - aVP$$

$$\frac{dP}{dt} = eaVP$$

Converting prey to new predators, the higher e is the more predators you make

Exponential decline when there is no prey

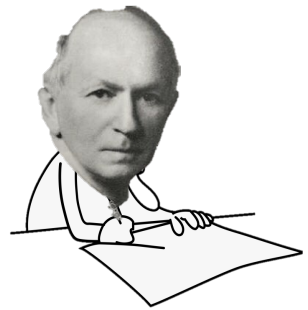
$$\frac{dV}{dt} = rV - aVP$$

$$\frac{dP}{dt} = eaVP - uP$$

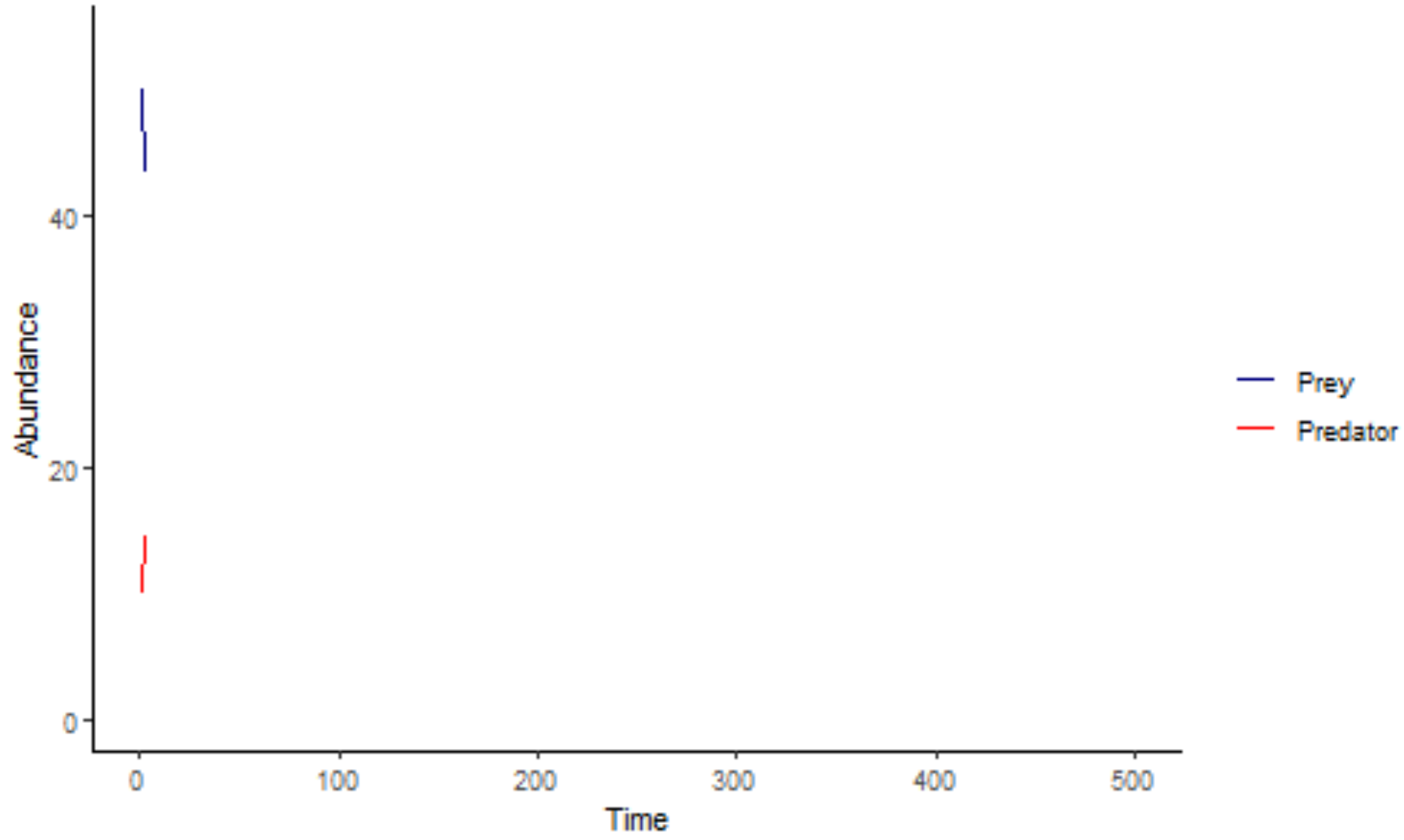
Voila!

$$\frac{dV}{dt} = rV - aVP$$

$$\frac{dP}{dt} = eaVP - uP$$



The predator lags behind the prey!



Isoclines

$$\frac{dV}{dt} = rV - aVP$$

$$0 = rV - aVP$$

$$aVP = rV$$

$$P = r/a$$

Isoclines

$$\frac{dV}{dt} = rV - aVP$$

$$0 = rV - aVP$$

$$aVP = rV$$

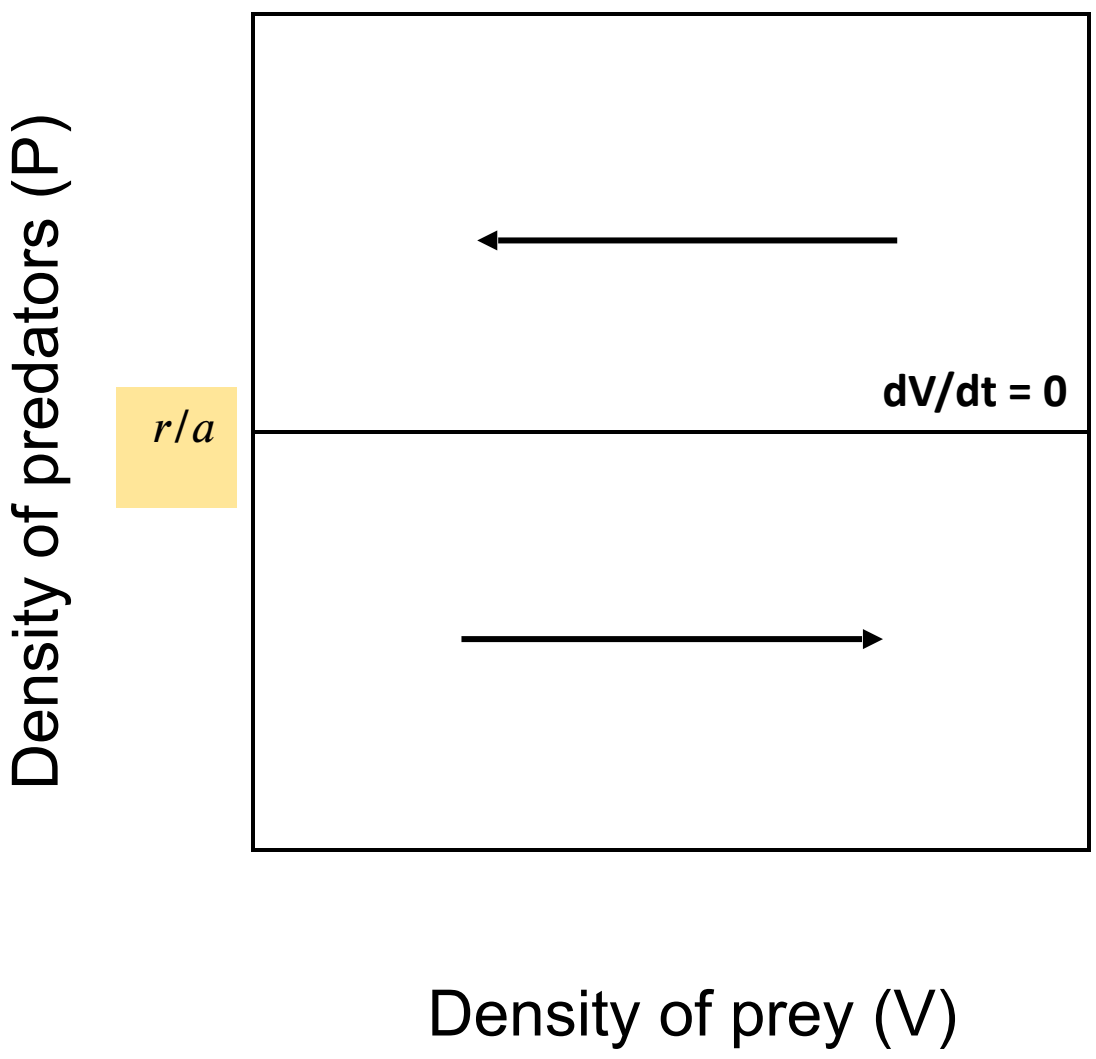
$$P = r/a$$

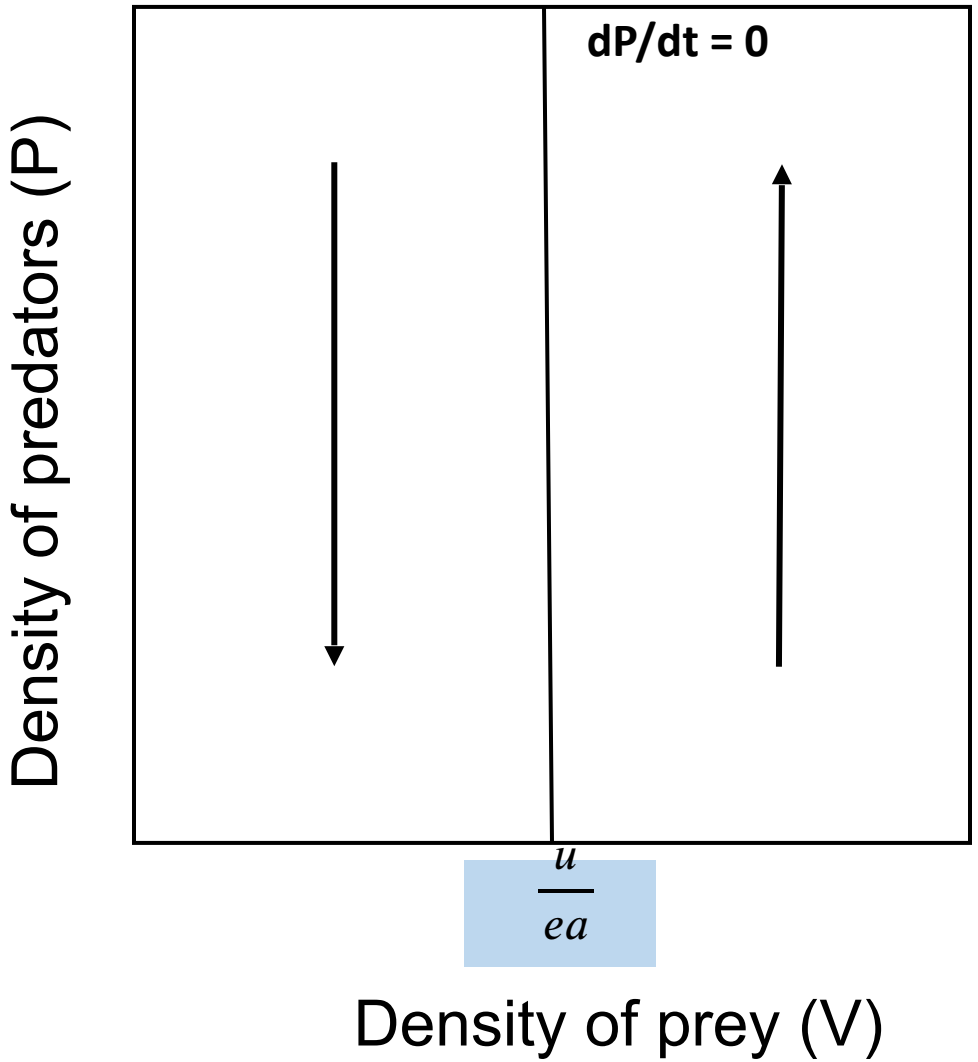
$$\frac{dP}{dt} = eaVP - uP$$

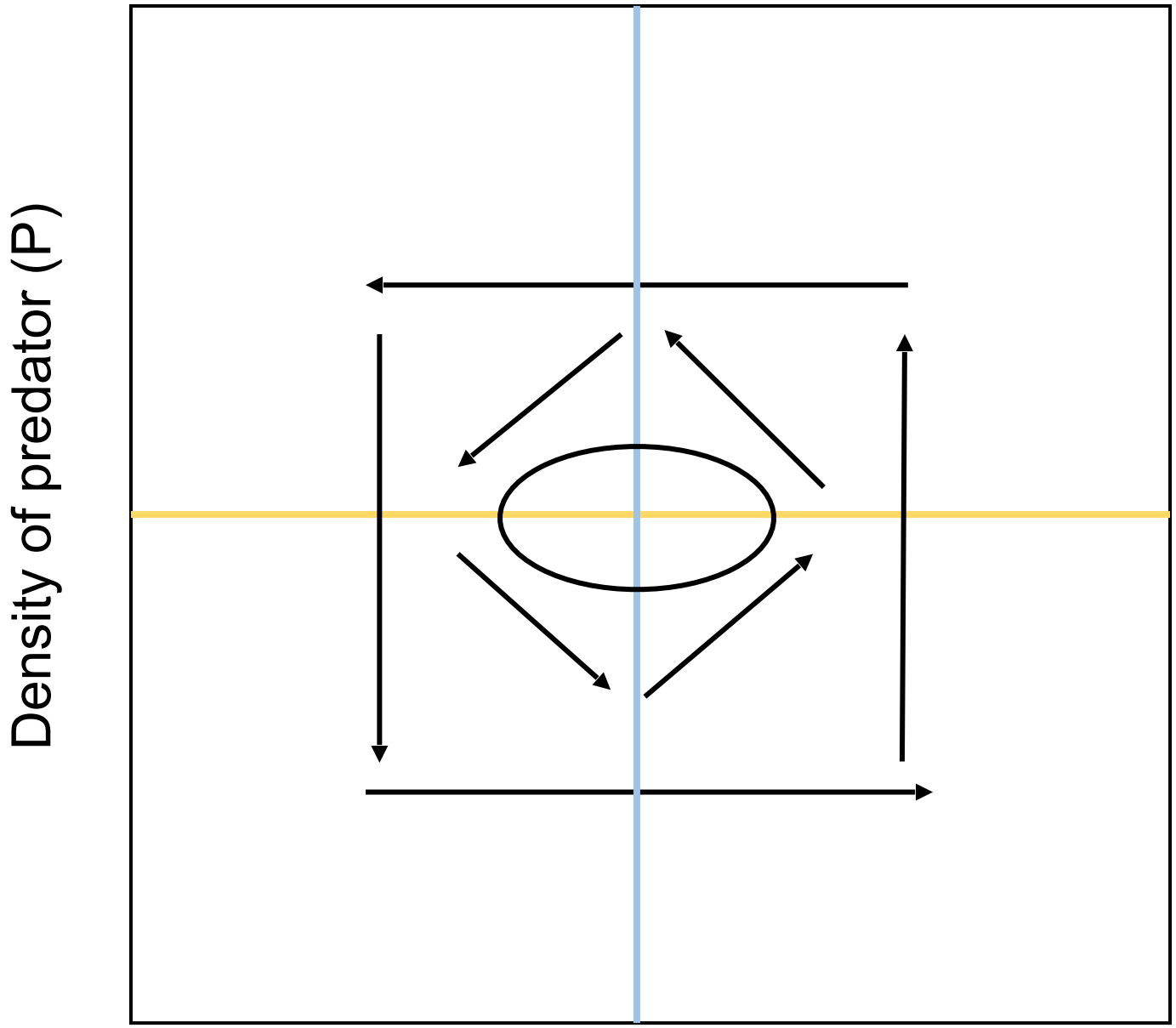
$$0 = eaVP - uP$$

$$uP = eaVP$$

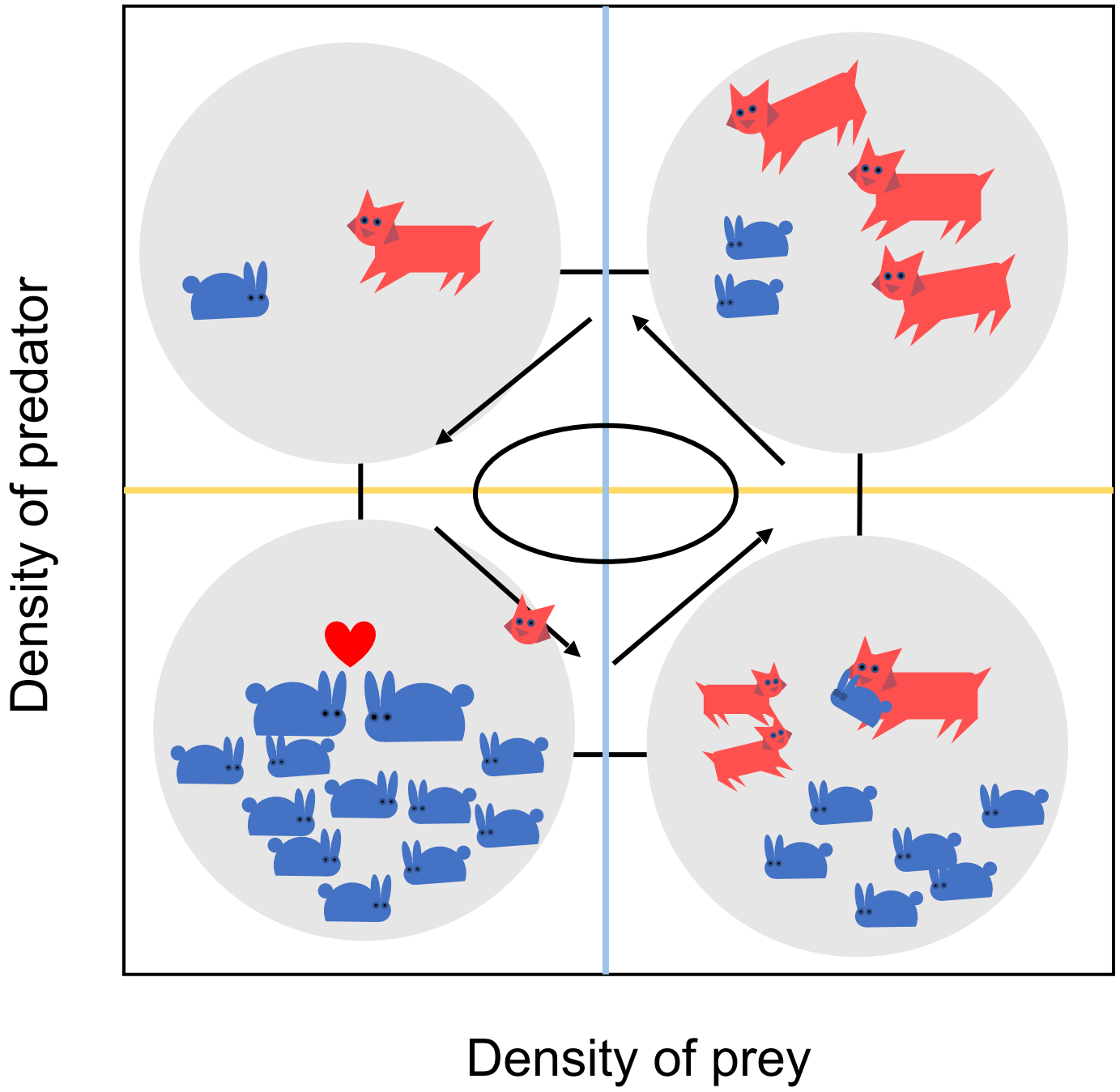
$$V = \frac{u}{ea}$$


Density of predators (P)
dV/dt = 0
r/a
Density of prey (V)

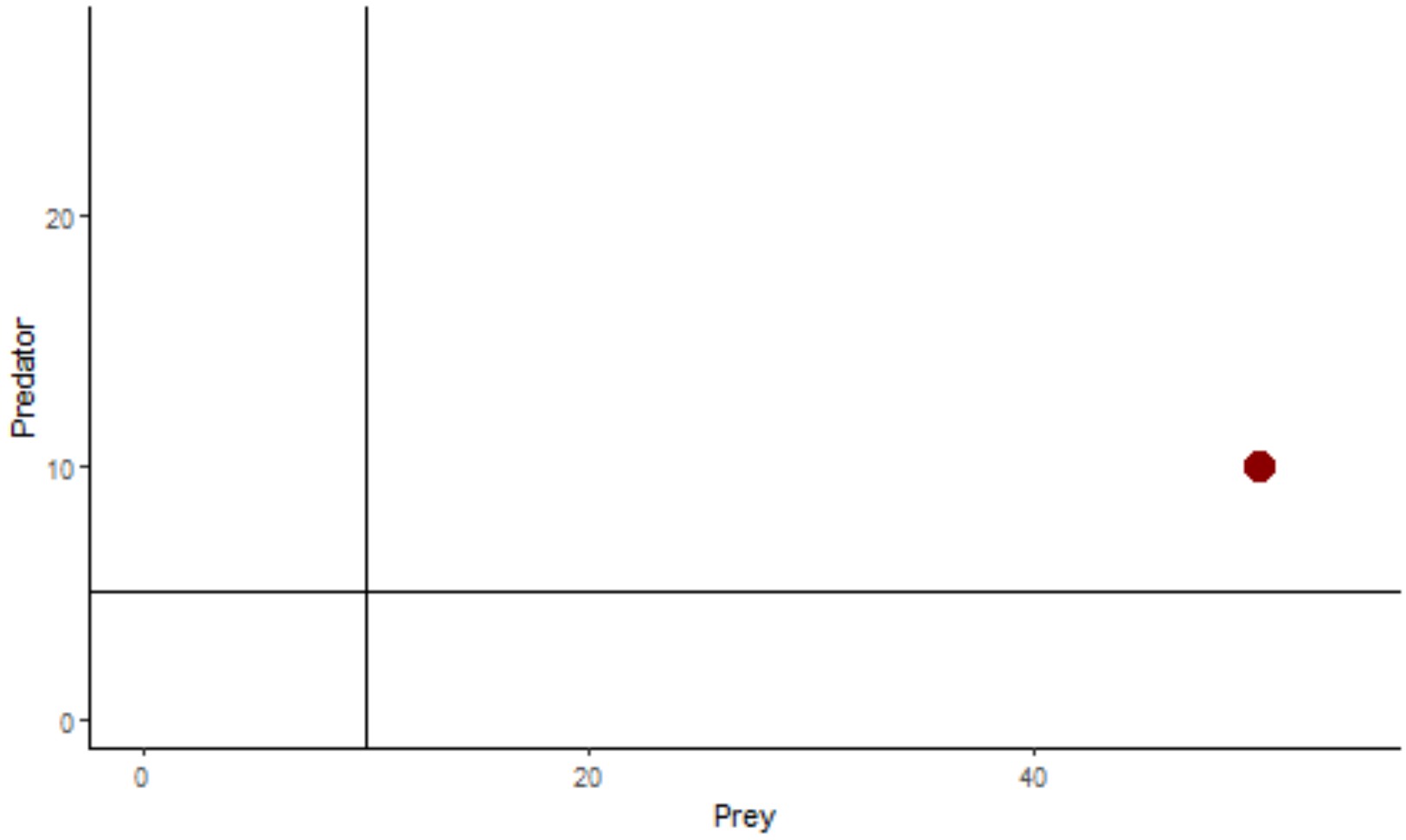

Density of predators (P)
dP/dt = 0
$\frac{u}{ea}$
Density of prey (V)



Neutrally Stable: Not stable or unstable


Density of predator
Density of prey

Neutrally Stable



Application

Solving differential equations/Quick Excel Demo

Euler and Runge Kutta (2nd order)*

Going to show that moving from Excel to R is quite simple!

*Solving differential equation in R uses Runge Kutta 4th order

The assumptions

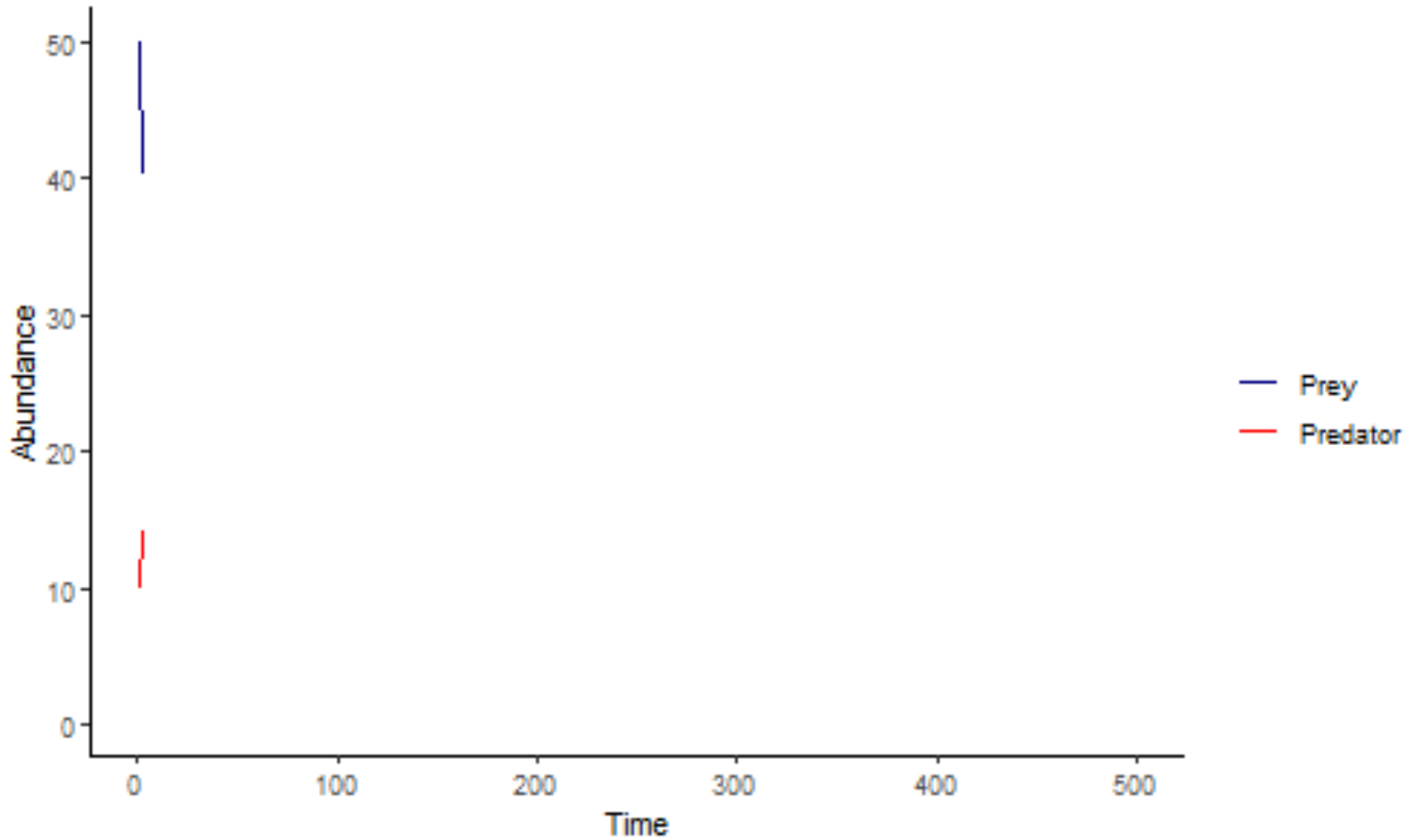
1) Prey is only limited by the predator
2) Predator can eat unlimited prey
3) Predator will starve if there is no prey
4) Predator come across prey at random

Adding some spice!
Adding some complexity!

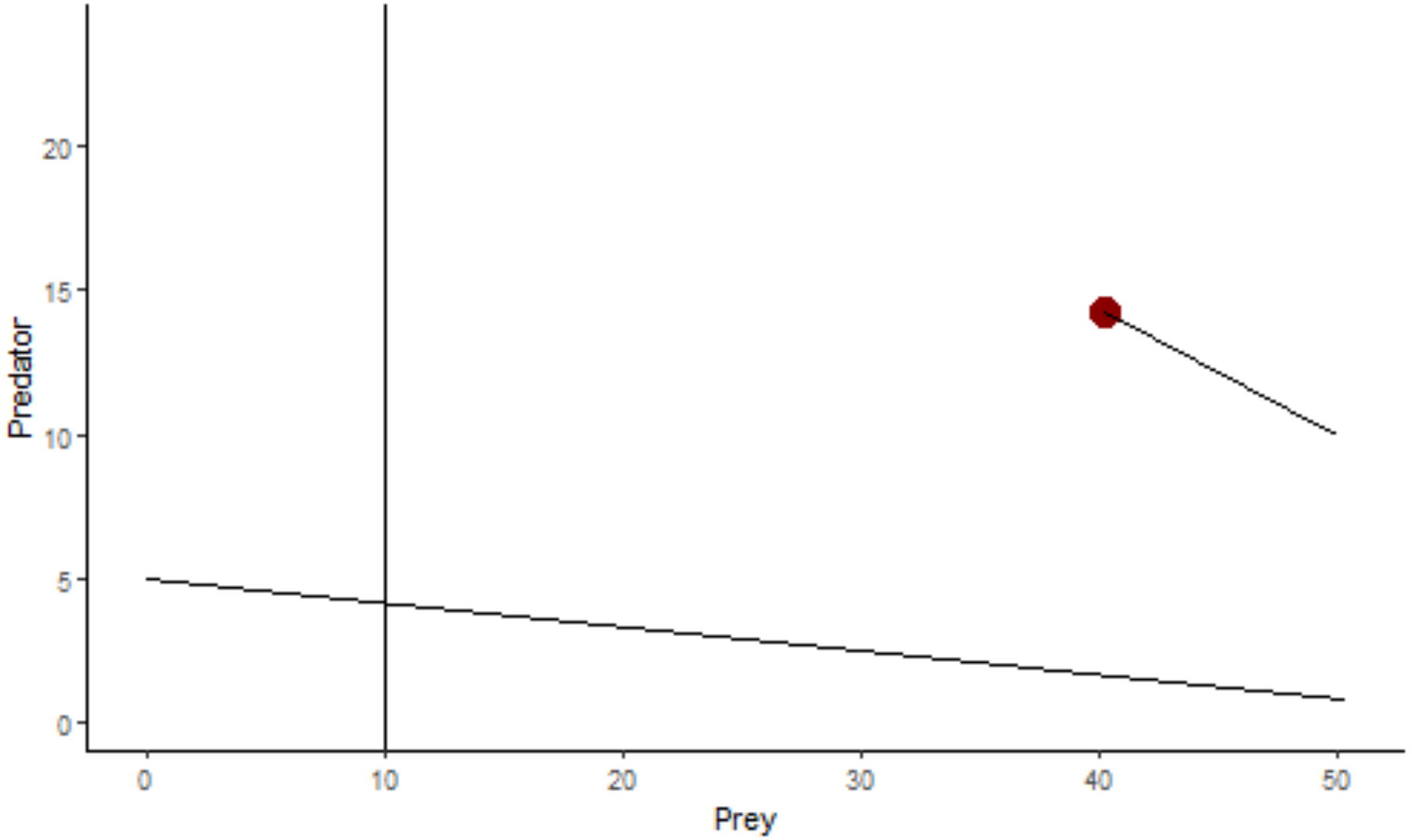
The prey has a carrying capacity, K

$$\frac{dV}{dt} = rV\left(1 - \frac{V}{K}\right) - aVP$$

Rabbits gotta eat too!


50
40
30
20
10
0
Abundance
0
100
200
300
400
500
Time
Prey
Predator

Stable dynamics

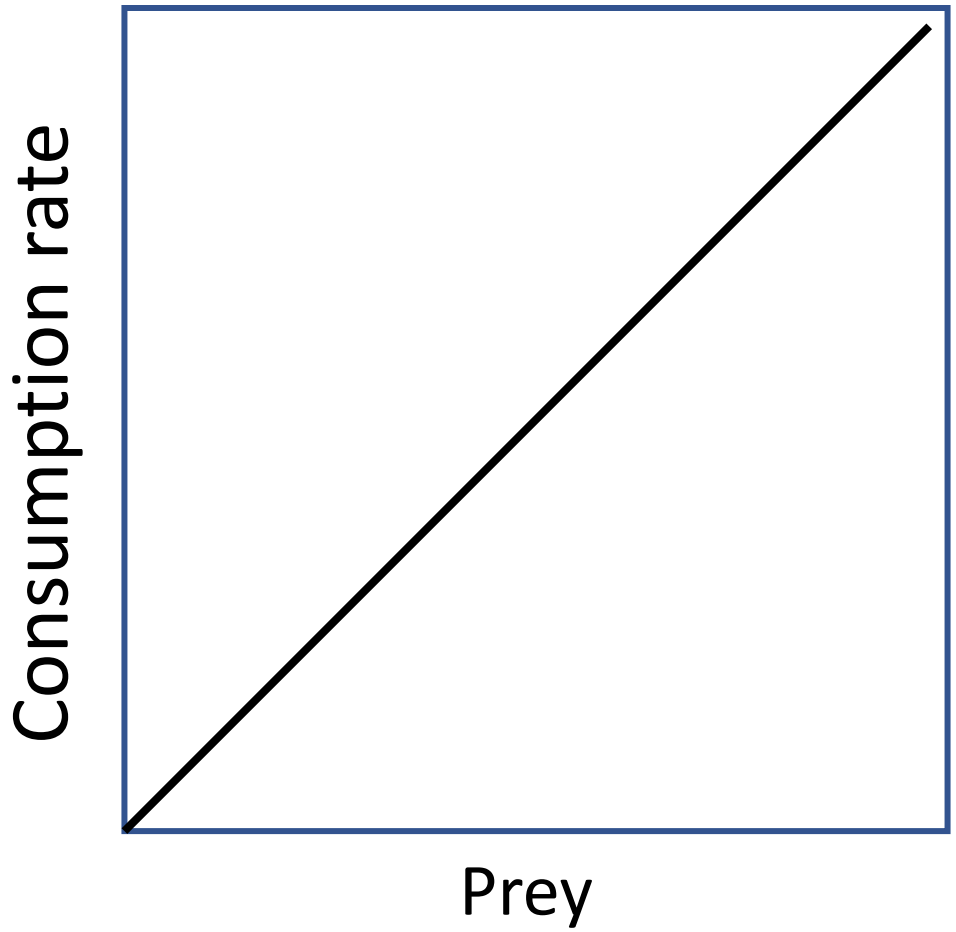


Functional Response/Numerical Response

- **Functional response:** Per capita consumption rate of the consumer

- **Numerical response:** Per capita growth rate of the consumer

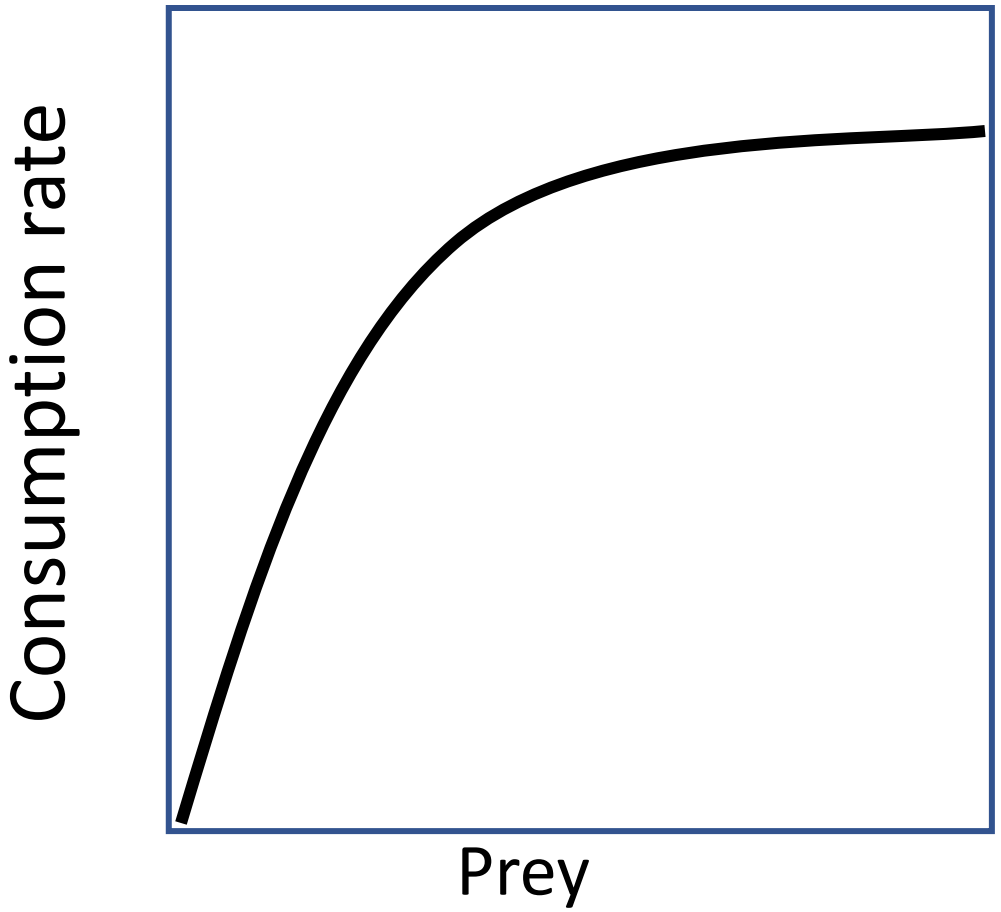
Functional Response Type 1



- No satiation
- No handling time

$$g(V) = aV$$

Functional Response Type 2

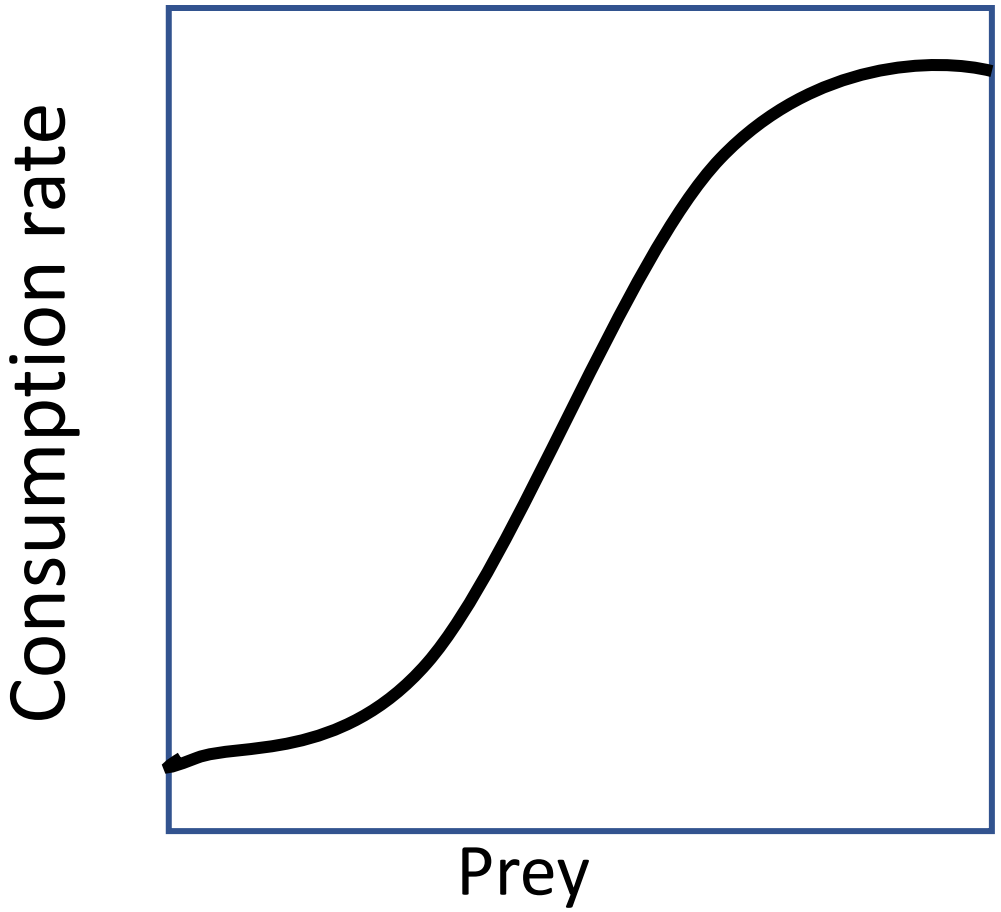


Cool experimental background!

$$g(v) = \frac{aV}{1 + ahV}$$

h = handling time

Functional Response Type 3



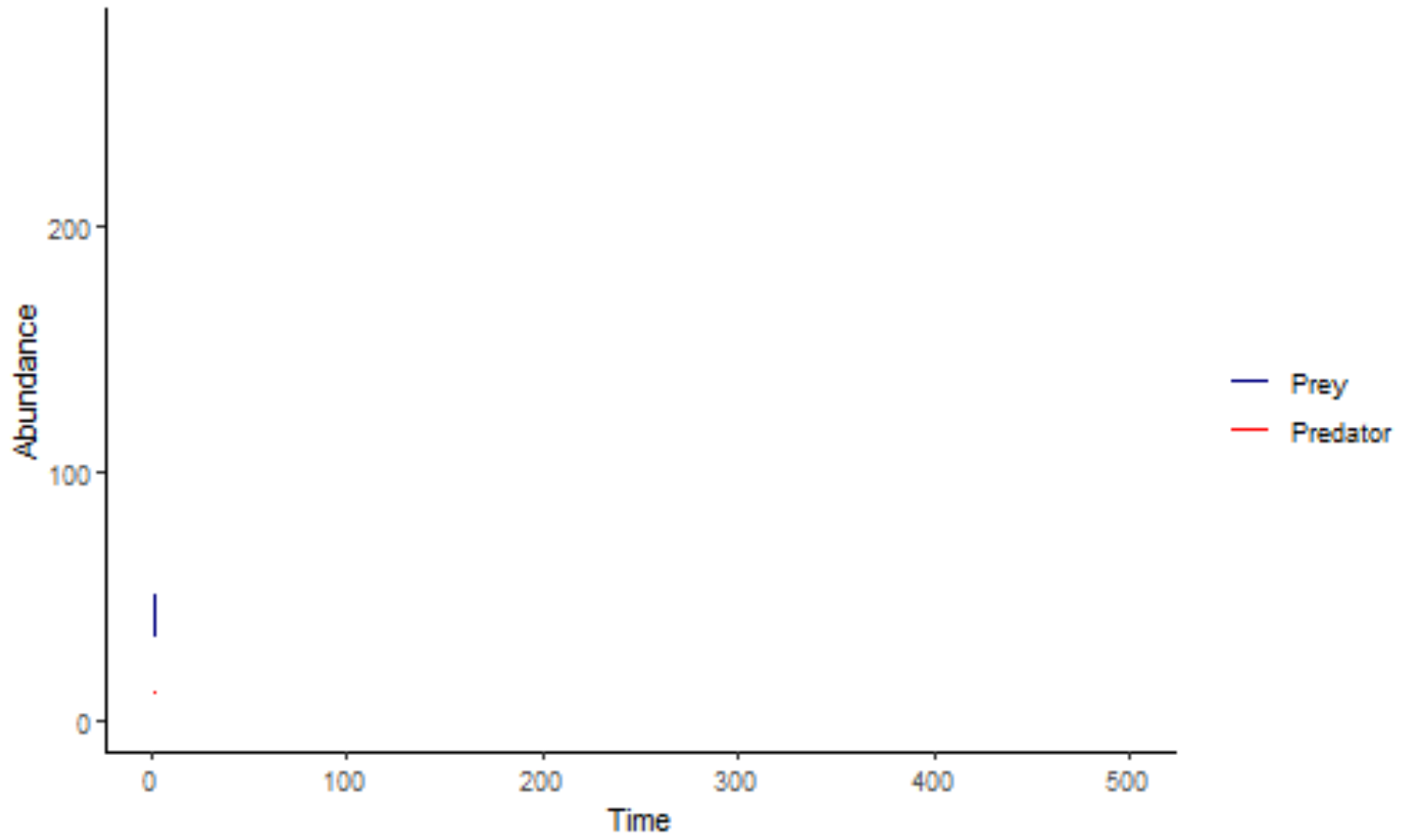
- S shaped
- Associated with prey switching!

The predator have a Type 2 functional response

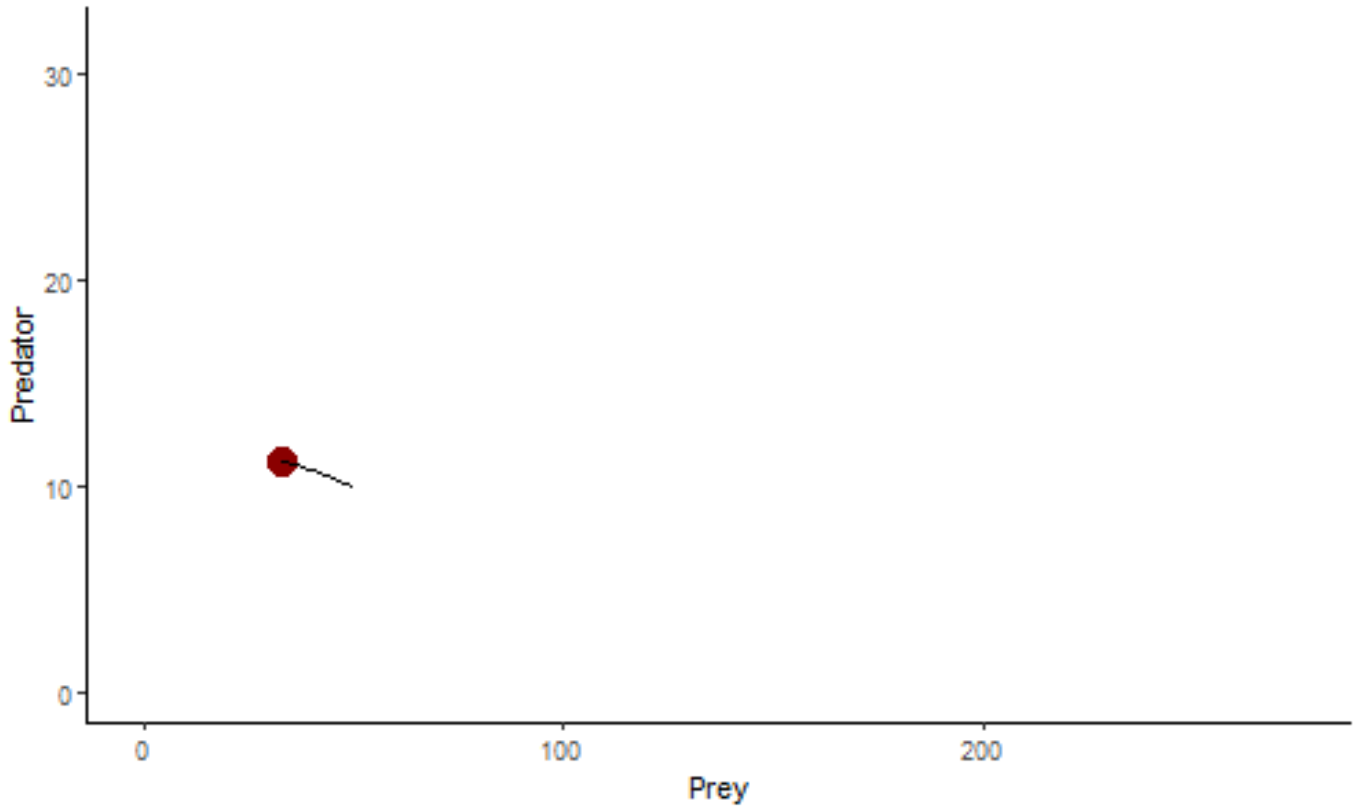
$$\frac{dV}{dt} = rV - \frac{aVP}{(1 + ahV)}$$

$$\frac{dP}{dt} = e\frac{aVP}{(1 + ahV)} - uP$$

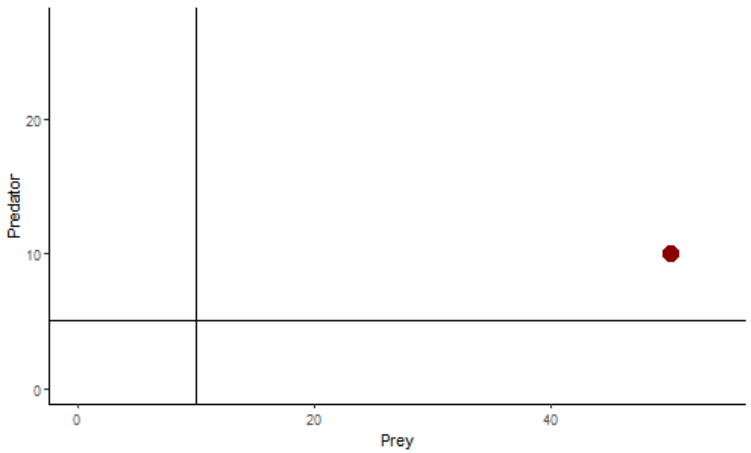
Cycles are getting bigger!



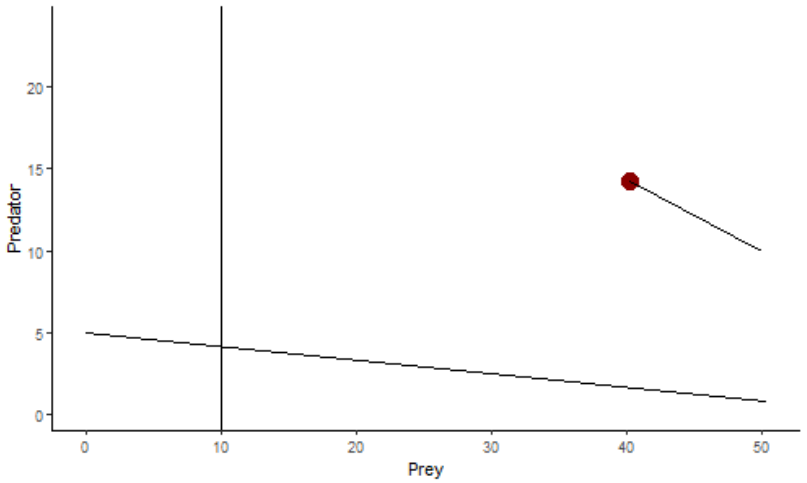
Unstable



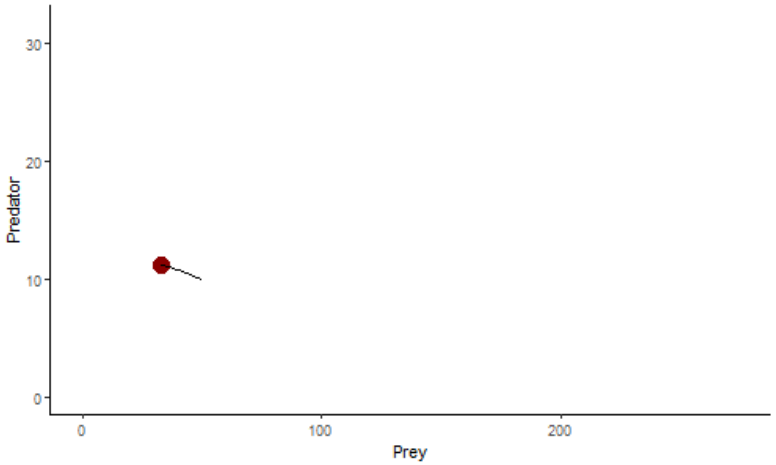
Neutral



Stable



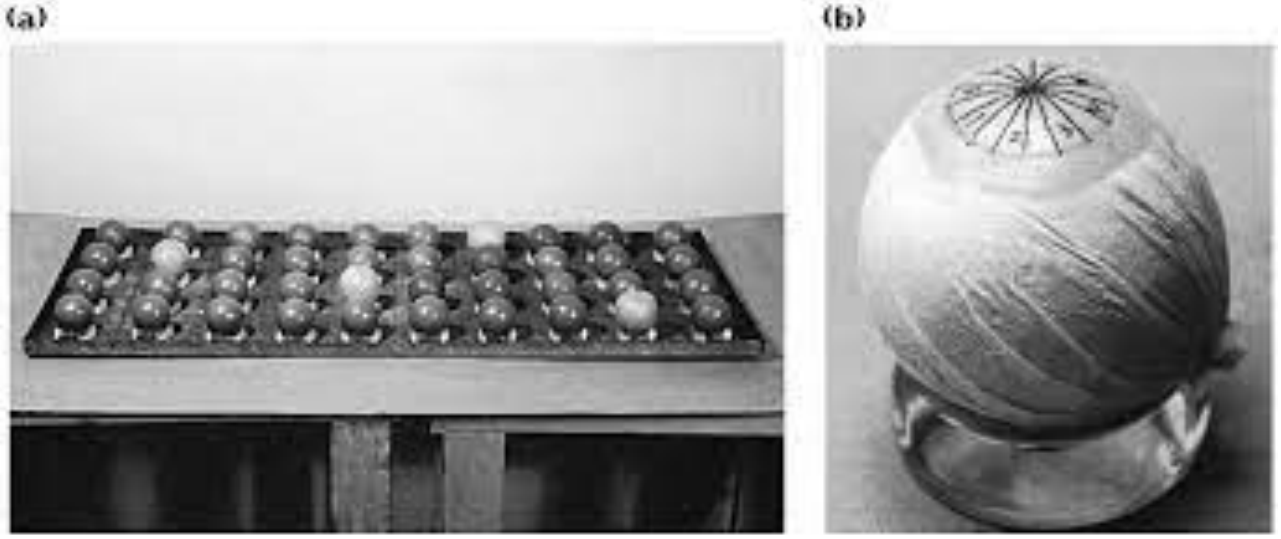
Unstable

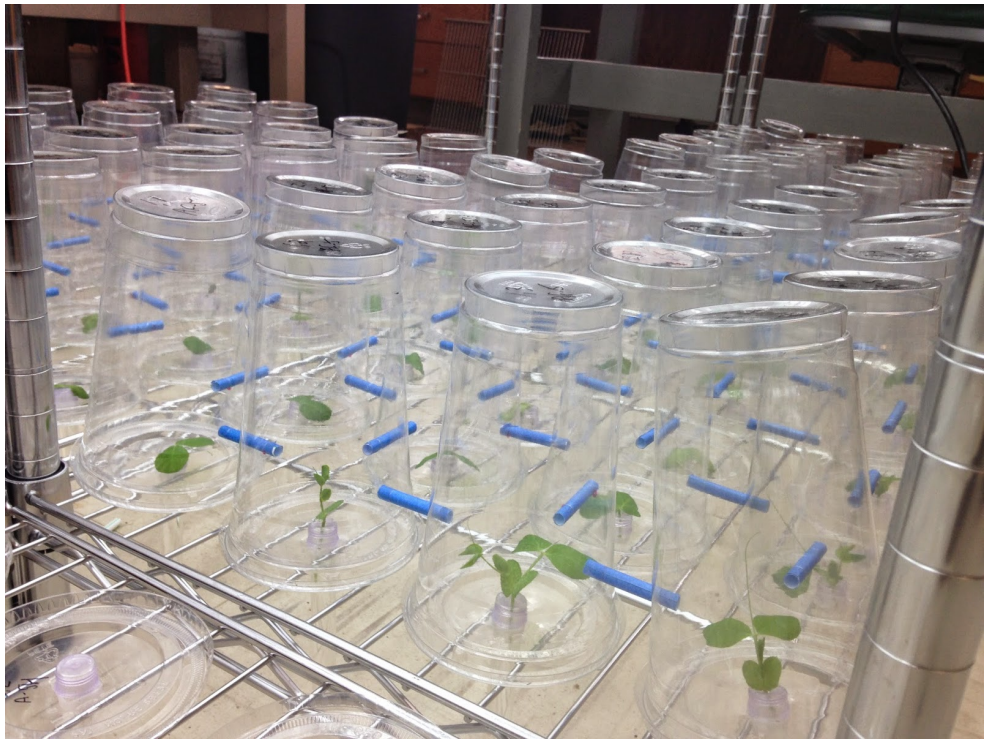


Modification

Prey refuges
Prey immigration
Predator density-dependence
Population structure
Explicit space…

Cool new experiments happening all the time





Other models

- Plant-herbivore models
- Host-parasitoid models
- Harvesting models

Thanks for listening!

- dkp5177@psu.edu

- **All code is in R (if anyone's interested, email me and I can send you my code)**