22S-CSB150-EEB159 Lab4

LISA WANG

TOTAL POINTS

90 / 100

QUESTION 1

1 1.a **15 / 15**

✓ **- 0 pts** *Correct*

- 5 pts Correct parameter setting

- 5 pts Correct plots

- 5 pts Need more detailed conclusion

- 2 pts Plot aesthetics (graph/axes titles, etc)

- 2 pts You have the right analysis and thought process but if you increased the time for your simulation you would see that it does indeed decrease by a squared factor - you can also justify this mathematically: when radius is decreased by $$\frac{1}{2}$$, the $$\pi \cdot r^2$$ term in definition of area of a circle of interaction decreases by a factor of 4.

QUESTION 2

2 1.b **15 / 15**

✓ **- 0 pts** *Correct*

- 2 pts Plot aesthetics (graph/axes titles)

- 5 pts Need better conclusion

- 5 pts Click here to replace this description.

QUESTION 3

3 1.c **15 / 15**

✓ **- 0 pts** *Correct*

- 2 pts Plot aesthetics (graph/axes titles)

- 5 pts Need more in depth conclusion

- 1 pts Final conclusion is wrong, but aligns with your investigation. The consumption rate *shouldn't* increase or decrease on average.

QUESTION 4

4 1.d **10 / 15**

- 0 pts Correct

- 2 pts Plot aesthetics (graph/axes titles)

✓ **- 5 pts** *Incorrect interpretation*

- 3 pts Insufficient discussion of results

- 5 pts Missing plots

QUESTION 5

5 1.e **10 / 15**

- 0 pts Correct

- 2 pts Plot aesthetics (graph/axes titles)

- 5 pts Missing plots

✓ **- 5 pts** *Incorrect/missing interpretation. If you ran the simulation for longer, you'd see that the consumption rate plateaus when there is no regeneration*

- 3 pts Insufficient discussion; need to mention how consumption plateaus

- 2 pts While you do mention that consumption rate decreases, you need to increase to time of the simulation to see that it eventually plateaus.

QUESTION 6

6 2 **25 / 25**

✓ **- 0 pts** *Correct*

- 5 pts Correctly answer the question: how does total number of prey consumed change compared to the prior case?

- 5 pts Correctly set parameters such that predators are essentially limited by handling time

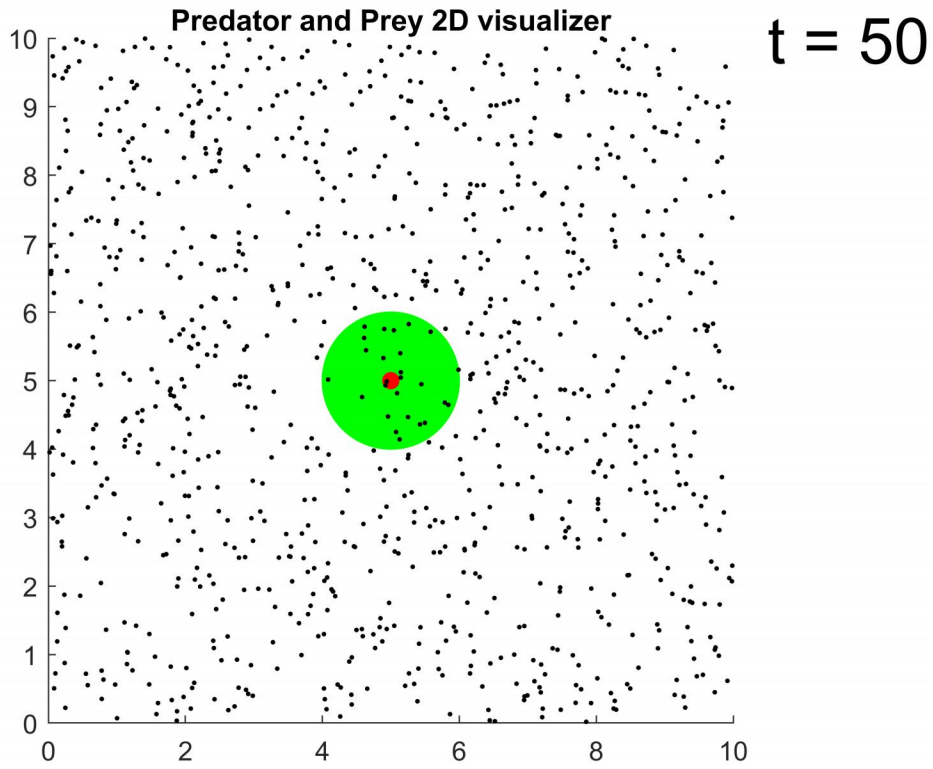
- 10 pts Correct plots/calculation

- 3 pts Correct conclusion - are predators limited by handling time?

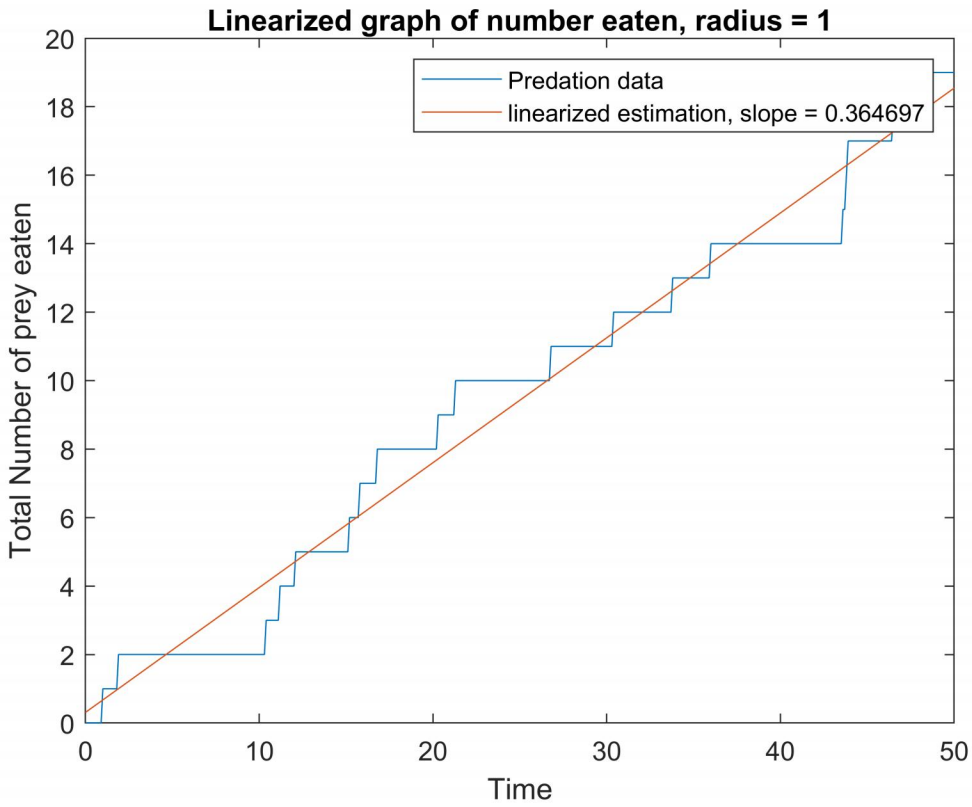
- 2 pts Plot aesthetics (graph/axes titles)

```
% An individual-based model of predators eating prey
% Joshua Weitz

% Basic information
info.prey_density=10;    % density/cm^2
info.maxX=10;        % cm
info.maxY=10;        % cm
info.tf=50;        % sec
info.dt=0.1;        % Time step
info.replenish_prey=1;  % Should prey regenerate?
info.viz_dyn=0;        % 1 for animation, 0 for no animation

% Define the prey
prey.num=info.prey_density*info.maxX*info.maxY;
prey.pos=rand(prey.num,2);   % Random positions
prey.pos(:,1)=prey.pos(:,1)*info.maxX;
prey.pos(:,2)=prey.pos(:,2)*info.maxY;
prey.diffusion=0.005;     % cm^2/sec

% Place the predator
predator.pos=[info.maxX/2 info.maxY/2];
predator.theta=rand*2*pi;  % Angle of movement
predator.r=1.25;           % Radius
predator.k=0.3;           % Detection
predator.f=0.05;           %  Successful capture per time
predator.vel=0.1;        % cm/sec
predator.handling_time=0.0;   % seconds
predator.tau=6;           % Run time length, seconds
predator.trun=0;       % Initialize each run

% % Simulate eating
% more off
% for ens=1:1,
%   ens
%   [t,numeaten]=ibm_predation(info,predator,prey);
%   total_eaten=cumsum(numeaten);
%   totend(ens)=total_eaten(end);
% end
```

```
%% Section 1A answers:

predator.r = 1;

% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

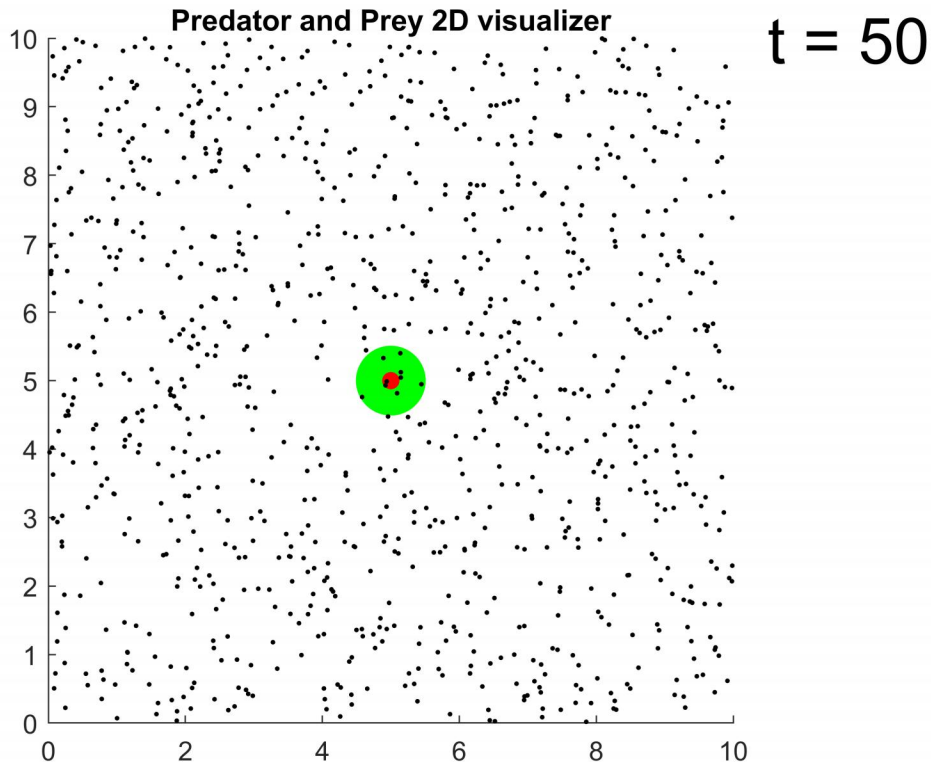



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, radius = 1');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

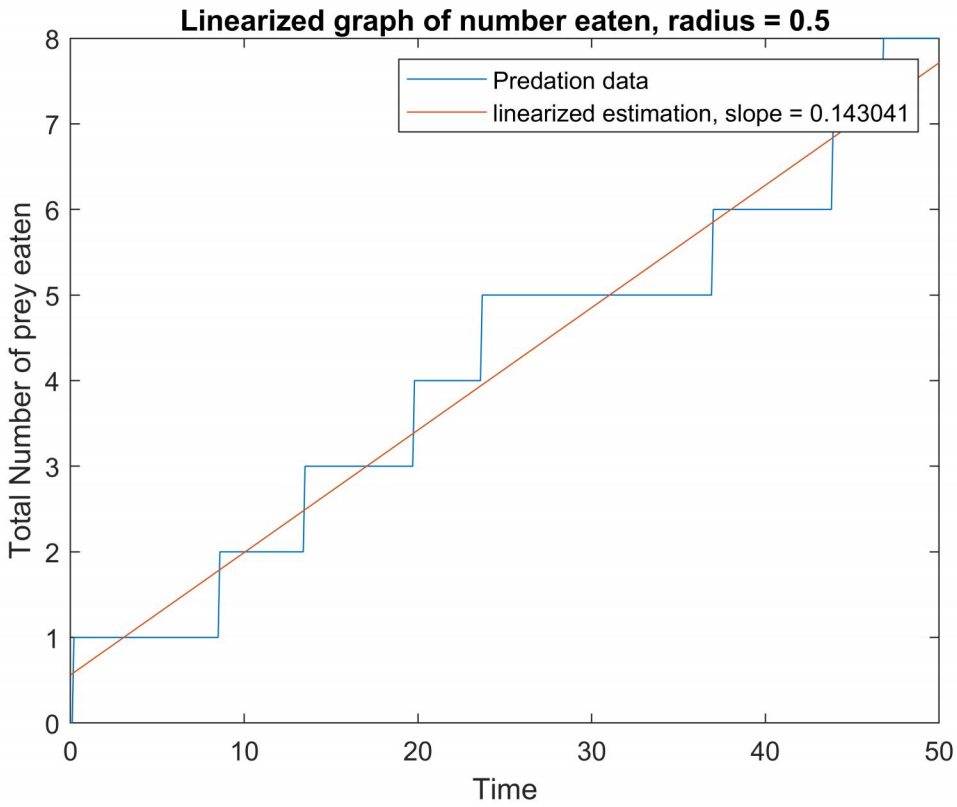



```
%%slope = 0.555901
```

```
predator.r = 0.5;


% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```




```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, radius = 0.5');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```




```
%%slope = 0.144239
%%From the comparison of the linearized graph of the predation data from
%%simulation, we can see that the slopes were different by roughly 1/4.
%%This confirms the hypothesis that radius and predation number are
%%related. The amount of total eaten is about 1/4 from the radius of 1.
predator.r = 1.25; % reset
```

```
%% Section 1B:

predator.vel=0.1;        % cm/sec
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

1 1.a **15 / 15**

✓ **- 0 pts** *Correct*

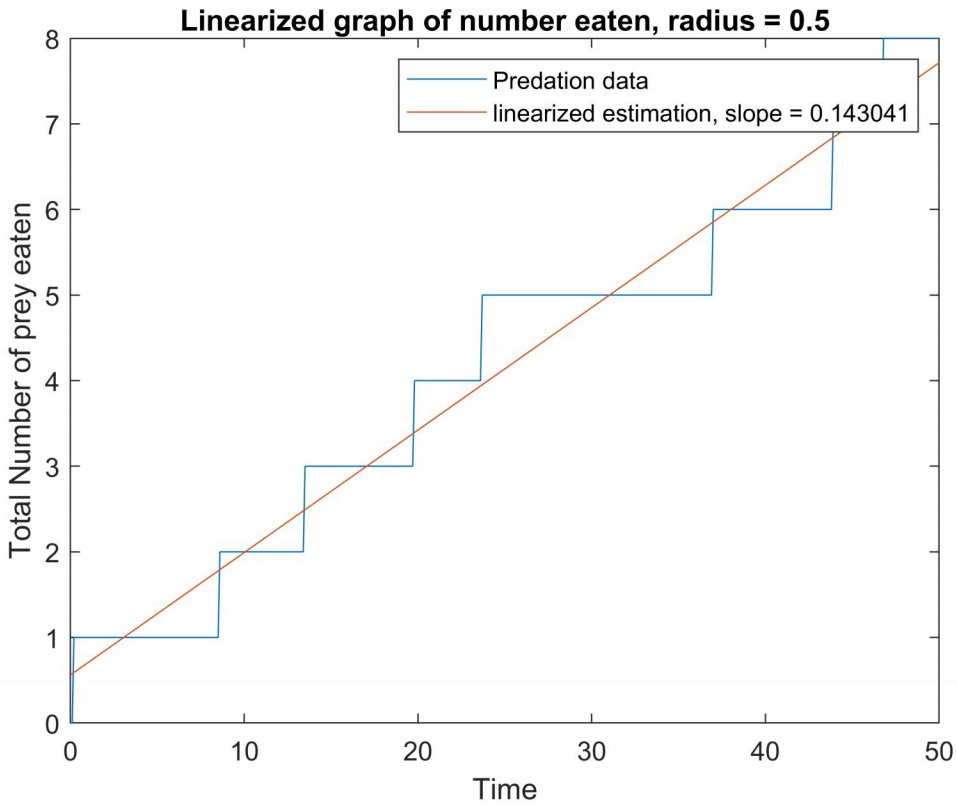
- 5 pts Correct parameter setting

- 5 pts Correct plots

- 5 pts Need more detailed conclusion

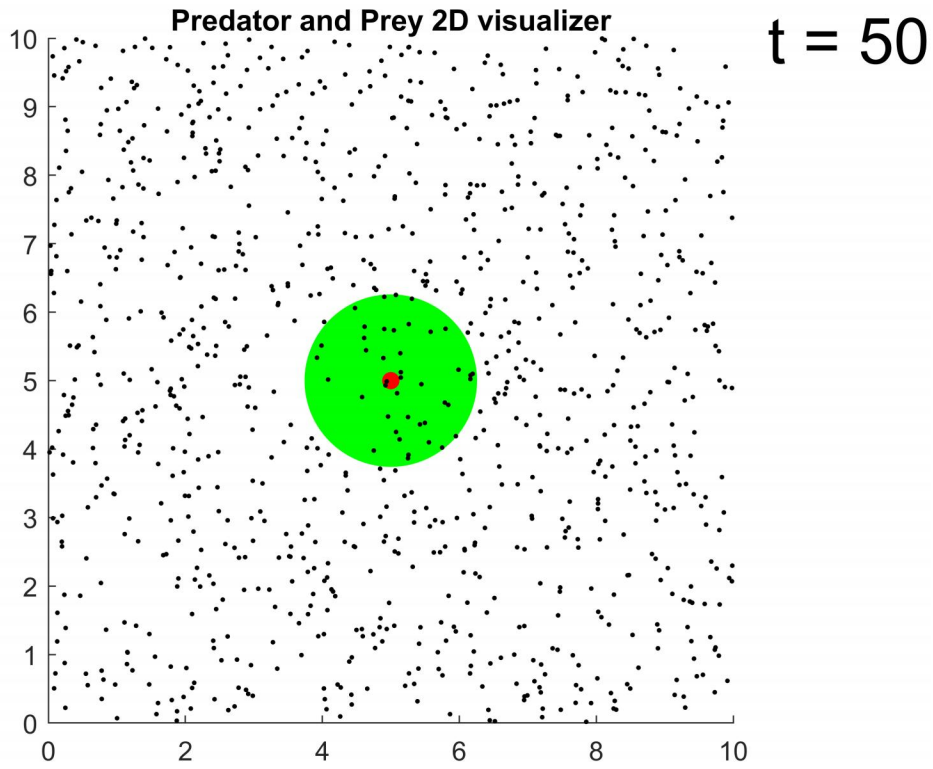
- 2 pts Plot aesthetics (graph/axes titles, etc)

- 2 pts You have the right analysis and thought process but if you increased the time for your simulation you would see that it does indeed decrease by a squared factor - you can also justify this mathematically: when radius is decreased by $$\frac{1}{2}$$, the $$\pi \cdot r^2$$ term in definition of area of a circle of interaction decreases by a factor of 4.

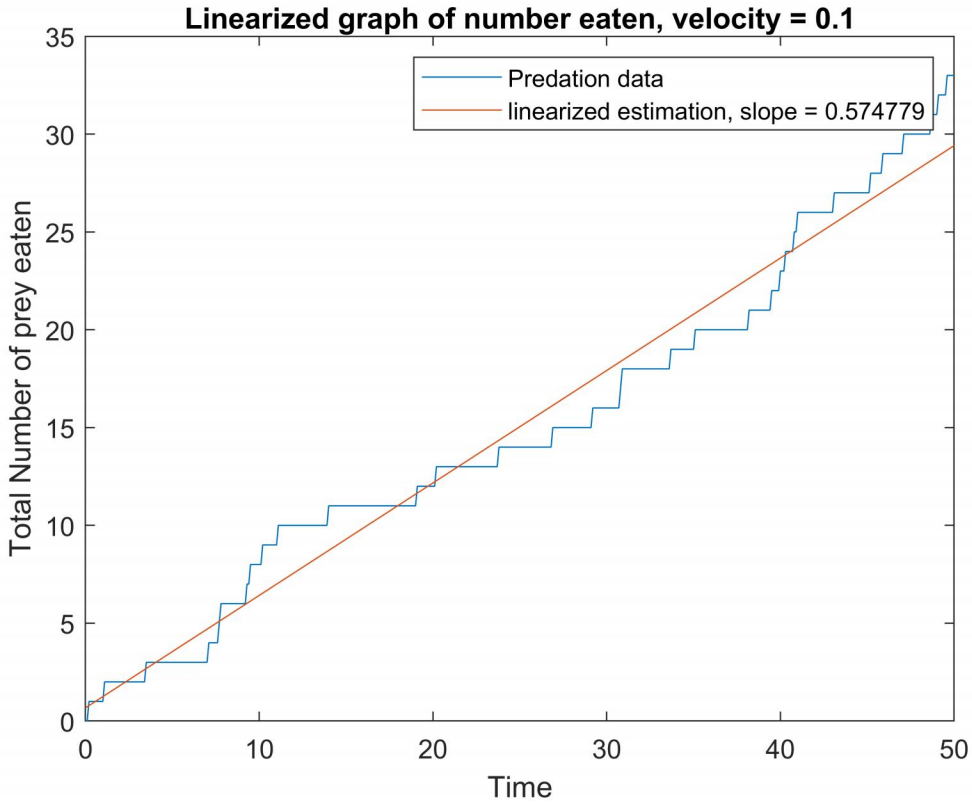



```
%%slope = 0.144239
%%From the comparison of the linearized graph of the predation data from
%%simulation, we can see that the slopes were different by roughly 1/4.
%%This confirms the hypothesis that radius and predation number are
%%related. The amount of total eaten is about 1/4 from the radius of 1.
predator.r = 1.25; % reset
```

```
%% Section 1B:

predator.vel=0.1;        % cm/sec
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

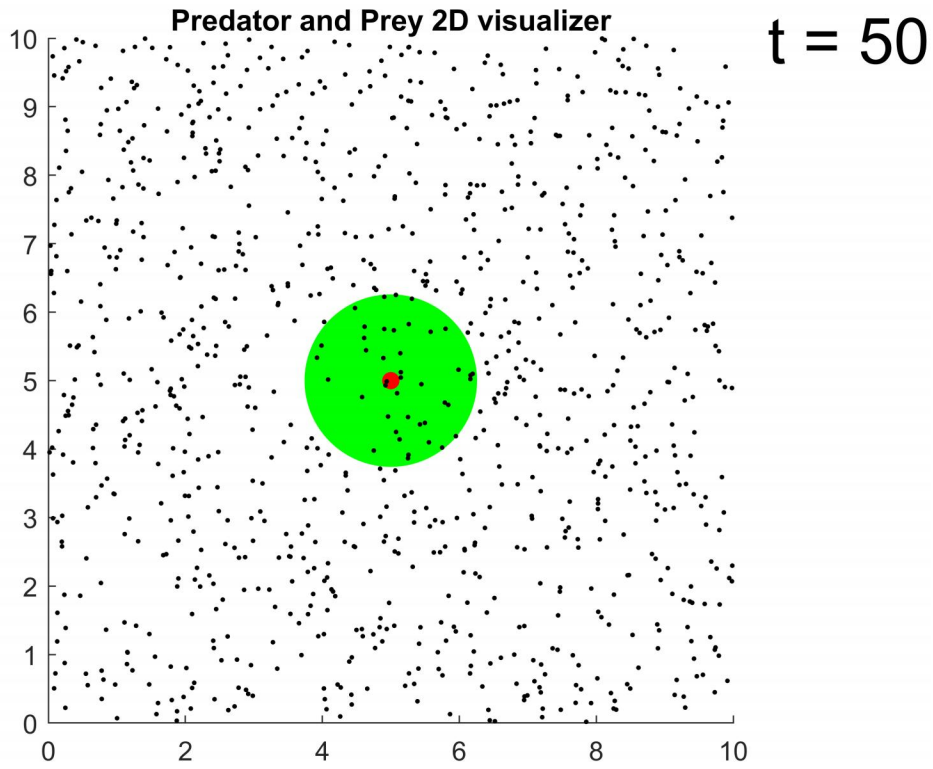



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, velocity = 0.1');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

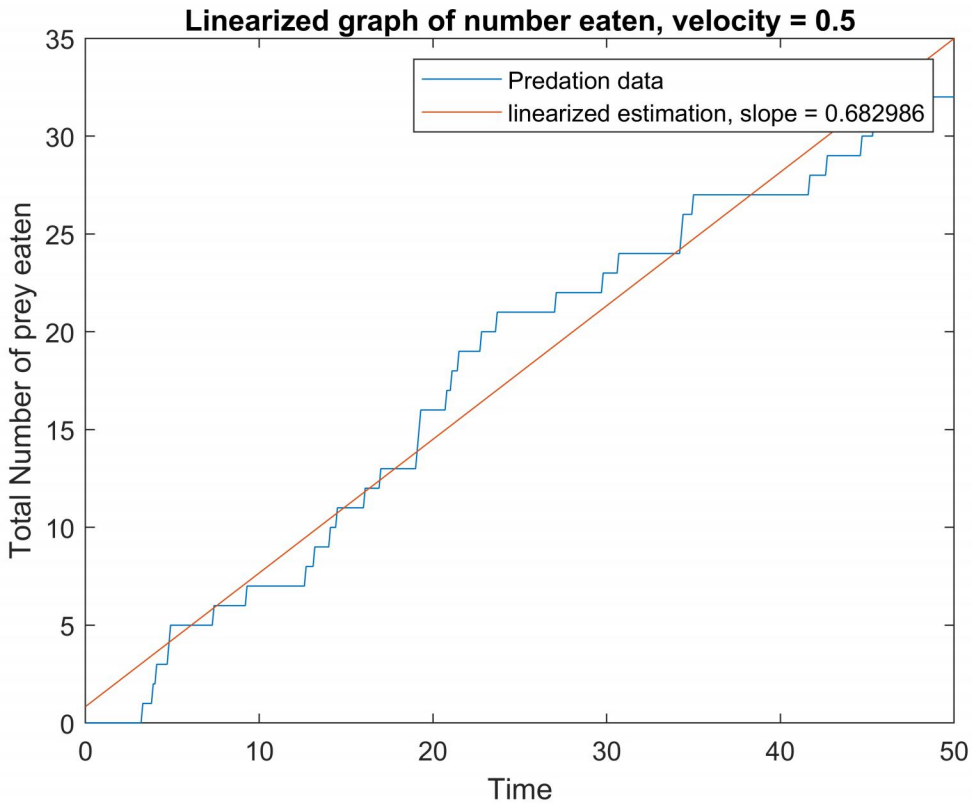



```
%% if the predator's velocity is low, then it would not affect
% the scaling. However, if the velocity is changed to a larger number
% the scaling does get affected. So as velocity increases, scaling the
% predator velocity would multiply the rate of consumption. I tried this
% first using a low velocity (close to initial velocity v = 0.1 cm/sec)
% then using a larger velocity for testing.
```

```
%% Section 1B:

predator.vel=0.01;        % cm/sec
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```




```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, velocity = 0.5');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```




```
%%the velocity does not seem to change. This is different from the radius
%%of the predator.

predator.vel = 0.1;
```

```
%% Section 1C:

prey.diffusion=0.005;     % cm^2/sec
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

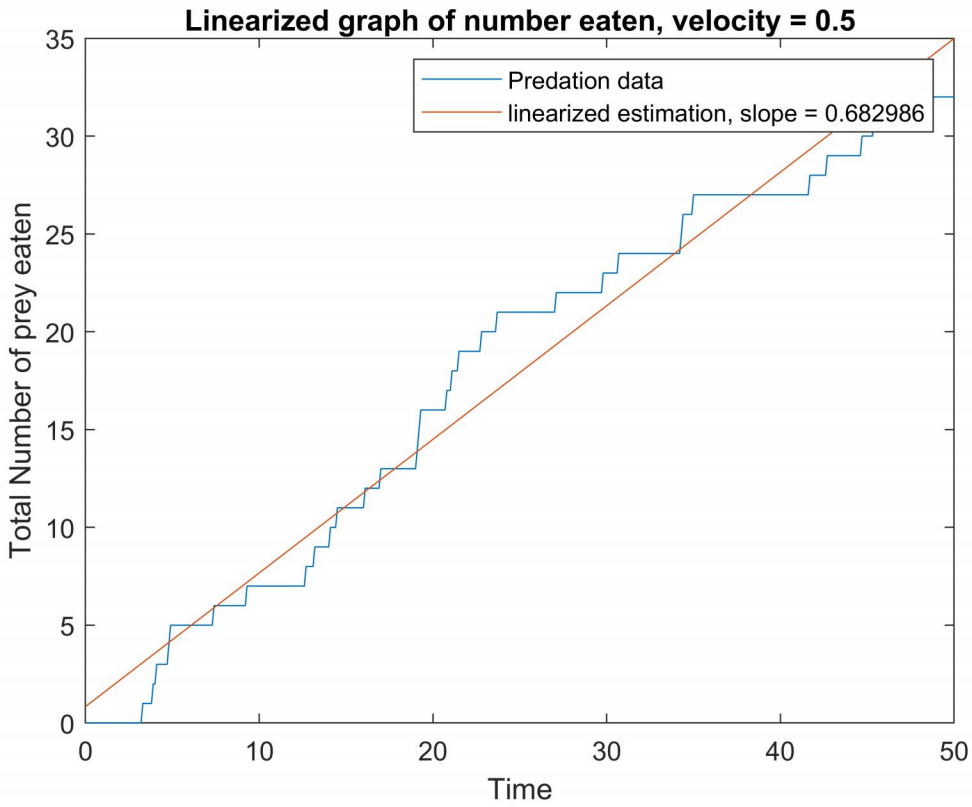
2 1.b **15 / 15**

✓ **- 0 pts** *Correct*

- 2 pts Plot aesthetics (graph/axes titles)

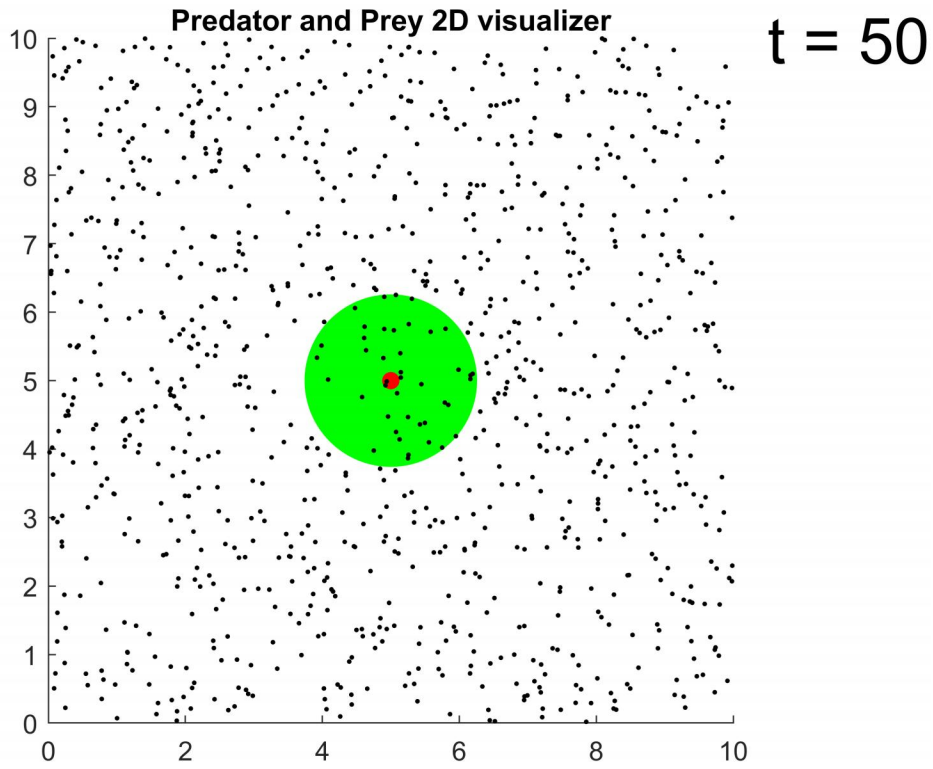
- 5 pts Need better conclusion

- 5 pts Click here to replace this description.

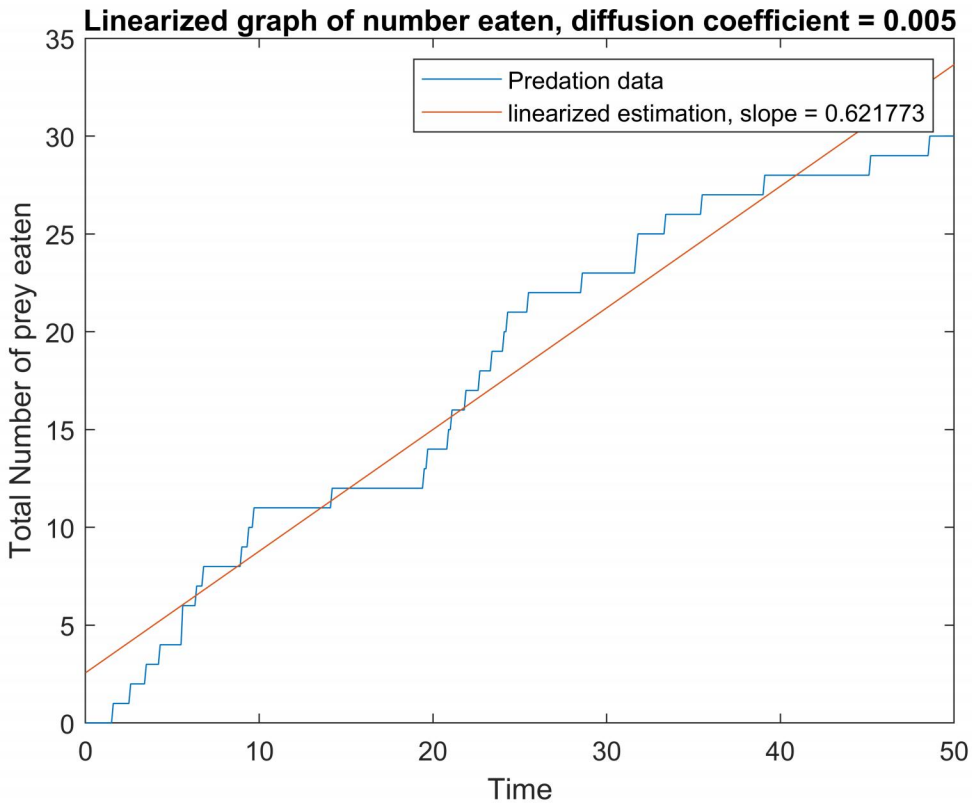



```
%%the velocity does not seem to change. This is different from the radius
%%of the predator.

predator.vel = 0.1;
```

```
%% Section 1C:

prey.diffusion=0.005;     % cm^2/sec
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

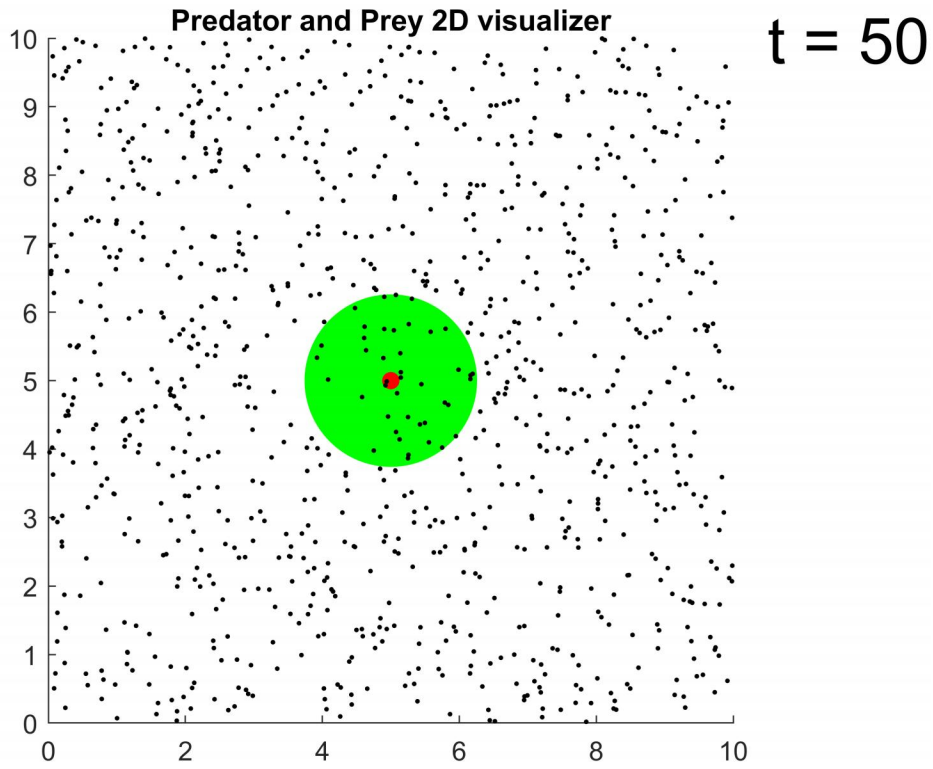



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, diffusion coefficient = 0.005');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

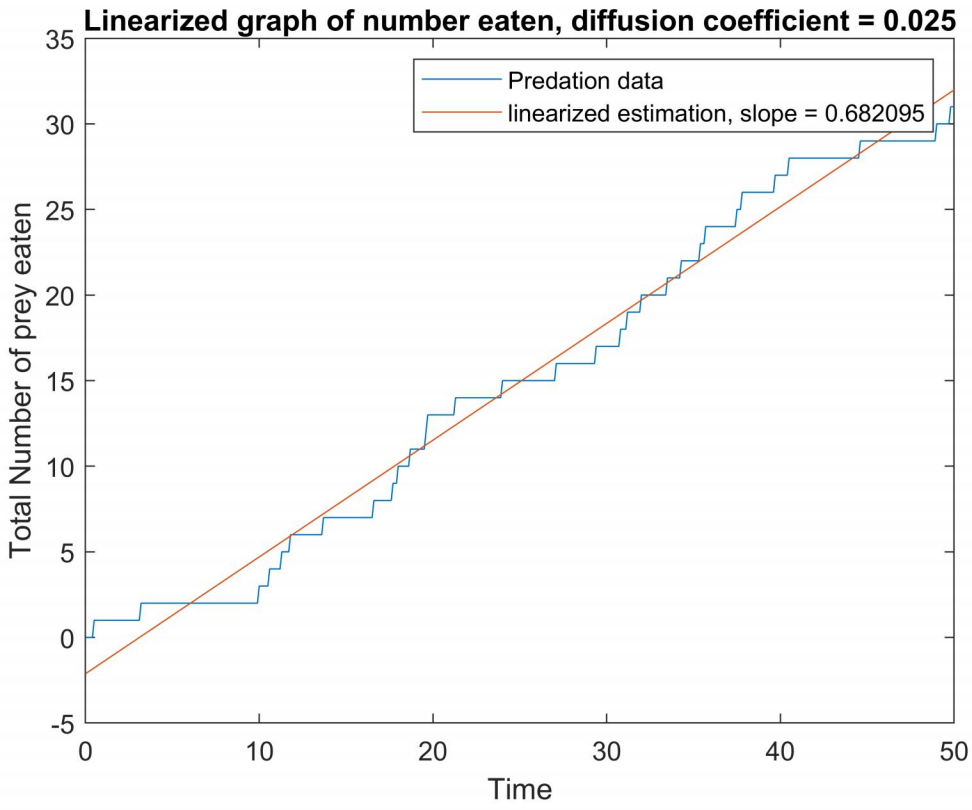



```
%slope = 0.62
```

```
prey.diffusion=0.025;     % cm^2/sec
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```




```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, diffusion coefficient = 0.025');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```




```
%slope = 0.682

%% the coefficient of diffusion doesn't affect the scaling, and this is shown by the slopes be
% close in value. This may also attribute to the randomness of the
% positioning.

prey.diffusion = 0.005; % original parameter
```

```
%% Section 1D
% changing the density of prey
info.prey_density=10;    % density/cm^2 of original simulation model
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

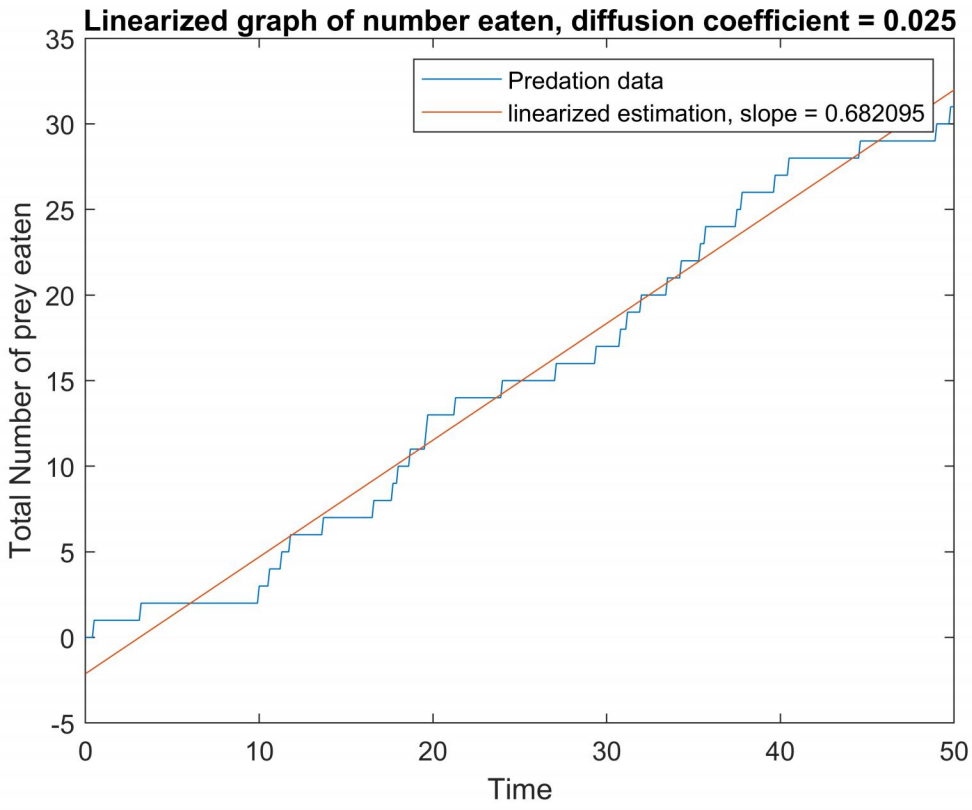
3 1.c **15 / 15**

✓ **- 0 pts** *Correct*

- 2 pts Plot aesthetics (graph/axes titles)

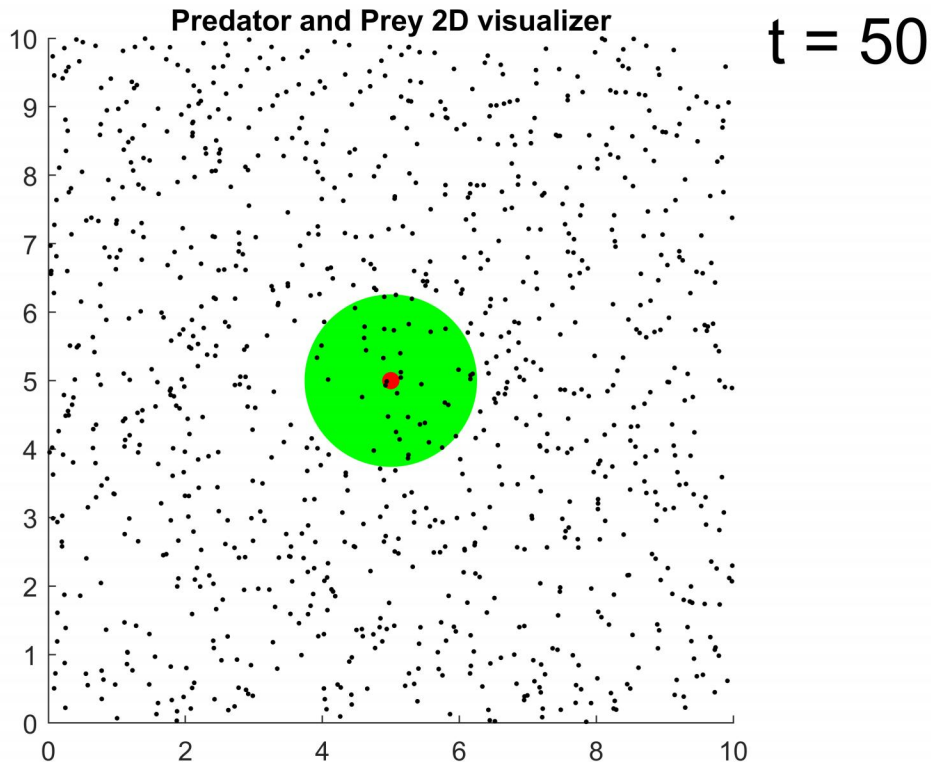
- 5 pts Need more in depth conclusion

- 1 pts Final conclusion is wrong, but aligns with your investigation. The consumption rate *shouldn't* increase or decrease on average.

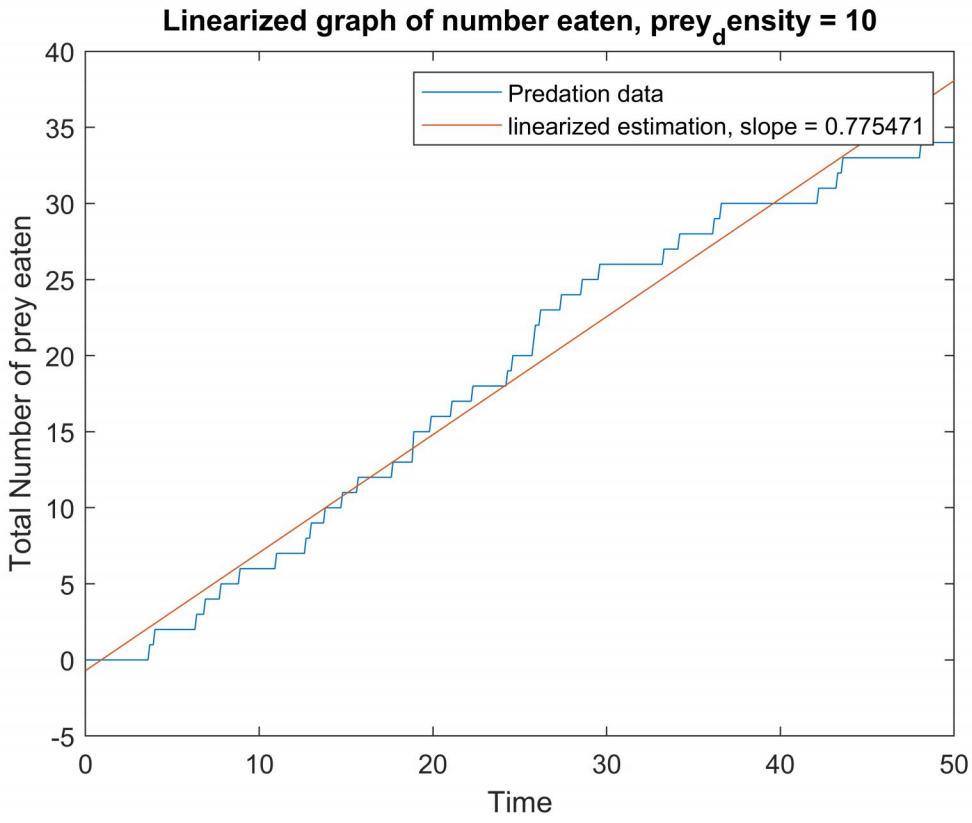



```
%slope = 0.682

%% the coefficient of diffusion doesn't affect the scaling, and this is shown by the slopes be
% close in value. This may also attribute to the randomness of the
% positioning.

prey.diffusion = 0.005; % original parameter
```

```
%% Section 1D
% changing the density of prey
info.prey_density=10;    % density/cm^2 of original simulation model
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

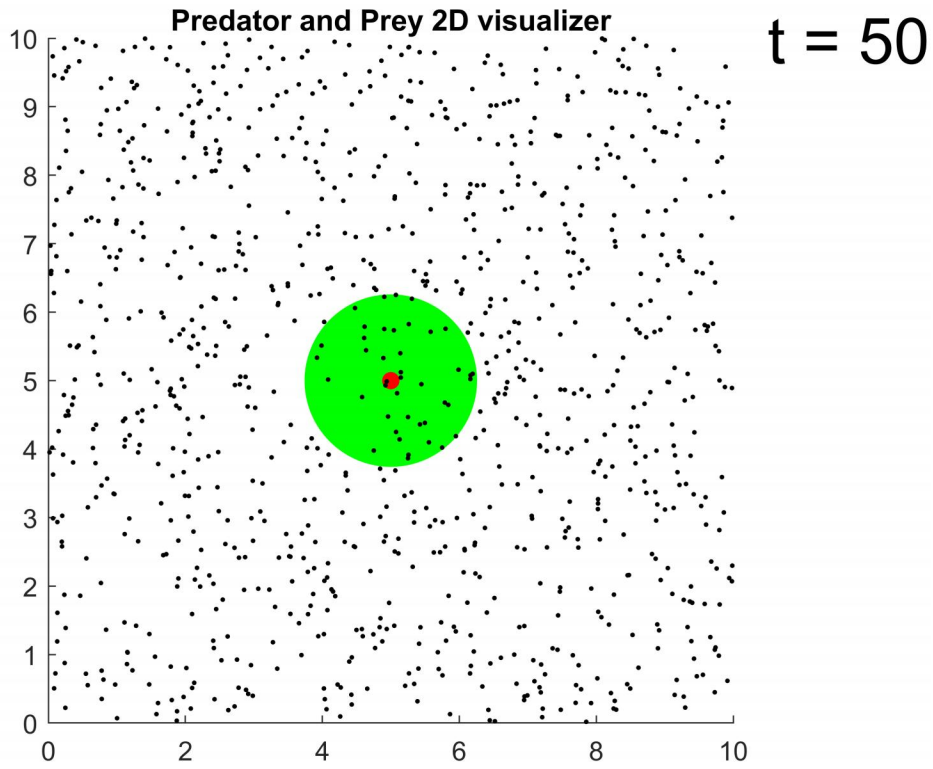



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, prey_density = 10');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

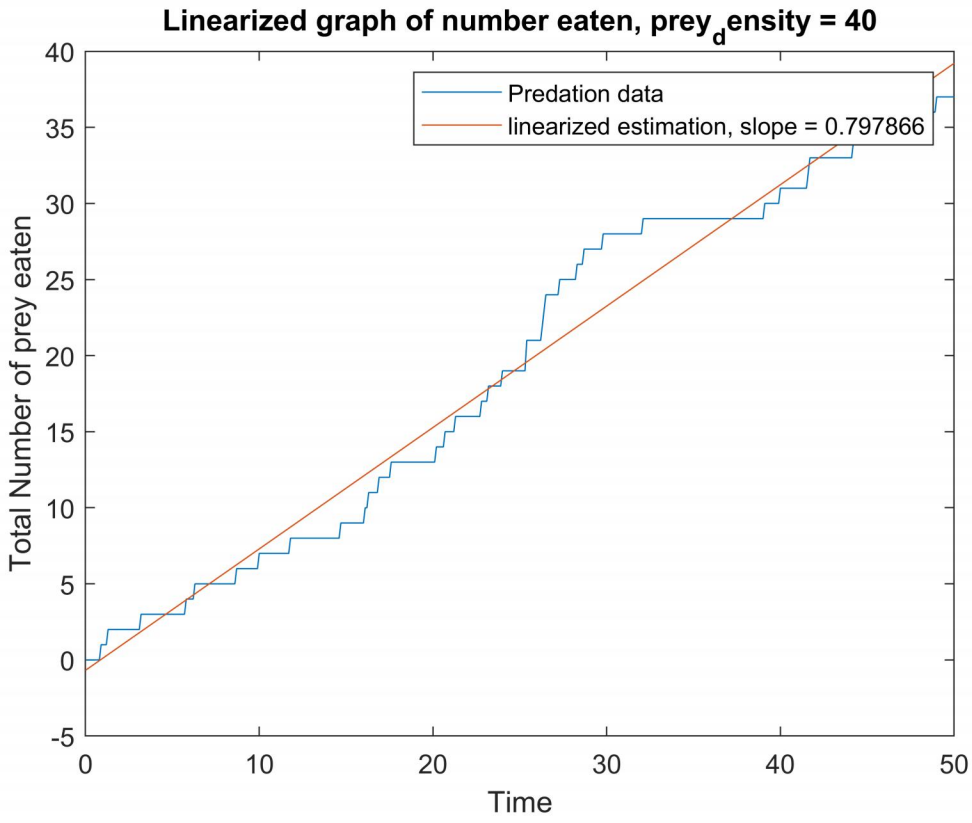



```
% slope = 0.775
%% comparing with density of prey, changed to 40
```

```
info.prey_density=40;    % density/cm^2 of original simulation model

% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```




```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, prey_density = 40');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```




```
%slope = 0.7978
%% the coefficient doesn't affect the scaling, like the coefficient of diffusion,
% the slope of the fitted line of graph of total number of prey eaten
% is close in value
```

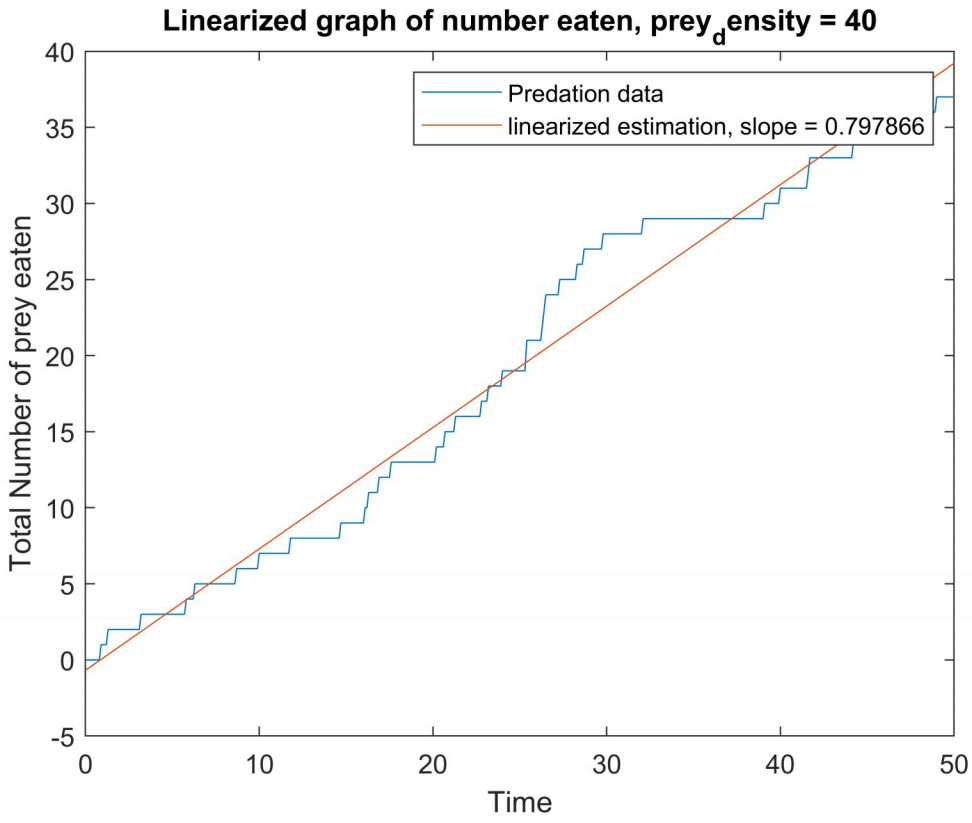
```
%% Section 1E
info.replenish_prey=1;  % Should prey regenerate?

% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

4 1.d **10 / 15**

- **0 pts** Correct
- **2 pts** Plot aesthetics (graph/axes titles)

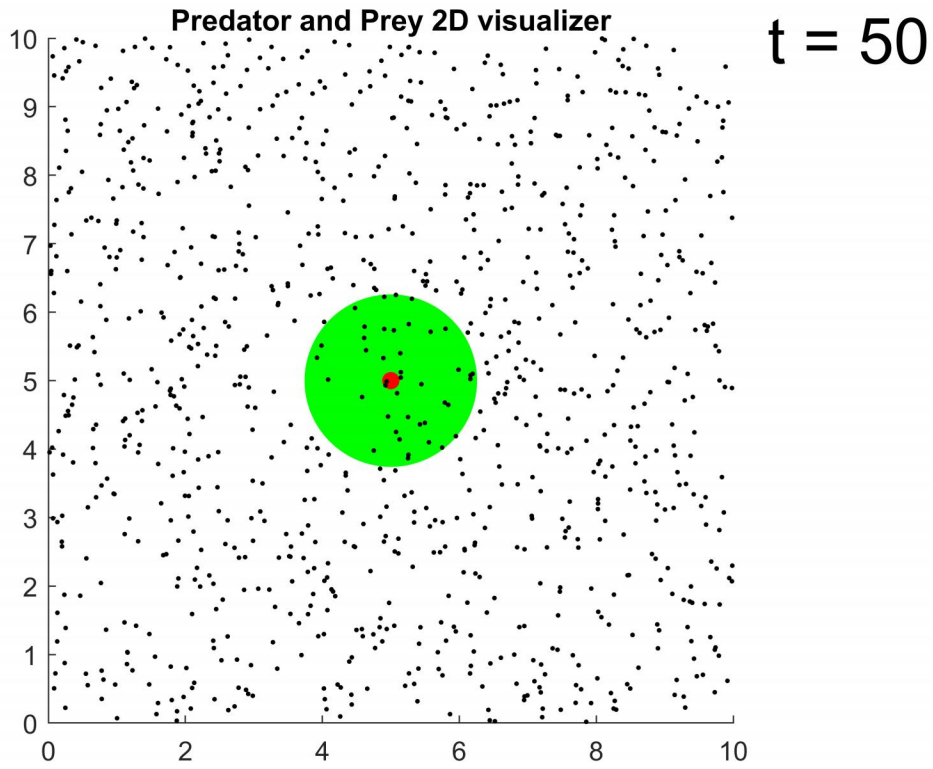
✓ **- 5 pts** *Incorrect interpretation*

- **3 pts** Insufficient discussion of results
- **5 pts** Missing plots

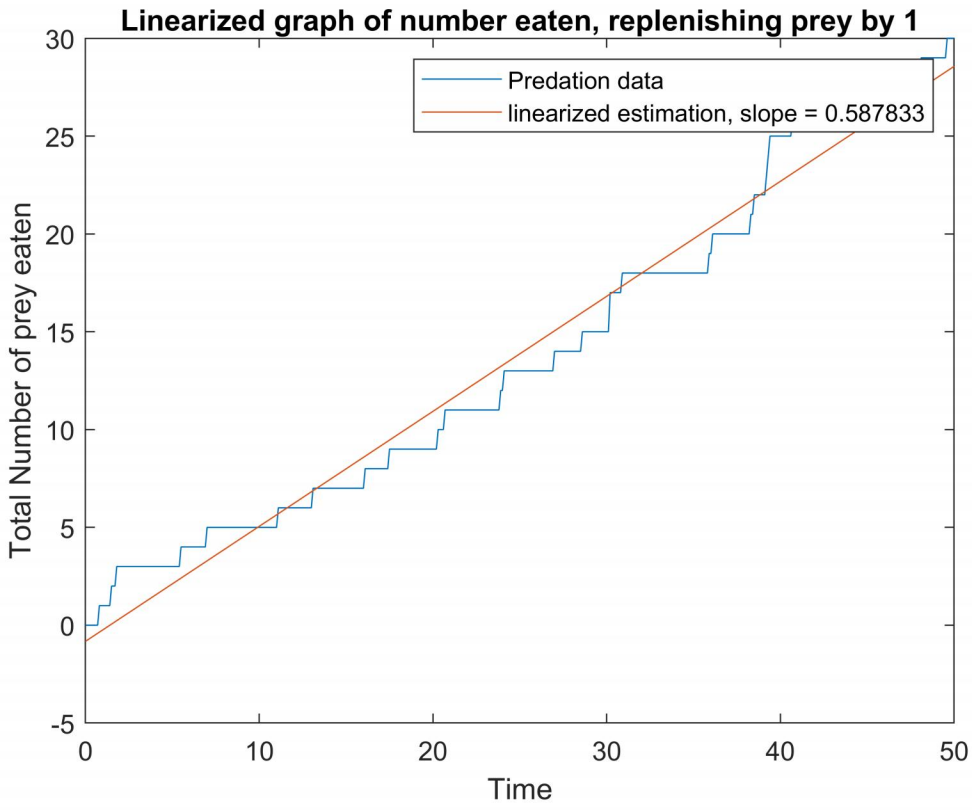



```
%slope = 0.7978
%% the coefficient doesn't affect the scaling, like the coefficient of diffusion,
% the slope of the fitted line of graph of total number of prey eaten
% is close in value
```

```
%% Section 1E
info.replenish_prey=1;  % Should prey regenerate?

% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

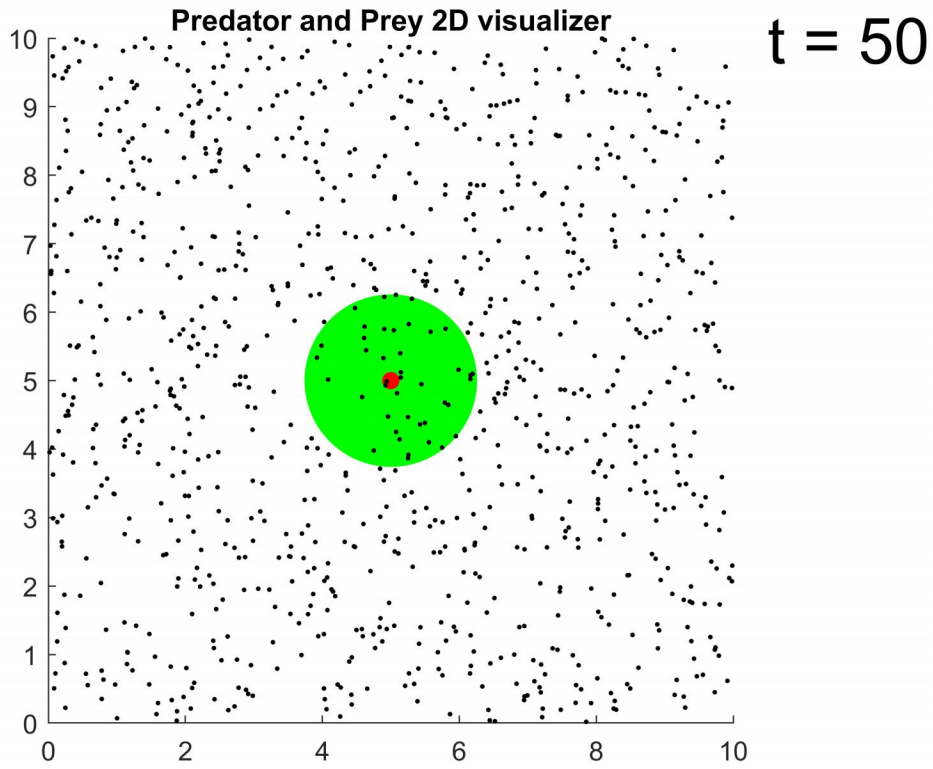



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, replenishing prey by 1');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

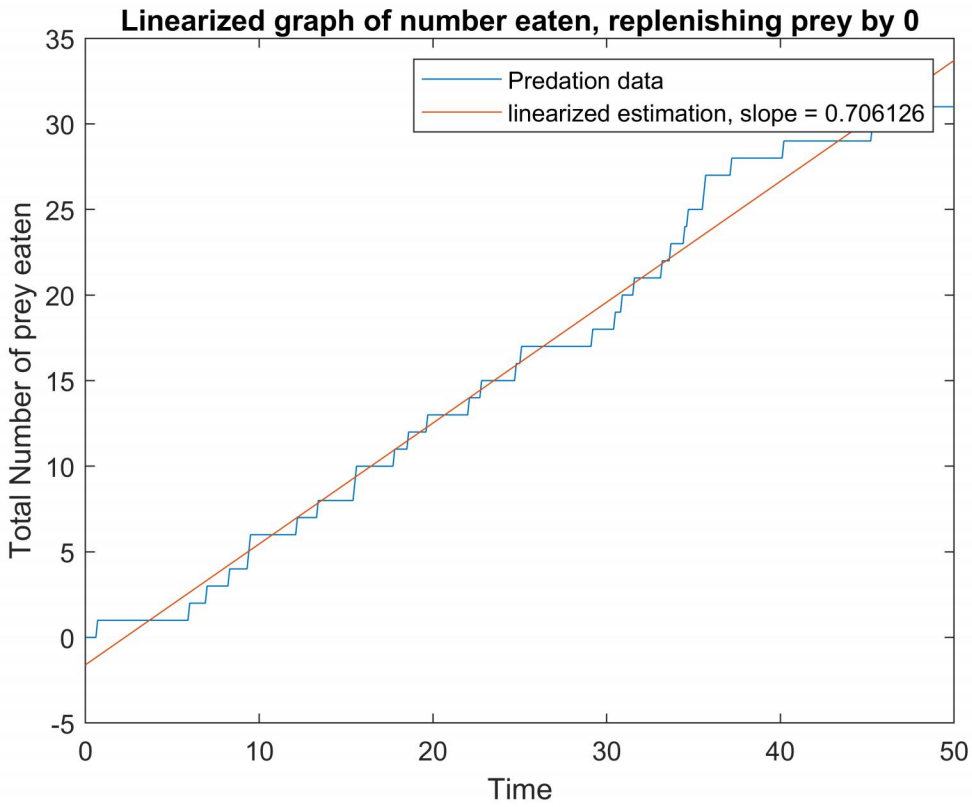



```
%slope = 0.694
```

```
info.replenish_prey=0;  % Should prey regenerate?

% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```




```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, replenishing prey by 0');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```




```
%slope = 0.706
% the replenishing rate is now changed to 0, and it does not seem to affect
% the rate of consumption. The slope is still extremely close to each other
% in values while all other variables are held constant.
```

```
%% Question 2

predator.handling_time = 0;
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

5 1.e **10 / 15**

- 0 pts Correct

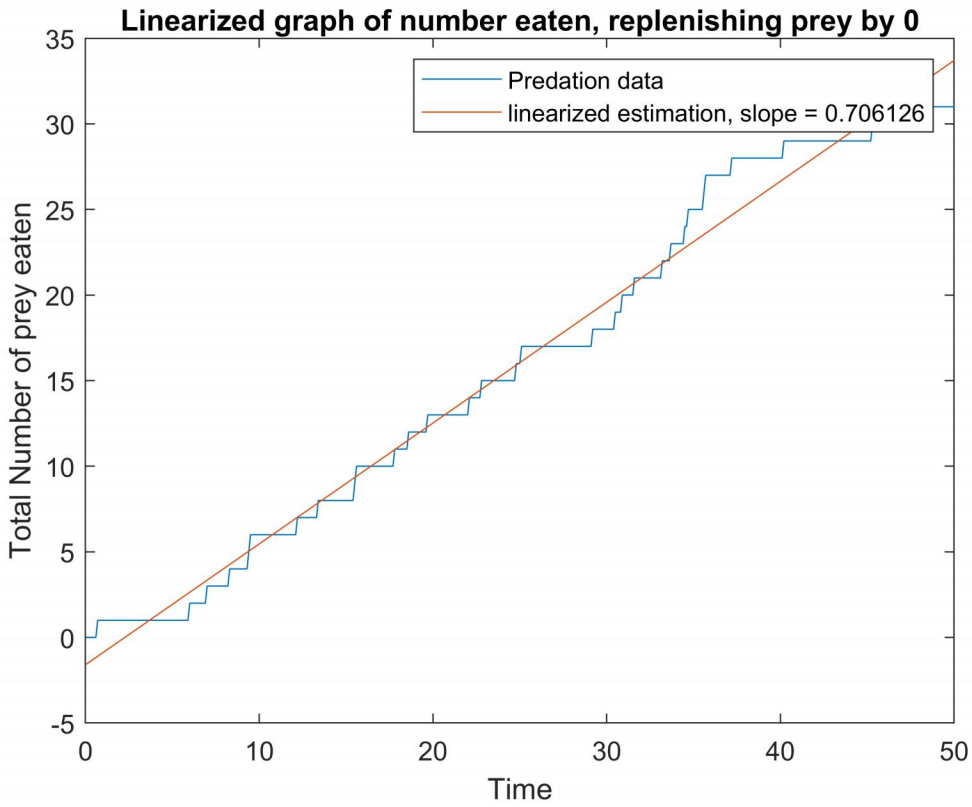
- 2 pts Plot aesthetics (graph/axes titles)

- 5 pts Missing plots

✓ **- 5 pts** *Incorrect/missing interpretation. If you ran the simulation for longer, you'd see that the consumption rate plateaus when there is no regeneration*

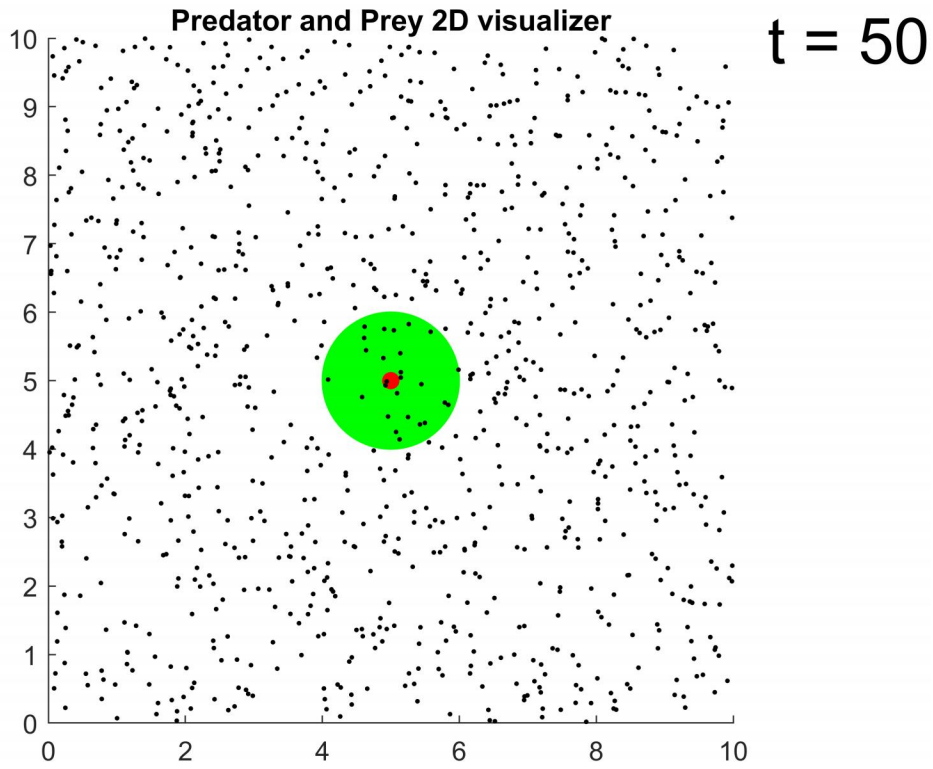
- 3 pts Insufficient discussion; need to mention how consumption plateaus

- 2 pts While you do mention that consumption rate decreases, you need to increase to time of the simulation to see that it eventually plateaus.

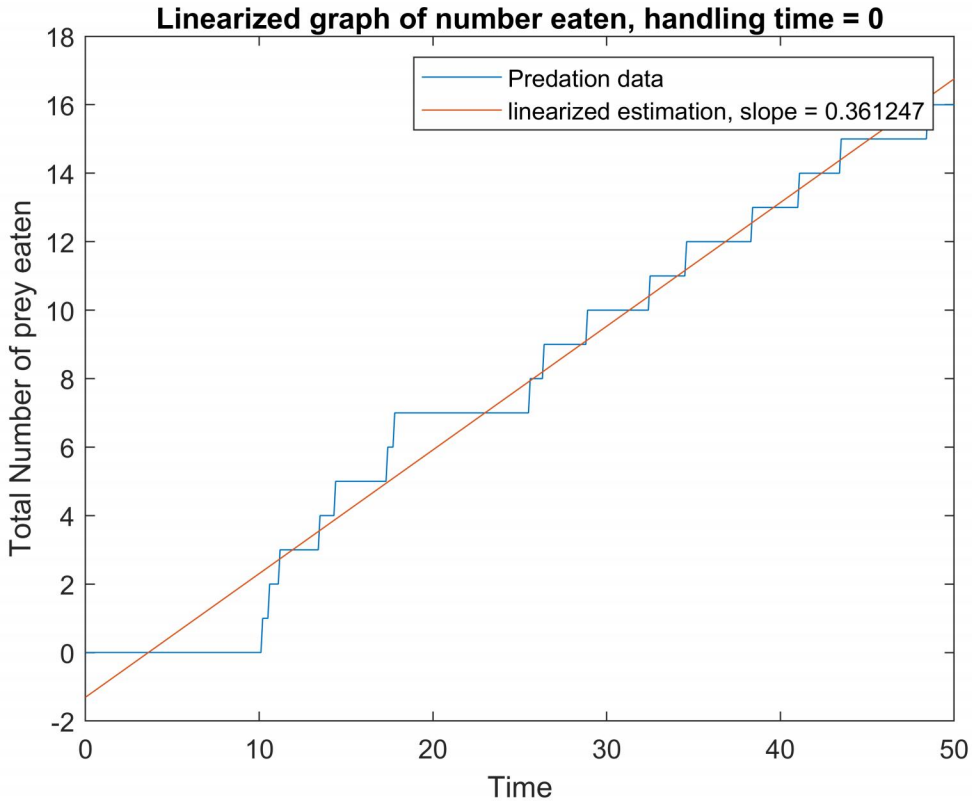



```
%slope = 0.706
% the replenishing rate is now changed to 0, and it does not seem to affect
% the rate of consumption. The slope is still extremely close to each other
% in values while all other variables are held constant.
```

```
%% Question 2

predator.handling_time = 0;
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

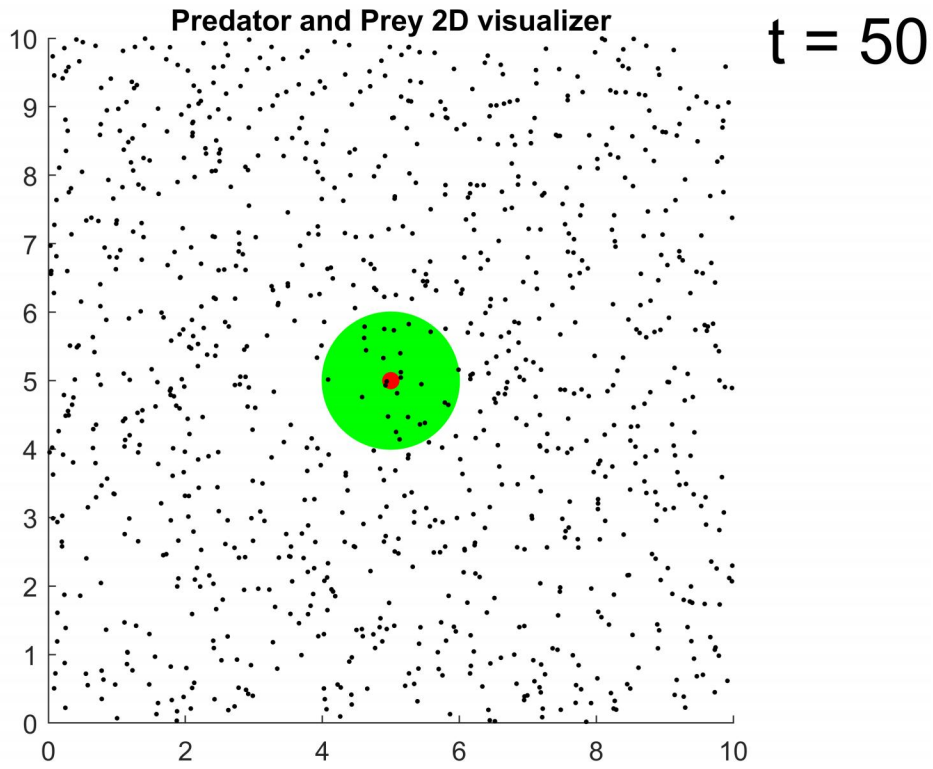



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, handling time = 0');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

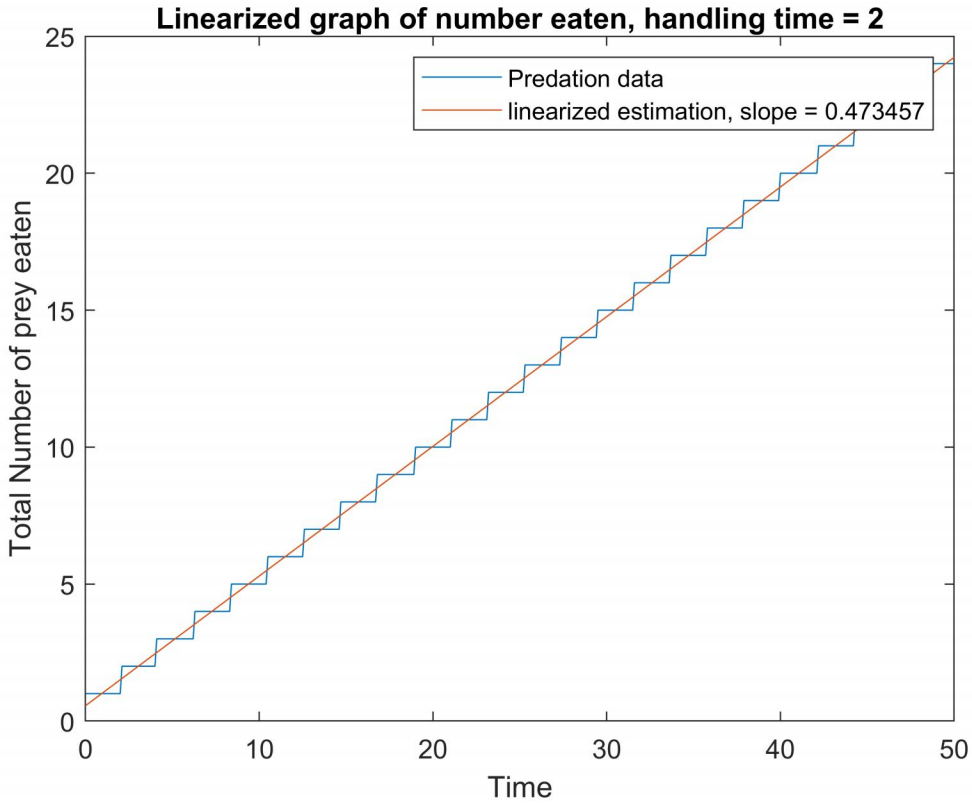



```
%slope = 0.36
%total prey consumed = 16
```

```
% comparing it with handling time t = 2
predator.handling_time=2;
% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```

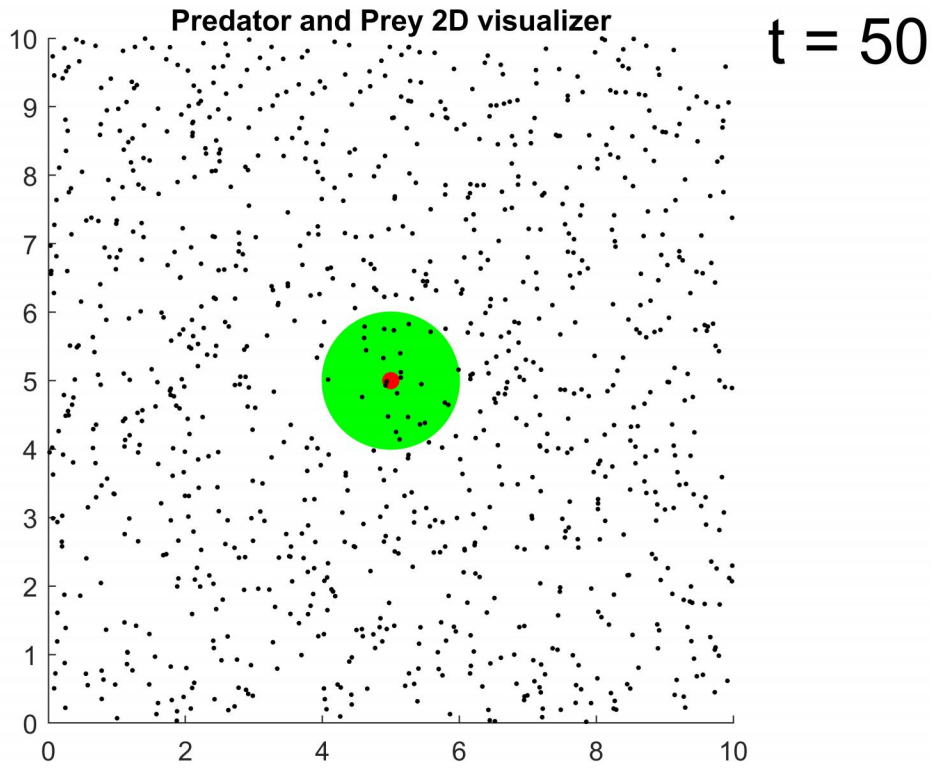



```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, handling time = 2');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```

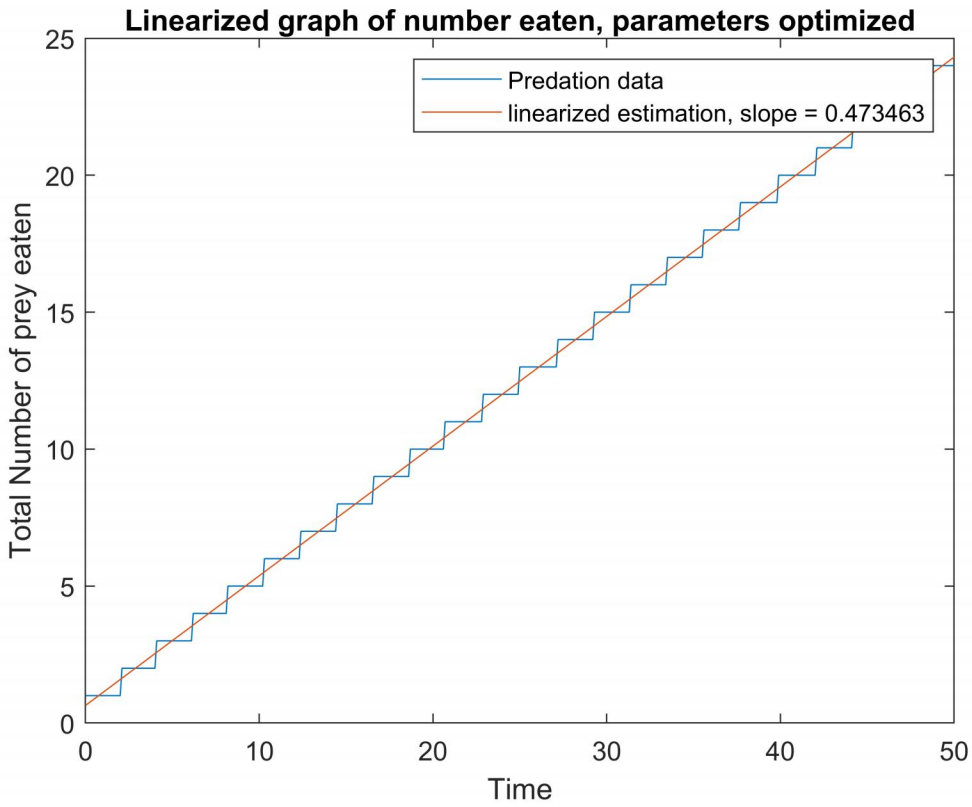



```
%slope = 0.473
%total prey consumed = 24
% By changing the parameter of handling time, we can see that it has a limiting effect
% on the total number of prey eaten and the rate of consumption is also cut
% in half, approximately.
% but if the k and f are increased, it will have more of an effect on the
% rate of consumption ->
```

```
% setting parameters to be nearly 1
predator.k=1;    % detection rate to be 1
predator.f=1; %  Successful capture per time
predator.handling_time= 2; % handling time increased

% Simulate eating
[t,numeaten]=ibm_predation(info,predator,prey);
```




```
total_eaten=cumsum(numeaten);

figure; plot(t,total_eaten)
c = polyfit(t,total_eaten,1);
y_est = polyval(c,t);
hold on
plot(t,y_est);
title('Linearized graph of number eaten, parameters optimized');
xlabel('Time'), ylabel('Total Number of prey eaten');
legend('Predation data', sprintf('linearized estimation, slope = %f', c(1)));
```




```
%slope = 0.473
%number eaten =24
% if the k and f are increased, the limiting factor of the handling time is
% not in consideration as much. Then it will have more of an effect on the
% rate of consumption, therefore a higher slope and a higher total prey
% eaten.

% In comparison with the consumption rate = bNP / 1 + aN
% let b be Th and a be 1,  since b/a  = 1/Th. N is number of prey and P is number of
% predators, b is 2,  then the equation gives:
% consumption rate = 24*1 / ( 1+ 2*24) = 0.489
% when compared to the slope of the linearized graph of number eaten with
% parameters optimized, this is very close in value. My model thereby
% agrees with the hypothesized consumption rate.
```

6 2 **25 / 25**

✓ **- 0 pts** *Correct*

- 5 pts Correctly answer the question: how does total number of prey consumed change compared to the prior case?

- 5 pts Correctly set parameters such that predators are essentially limited by handling time

- 10 pts Correct plots/calculation

- 3 pts Correct conclusion - are predators limited by handling time?

- 2 pts Plot aesthetics (graph/axes titles)