Weihnachtsbaum

June 15, 2020

0.1 Sequenz Weihnachtsbaum

Ein Räuber-Beute-Modell mit Giftkomponente

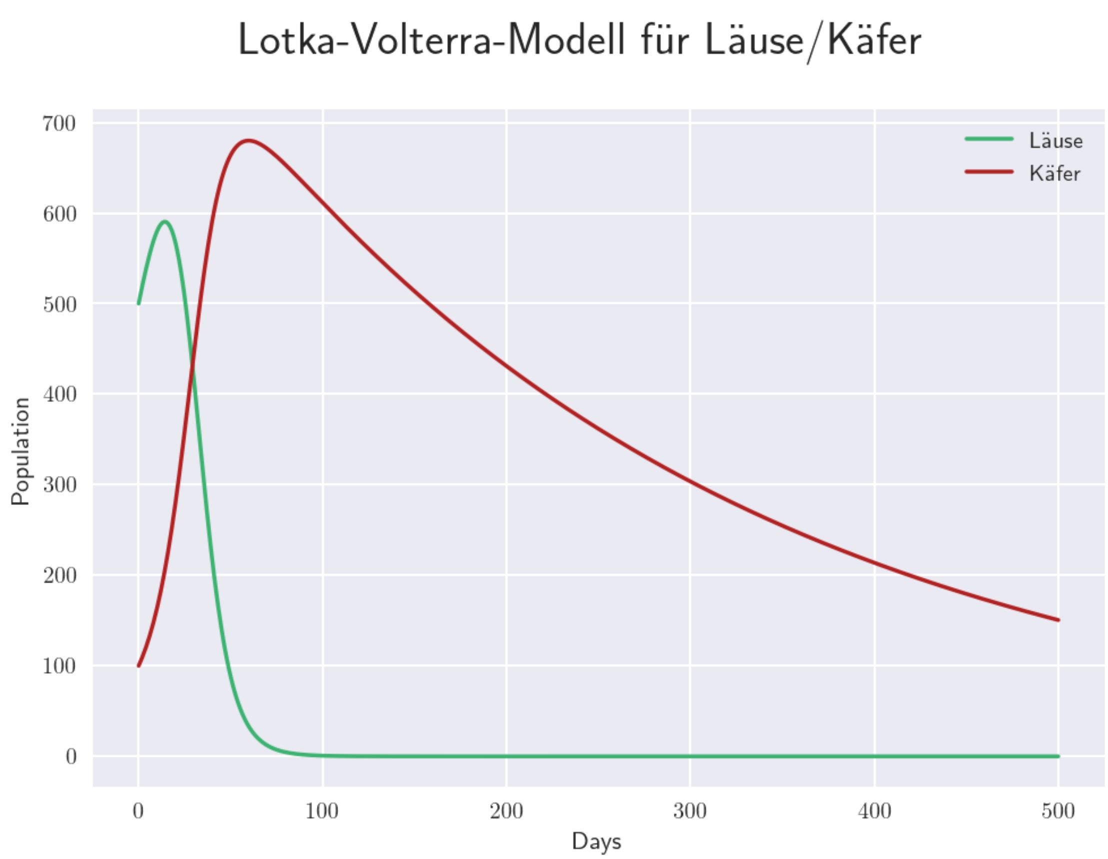
Ausgehend vom Lotka-Volterra-Modell für *lice* und *ladybugs*

$$L_{k+1} = (1+\alpha) \cdot L_k - \beta \cdot L_k \cdot B_k \tag{1}$$
$$B_{k+1} = (1-\gamma) \cdot B_k - \delta \cdot L_k \cdot B_k \tag{2}$$

bringen wir eine Giftkomponente ins Spiel, welche Insekten gleichermassen angreift. Zuerst das Räuber-Beute-Modell:

[1]:
```
# Hier gehts darum zu analysieren, was mit einem Räuber-Beute-Modell␣
 ↪prognostiziert wird, falls man einen äusseren Einfluss ins Spiel bringt.
%matplotlib inline
%config InlineBackend.figure_format = 'retina'
import matplotlib
matplotlib.rcParams["text.usetex"] = True
import matplotlib.pyplot as plt
import numpy as np
from numpy import zeros,linspace

plt.style.use('seaborn')

alpha = 0.04         # growthrate lice
beta = 0.0002         # deathrate lice
gamma = 0.0035           # diminishing ladybugs
delta = 0.0001        # growing ladybugs
epsilon = 0.025       # pesticide efficiency

tsteps = 500

t = linspace(0, tsteps, tsteps+1)
L = zeros(tsteps+1) # Sitkaäuse
B = zeros(tsteps+1) # Marienkäfer

# Initial condition
L[0] = 500 # lice
```

```
B[0] = 100 # ladybug

# Step equations forward in time
for k in range(tsteps):
    L[k+1] = (1+alpha)*L[k] - beta*L[k]*B[k]
    B[k+1] = (1-gamma)*B[k] + delta*B[k]*L[k]

fig = plt.figure()
fig.suptitle('Lotka-Volterra-Modell für Läuse/Käfer', fontsize=20)
l1, = plt.plot(t, L, color='mediumseagreen', label='Läuse')
l2, = plt.plot(t, B, color='firebrick', label='Käfer')
plt.legend()
plt.xlabel('Days')
plt.ylabel('Population')
plt.show()
# plt.savefig('tmp.pdf'); plt.savefig('tmp.svg')
```



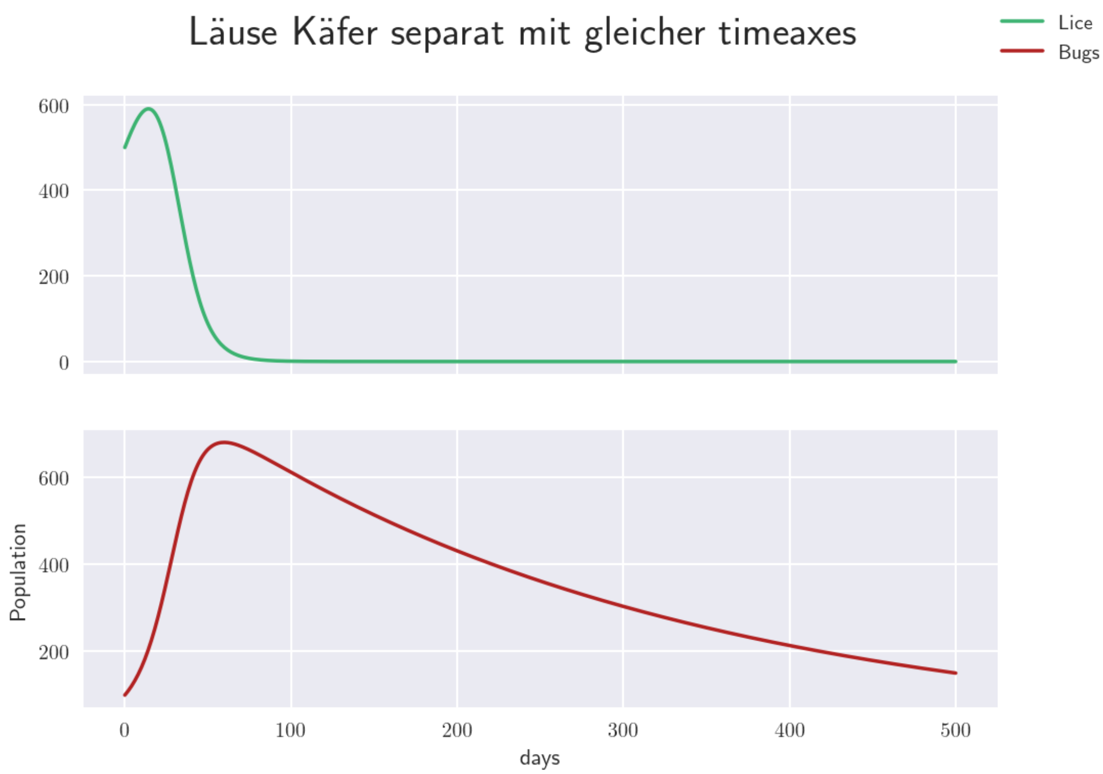
Jetzt fügen wir Gift dazu, mit einem “Wirkungsgrad” von ϵ:

$$L_{k+1} = (1+\alpha) \cdot L_k - \beta \cdot L_k B_k - \epsilon \cdot L_k \tag{3}$$
$$B_{k+1} = (1-\gamma) \cdot B_k - \delta \cdot L_k B_k - \epsilon \cdot B_k \tag{4}$$

[2]:
```
def lotkavolterrapoison(prey=500,predator=100,preygrowth=0.04,preymort=0.
↪0002,predatordecay=0.0035,predatorhunt=0.0001,poison=0.025,timesteps=500):

    L = zeros(timesteps+1)
    B = zeros(timesteps+1)

    # Initial condition
    L[0] = prey # susceptibles
    B[0] = predator # infected
    a = preygrowth
    b = preymort
    c = predatordecay
    d = predatorhunt
    e = poison

    # Step equations forward in time
    for k in range(timesteps):
        L[k+1] = (1+a)*L[k] - b*L[k]*B[k] - poison*L[k]
        B[k+1] = (1-c)*B[k] + d*B[k]*L[k] - poison*B[k]
    return L, B
```

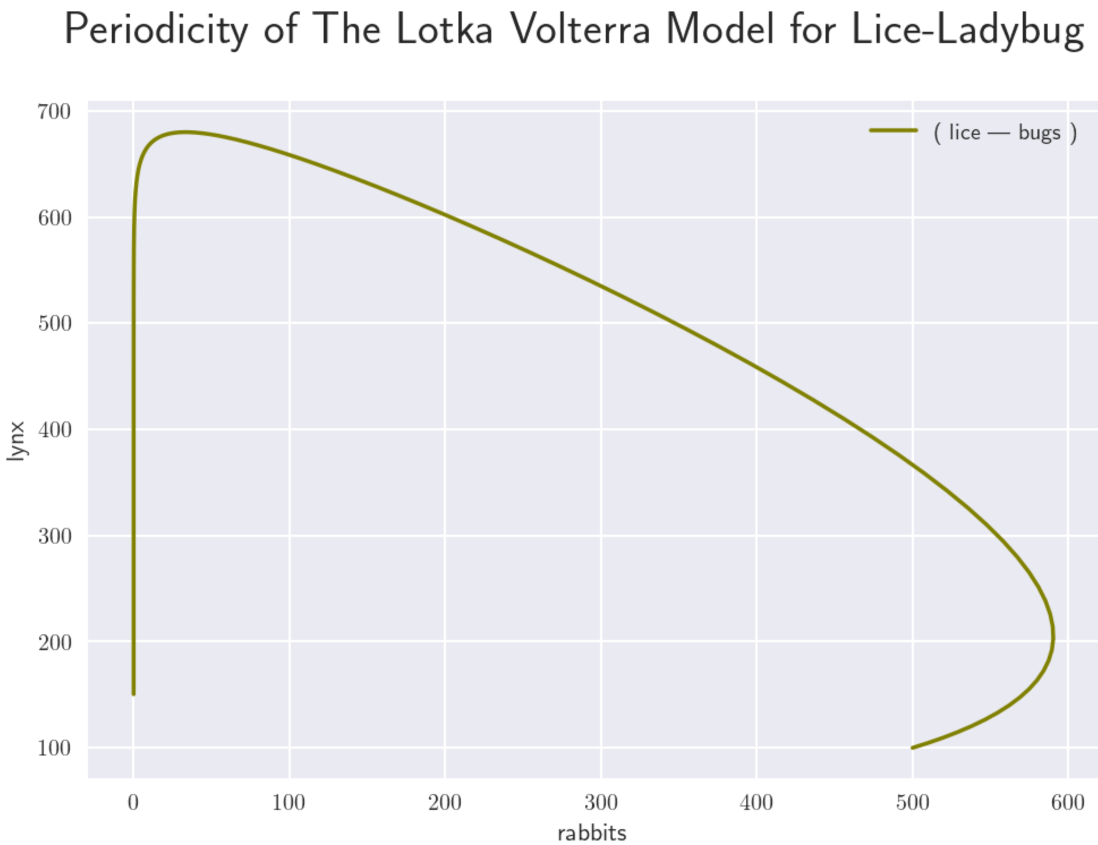
So, nach einmal alles schön der Reihe nach:

[3]:
```
fig, (ax1, ax2) = plt.subplots(2, sharex=True)
fig.suptitle('Läuse Käfer separat mit gleicher timeaxes', fontsize=20)
l1, = ax1.plot(t, L, color='mediumseagreen', label='Lice')
l2, = ax2.plot(t, B, color='firebrick', label='Bugs')

fig.legend()
plt.xlabel('days')
plt.ylabel('Population')
plt.show()
```



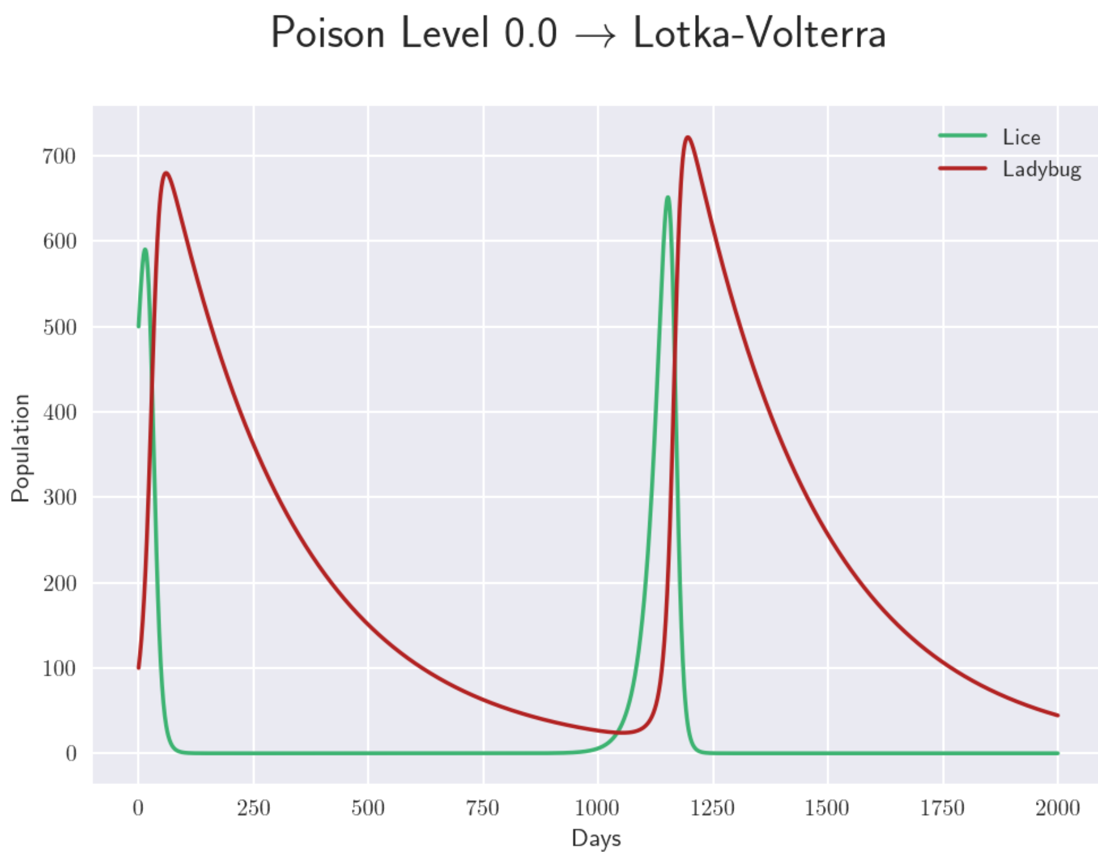
nicht vergessen: Auch wenn es oben nicht danach aussieht, dieses Modell ist periodisch!

[4]:
```
fig = plt.figure()
fig.suptitle('Periodicity of The Lotka Volterra Model for Lice-Ladybug',␣
 ↪fontsize=20)
plt.plot(L,B, color='olive', label='( lice | bugs )')
plt.xlabel('rabbits')
plt.ylabel('lynx')
plt.legend()
plt.show()
```

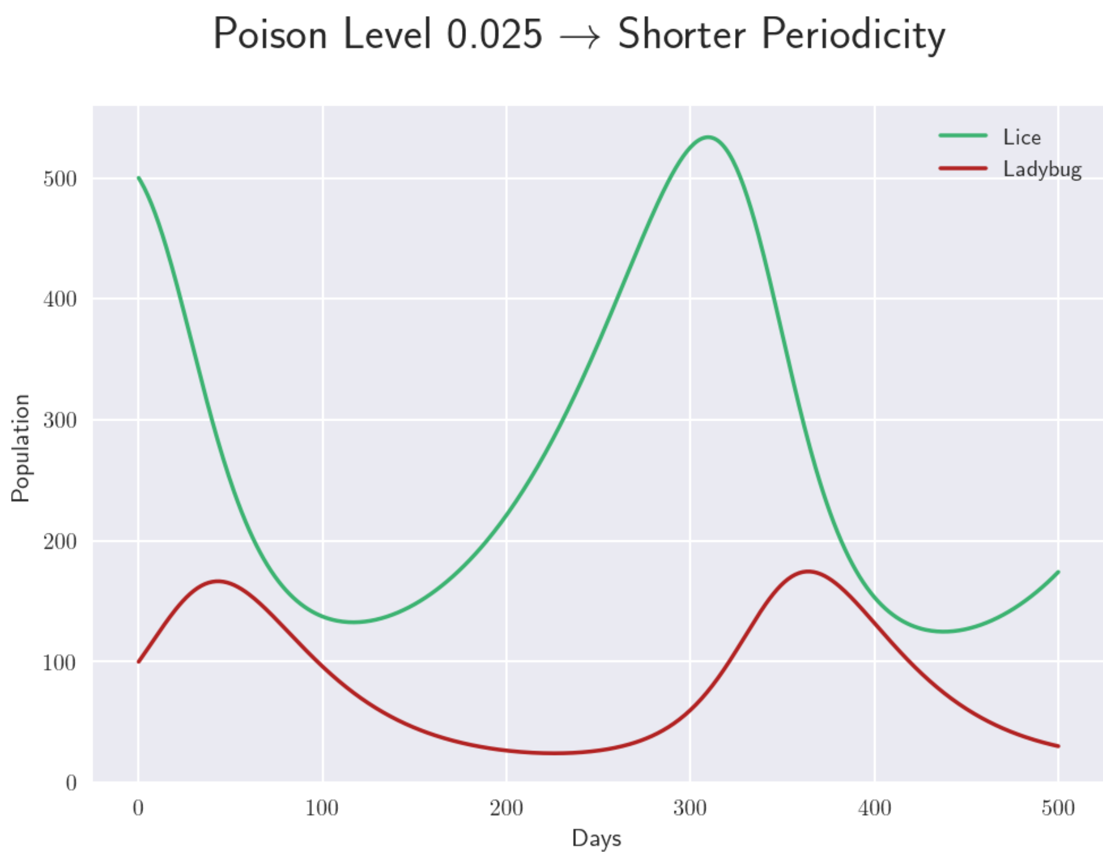


Deutlich wirds, wenn man den timeframe erhöht...
Man sieht auch schön den Phase-Shift.

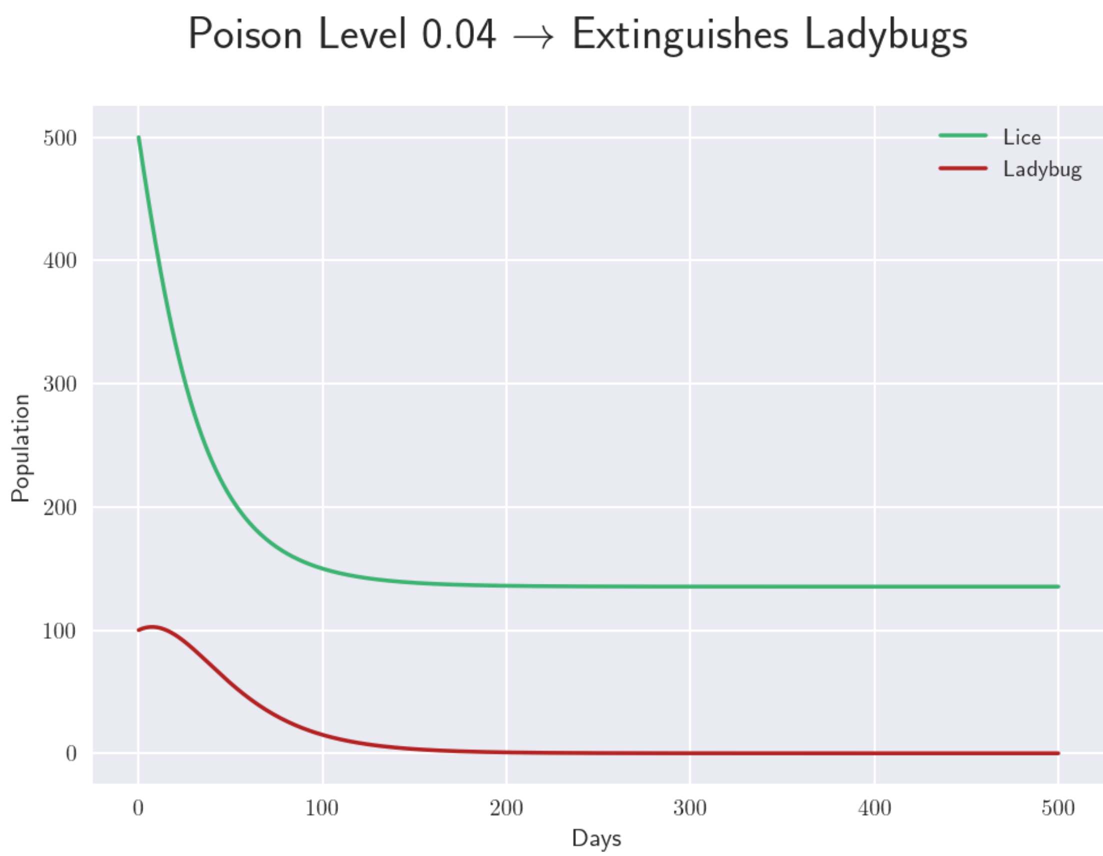
[5]:
```
lv2 = lotkavolterrapoison(prey=500,predator=100,preygrowth=0.04,preymort=0.
↪0002,predatordecay=0.0035,predatorhunt=0.0001,poison=0.0,timesteps=2000)
fig = plt.figure()
fig.suptitle(r'Poison Level 0.0 $\rightarrow$ Lotka-Volterra', fontsize=20)
plt.xlabel('Days')
plt.ylabel('Population')
plt.plot(lv2[0], color='mediumseagreen', label='Lice')
plt.plot(lv2[1], color='firebrick', label='Ladybug')
plt.legend()
plt.show()
```



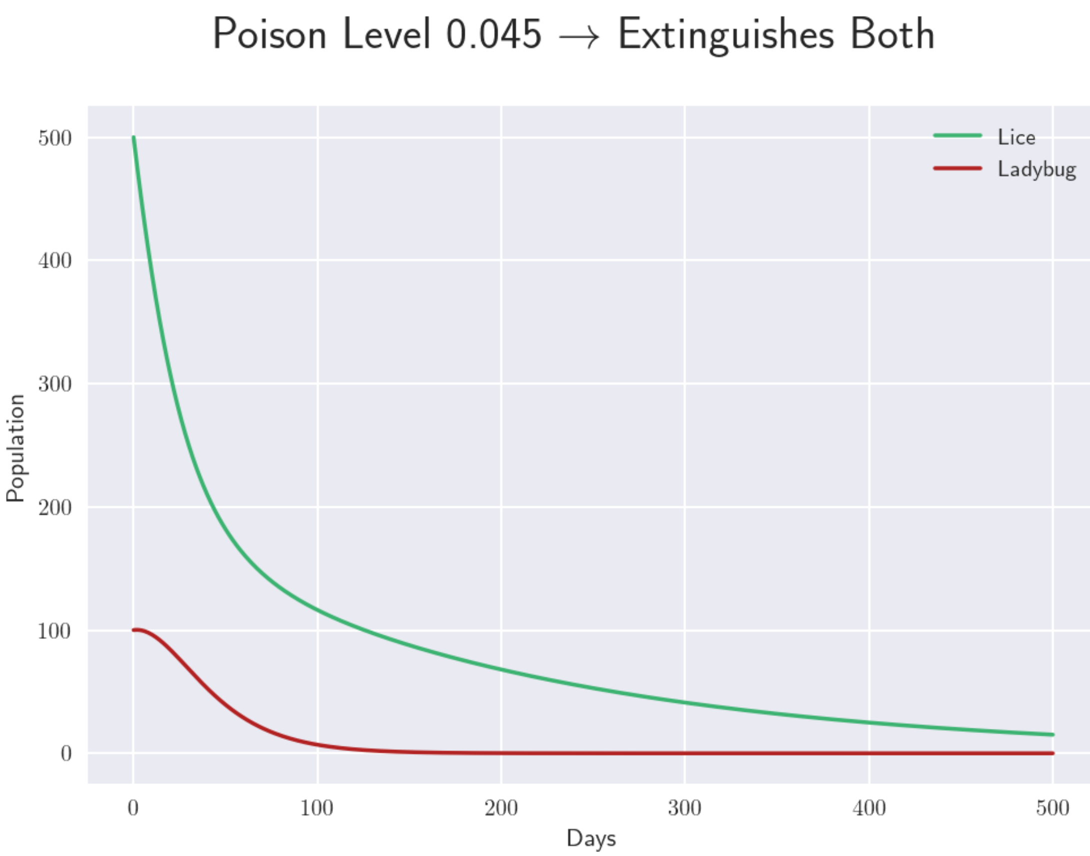
[6]:
```
lv1 = lotkavolterrapoison(prey=500,predator=100,preygrowth=0.04,preymort=0.0002,predatordecay=0.0035,predatorhunt=0.0001,poison=0.025,timesteps=500)
fig = plt.figure()
fig.suptitle(r'Poison Level 0.025 $\rightarrow$ Shorter Periodicity', fontsize=20)
plt.xlabel('Days')
plt.ylabel('Population')
plt.plot(lv1[0], color='mediumseagreen', label='Lice')
plt.plot(lv1[1], color='firebrick', label='Ladybug')
plt.legend()
plt.show()
```



[7]:
```
lv3 = lotkavolterrapoison(prey=500,predator=100,preygrowth=0.04,preymort=0.
↪0002,predatordecay=0.0035,predatorhunt=0.0001,poison=0.04,timesteps=500)
fig = plt.figure()
fig.suptitle(r'Poison Level 0.04 $\rightarrow$ Extinguishes Ladybugs',␣
↪fontsize=20)
plt.xlabel('Days')
plt.ylabel('Population')
plt.plot(lv3[0], color='mediumseagreen', label='Lice')
plt.plot(lv3[1], color='firebrick', label='Ladybug')
plt.legend()
plt.show()
```



[8]:
```
lv4 = lotkavolterrapoison(prey=500,predator=100,preygrowth=0.04,preymort=0.
↪0002,predatordecay=0.0035,predatorhunt=0.0001,poison=0.045,timesteps=500)
fig = plt.figure()
fig.suptitle(r'Poison Level 0.045 $\rightarrow$ Extinguishes Both', fontsize=20)
plt.xlabel('Days')
plt.ylabel('Population')
plt.plot(lv4[0], color='mediumseagreen', label='Lice')
plt.plot(lv4[1], color='firebrick', label='Ladybug')
plt.legend()
plt.show()
```



Poison Level 0.045 → Extinguishes Both
Lice
Ladybug
Population
Days
0
100
200
300
400
500