MN

LISTA 10

WIOLETTA ŁUPKOWSKA

244831, CZW. 9:15

Zad.1

```
import org.apache.commons.math3.ode.FirstOrderDifferentialEquations;
import org.apache.commons.math3.ode.FirstOrderIntegrator;
import org.apache.commons.math3.ode.nonstiff.EulerIntegrator;

import java.util.ArrayList;

public class TestLotkaVolterra {

    public static void main(String[] args) {
        double[] params= new double[]{1.5,1,1,3,1,2,0.2,0.4};
        double[] xStart= new double[]{50,10};
        double[] xStop= new double[]{0,0};


        FirstOrderDifferentialEquations lotkaVolterraODE = new LotkaVolterraODE(params);
        FirstOrderIntegrator eulerInt = new EulerIntegrator(0.01);
        LotkaVolterraPath lotkaVolterraPath = new LotkaVolterraPath();
        eulerInt.addStepHandler(lotkaVolterraPath);
        eulerInt.integrate(lotkaVolterraODE,0,xStart,50,xStop);

        FirstOrderDifferentialEquations lotkaVolterraODE2 = new LotkaVolterraODE2(params);
        FirstOrderIntegrator eulerInt2 = new EulerIntegrator(0.01);
        LotkaVolterraPath lotkaVolterraPath2 = new LotkaVolterraPath();
        eulerInt2.addStepHandler(lotkaVolterraPath2);
        eulerInt2.integrate(lotkaVolterraODE2,0,xStart,100,xStop);


        FirstOrderDifferentialEquations lotkaVolterraODE3 = new LotkaVolterraODE3(params);
        FirstOrderIntegrator eulerInt3 = new EulerIntegrator(0.01);
        LotkaVolterraPath lotkaVolterraPath3 = new LotkaVolterraPath();
        eulerInt3.addStepHandler(lotkaVolterraPath3);
        eulerInt3.integrate(lotkaVolterraODE3,0,xStart,100,xStop);

        System.out.println("t,preys,predators");
        //System.out.println(lotkaVolterraPath3.getTime());
        //System.out.println(lotkaVolterraPath3.getPreys());
        System.out.println(lotkaVolterraPath3.getPredators());



    }


}
```

```
import org.apache.commons.math3.exception.MaxCountExceededException;
import org.apache.commons.math3.ode.sampling.StepHandler;
import org.apache.commons.math3.ode.sampling.StepInterpolator;

import java.util.ArrayList;

public class LotkaVolterraPath implements StepHandler {

    ArrayList<Double> time = new ArrayList<>();
    ArrayList<Double> preys = new ArrayList<>();
```

```
    ArrayList<Double> predators = new ArrayList<>();

    public ArrayList<Double> getTime() {
        return time;
    }

    public ArrayList<Double> getPreys() {
        return preys;
    }

    public ArrayList<Double> getPredators() {
        return predators;
    }

    @Override
    public void init(double t0, double[] y0, double t) {

    }

    @Override
    public void handleStep(StepInterpolator interpolator, boolean isLast) throws
MaxCountExceededException {

        time.add(interpolator.getCurrentTime());
        double[] x = interpolator.getInterpolatedState();
        preys.add(x[0]);
        predators.add(x[1]);



    }
}
```

```
import org.apache.commons.math3.exception.DimensionMismatchException;
import org.apache.commons.math3.exception.MaxCountExceededException;
import org.apache.commons.math3.ode.FirstOrderDifferentialEquations;

public class LotkaVolterraODE implements FirstOrderDifferentialEquations {

    private double[] params;

    public LotkaVolterraODE(double[] params){
        this.params = params;
    }

    @Override
    public int getDimension() {
        return 2;
    }

    @Override
    public void computeDerivatives(double t, double[] x, double[] dxdt) throws
MaxCountExceededException, DimensionMismatchException {
        dxdt[0]=(params[0]-params[1]*x[1])*x[0];
        dxdt[1]=(params[2]*x[0]-params[3])*x[1];
    }
}
```

```
import org.apache.commons.math3.exception.DimensionMismatchException;
import org.apache.commons.math3.exception.MaxCountExceededException;
import org.apache.commons.math3.ode.FirstOrderDifferentialEquations;

public class LotkaVolterraODE2 implements FirstOrderDifferentialEquations {
```

```
    private double[] params;

    public LotkaVolterraODE2(double[] params){
        this.params = params;
    }

    @Override
    public int getDimension() {
        return 2;
    }

    //params={a,b,c,d,e,f}
    //        0,1,2,3,4,5

    @Override
    public void computeDerivatives(double t, double[] x, double[] dxdt) throws
MaxCountExceededException, DimensionMismatchException {
        dxdt[0]=(params[0]-params[1]*x[1])*x[0] - params[4]*x[0];
        dxdt[1]=(params[2]*x[0]-params[3])*x[1]- params[5]*x[1];
    }
}
```

```
import org.apache.commons.math3.exception.DimensionMismatchException;
import org.apache.commons.math3.exception.MaxCountExceededException;
import org.apache.commons.math3.ode.FirstOrderDifferentialEquations;

public class LotkaVolterraODE3 implements FirstOrderDifferentialEquations {

    private double[] params;

    public LotkaVolterraODE3(double[] params){
        this.params = params;
    }

    @Override
    public int getDimension() {
        return 2;
    }

    //params={a,b,c,d,e,f,g,h}
    //        0,1,2,3,4,5,6,7

    @Override
    public void computeDerivatives(double t, double[] x, double[] dxdt) throws
MaxCountExceededException, DimensionMismatchException {
        dxdt[0]=(params[0]-params[1]*x[1])*x[0] - params[6]*Math.pow(x[0],2);
        dxdt[1]=(params[2]*x[0]-params[3])*x[1]- params[7]*Math.pow(x[1],2);
    }
}
```

W MATLABIE

```
[t,x] = ode45(@odefunLV,[0 30],[50 10],[],[1.5 1 1 3 ]);


figure;
plot(t,x);
legend('ofiary','drapiezniki')

figure
plot(x(:,1),x(:,2));
```

```
%%

[t2,x2] = ode45(@odefunLV2,[0 60],[50 10],[],[1.5 1 1 3 1 2]);

figure;
plot(t2,x2);
legend('ofiary','drapiezniki')

figure
plot(x2(:,1),x2(:,2));


%%

[t3,x3] = ode45(@odefunLV3,[0 60],[50 10],[],[1.5 1 1 3 1 2 0.2 0.4]);

figure;
plot(t3,x3);
legend('ofiary','drapiezniki')

figure
plot(x3(:,1),x3(:,2));
```

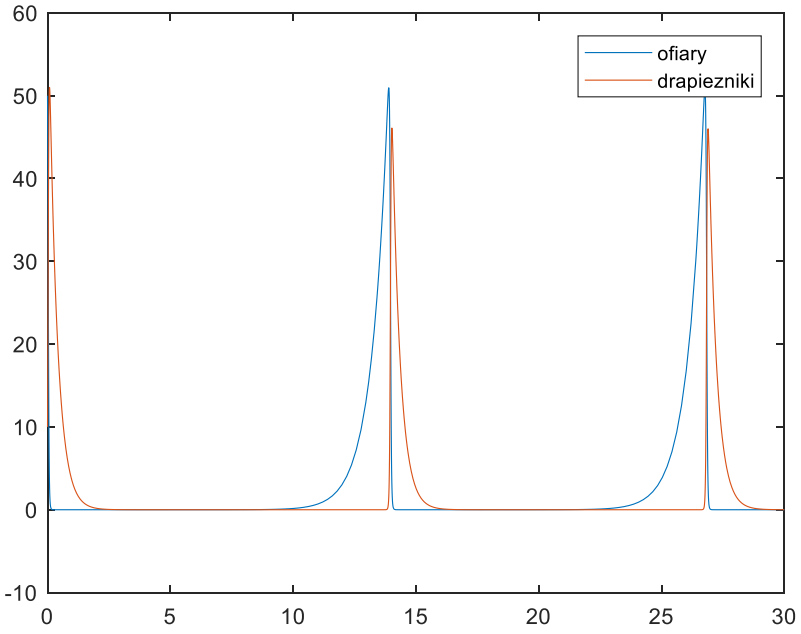
```
function dxdt = odefunLV(t,x,params)

dxdt = [(params(1)-params(2)*x(2))*x(1); ((params(3))*x(1)-
params(4))*x(2)];
end
```

```
function dxdt = odefunLV2(t,x,params)

dxdt = [(params(1)-params(2)*x(2))*x(1)-params(5)*x(1);
((params(3))*x(1)-params(4))*x(2)-params(6)*x(2)];
end
```

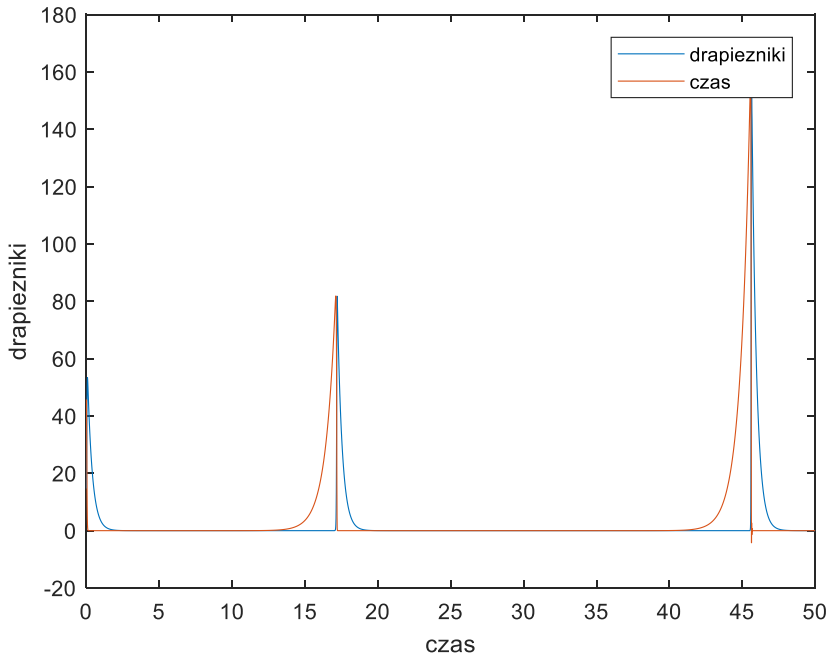
```
function dxdt = odefunLV3(t,x,params)

dxdt = [(params(1)-params(2)*x(2))*x(1)-params(7)*x(1)*x(1);
((params(3))*x(1)-params(4))*x(2)-params(8)*x(2)*x(2)];
end
```

Zad.1 wyniki

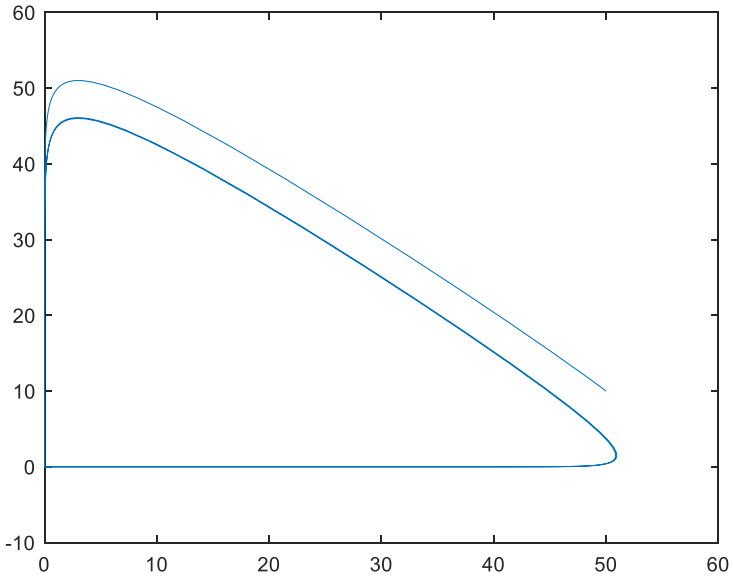
1a



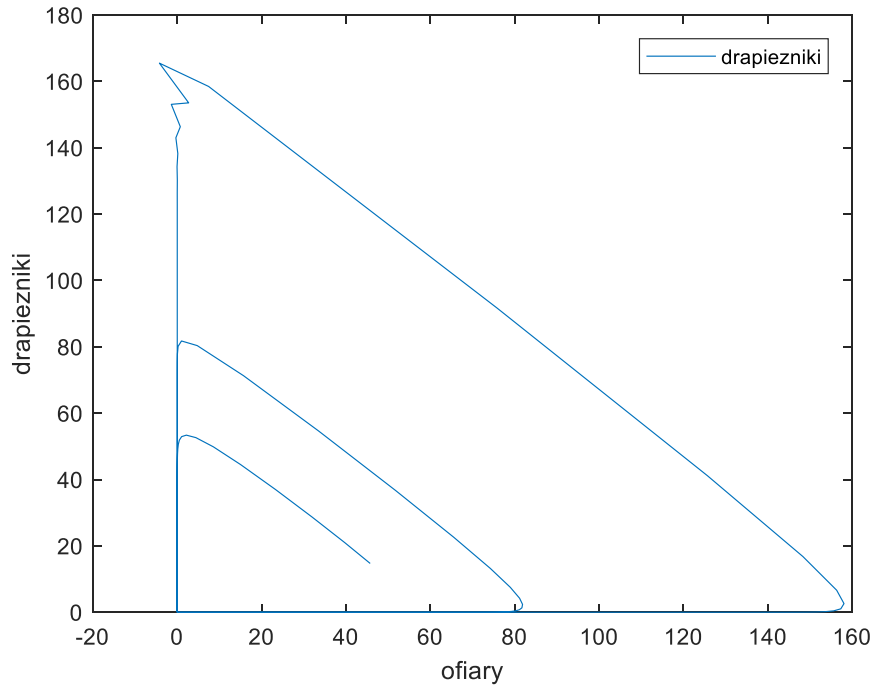
Rysunek 1:Wykres populacji drapieżników i ofiar w funkcji czasu, ***Matlab.***



Rysunek 2: Wykres populacji drapieżników i ofiar w funkcji czasu, ***java.***

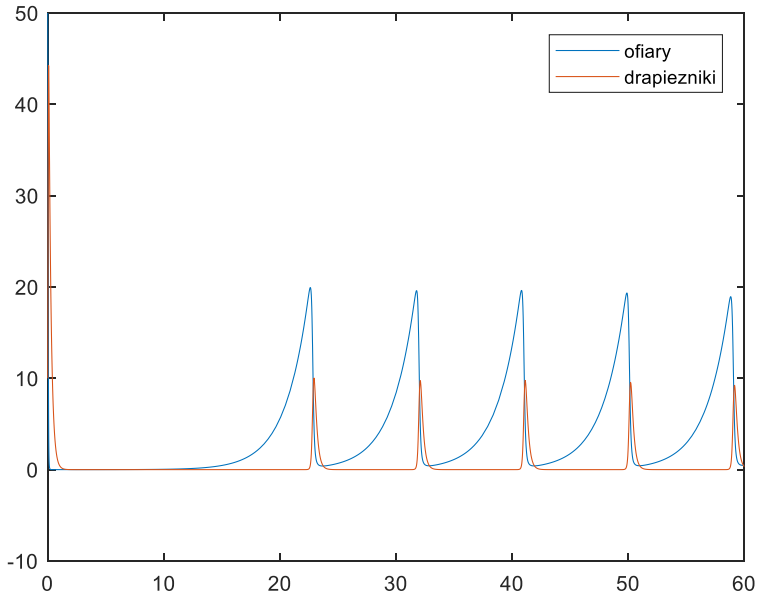


*Rysunek 3: przestrzeń fazowa narysowana przy uzyciu wyników z pragramu **MatLab***

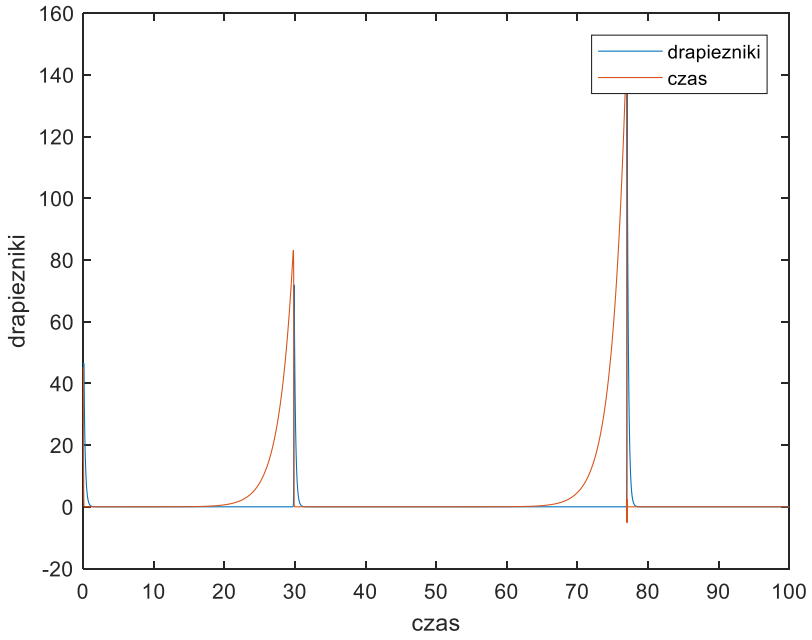


*Rysunek 4:przestrzeń fazowa narysowana przy uzyciu wyników wygenerowanych na podstawie kodu j**ava***

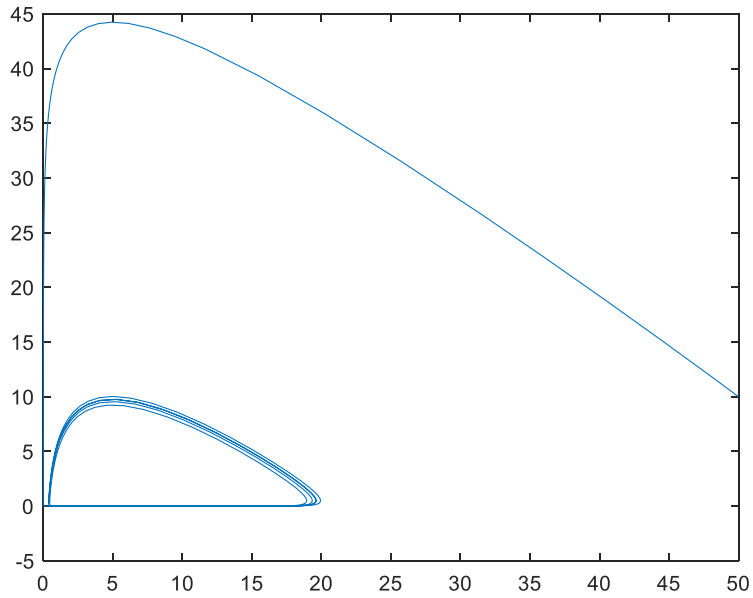
1b (e=1, f=2)



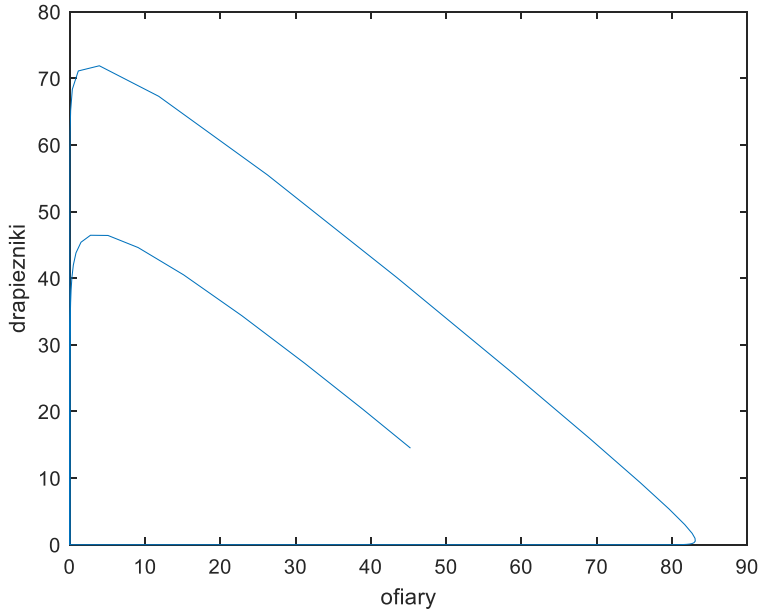
Rysunek 5:Wykres populacji drapieżników i ofiar w funkcji czasu, ***matlab.***



*Rysunek 6: Wykres populacji drapieżników i ofiar w funkcji czasu****, java.***



Rysunek 7: Przestrzeń fazowa, ***matlab.***

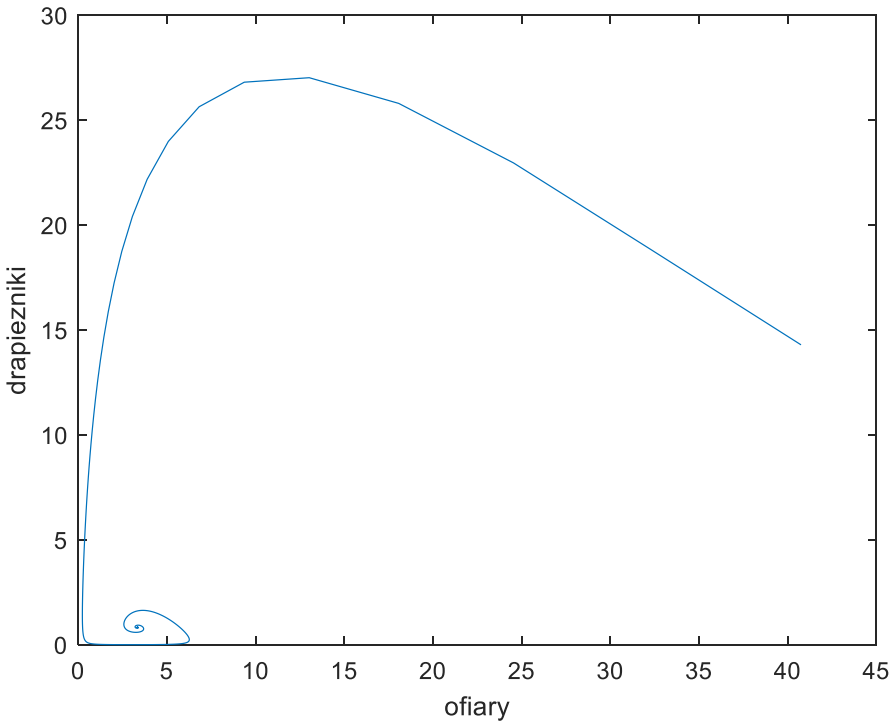


Rysunek 8:Przestrzen fazowa, ***java.***

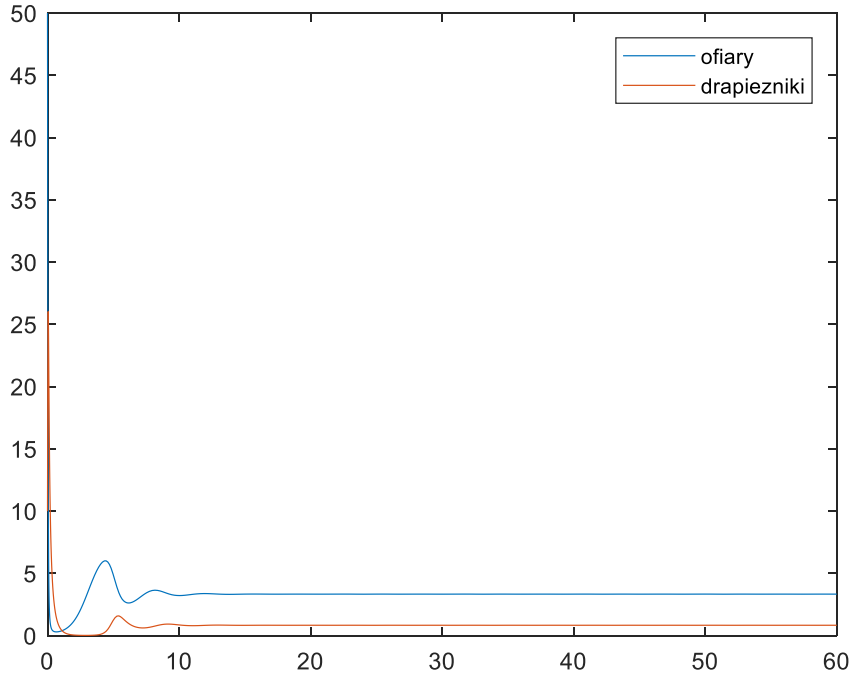
Wykresy otrzymane z javy wydają mi się błędne ze względu na wzrastającą wysokość pików w czasie obu populacji.

1c

Wyniki Matlab:

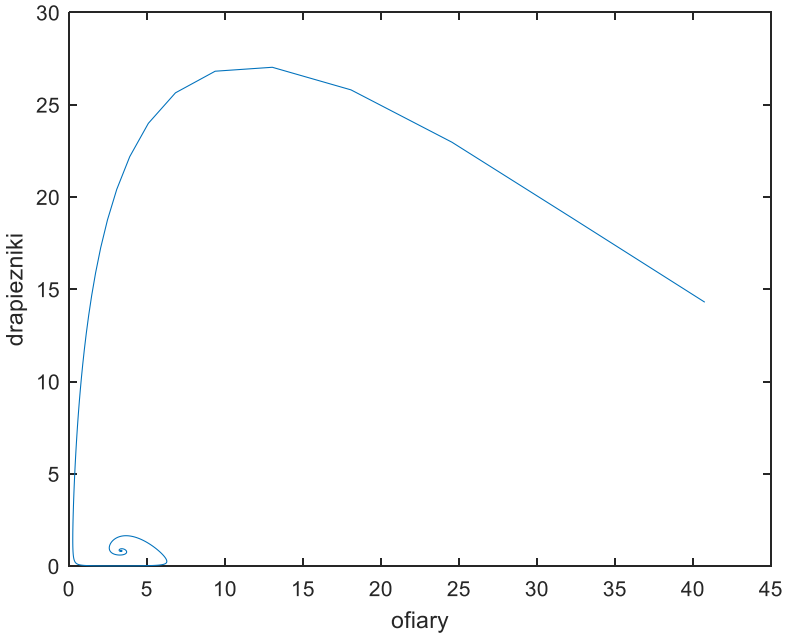


Rysunek 9: Przestrzeń fazowa, matlab.

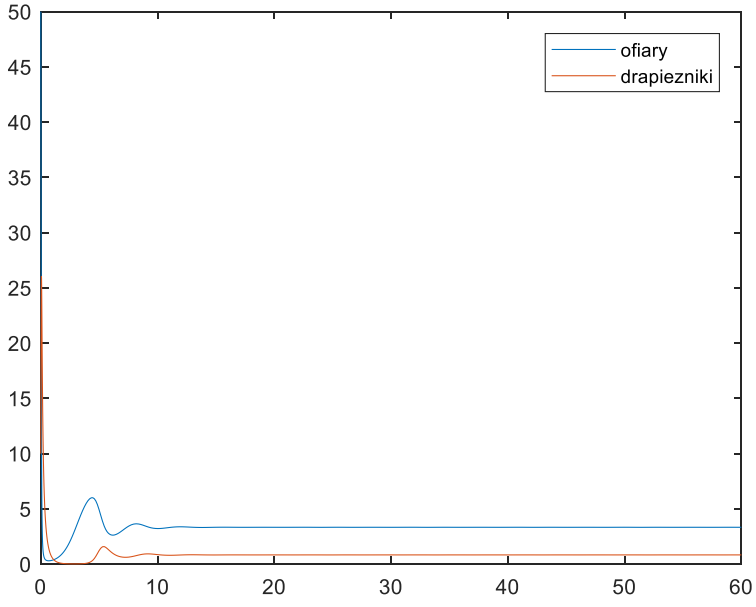


Rysunek 10: Wykres ofiar, drapieżników w czasie.

Wyniki java:



Rysunek 11: Przestrzeń fazowa, matlab.



Rysunek 1211: Wykres ofiar, drapieżników w czasie.

Minimum ofiar w przybliżeniu przypada na maksimum drapieżników.

Zad. 2

```
package Zad2;

import org.apache.commons.math3.ode.FirstOrderDifferentialEquations;
import org.apache.commons.math3.ode.FirstOrderIntegrator;
import org.apache.commons.math3.ode.nonstiff.EulerIntegrator;

import java.util.ArrayList;

public class TestLotkaVolterra {

    public static void main(String[] args) {
        double[] params= new double[]{3,13,1000};
        double[] xStart= new double[]{90,90,10};
        double[] xStop= new double[]{0,0,0};

        double max;

        FirstOrderDifferentialEquations lotkaVolterraODE = new LotkaVolterraODE(params);
        FirstOrderIntegrator eulerInt = new EulerIntegrator(0.01);
        LotkaVolterraPath lotkaVolterraPath = new LotkaVolterraPath();
        eulerInt.addStepHandler(lotkaVolterraPath);
        eulerInt.integrate(lotkaVolterraODE,0,xStart,50,xStop);

        ArrayList<Double> narazeni = lotkaVolterraPath.getNarazeni();
        ArrayList<Double> chorzy = lotkaVolterraPath.getChorzy();
        ArrayList<Double> odporni = lotkaVolterraPath.getOdporni();
        ArrayList<Double> time = lotkaVolterraPath.getTime();
        //System.out.println(chorzy)

        max=max(chorzy);
        System.out.println("beta: " + params[0]);
        System.out.println("gamma: " + params[1]);
        System.out.println("dzień, w którym było najwięcej chorych: "+max);
       System.out.println(chorzy);

    }

   public static double max(ArrayList<Double> array){
        double max=0;

        for(int i= 0; i<array.size()-3; i++){
            if(array.get(i)-array.get(i+1)<0  && array.get(i+2)-array.get(i+3)<0 ){
                max= i+2;
            }
        }
        return max;
    };

}
```

```
package Zad2;

import org.apache.commons.math3.exception.MaxCountExceededException;
import org.apache.commons.math3.ode.sampling.StepHandler;
import org.apache.commons.math3.ode.sampling.StepInterpolator;

import java.util.ArrayList;

public class LotkaVolterraPath implements StepHandler {

    ArrayList<Double> narazeni = new ArrayList<>();
    ArrayList<Double> chorzy = new ArrayList<>();
    ArrayList<Double> odporni = new ArrayList<>();
    ArrayList<Integer> czas= new ArrayList<>();
```

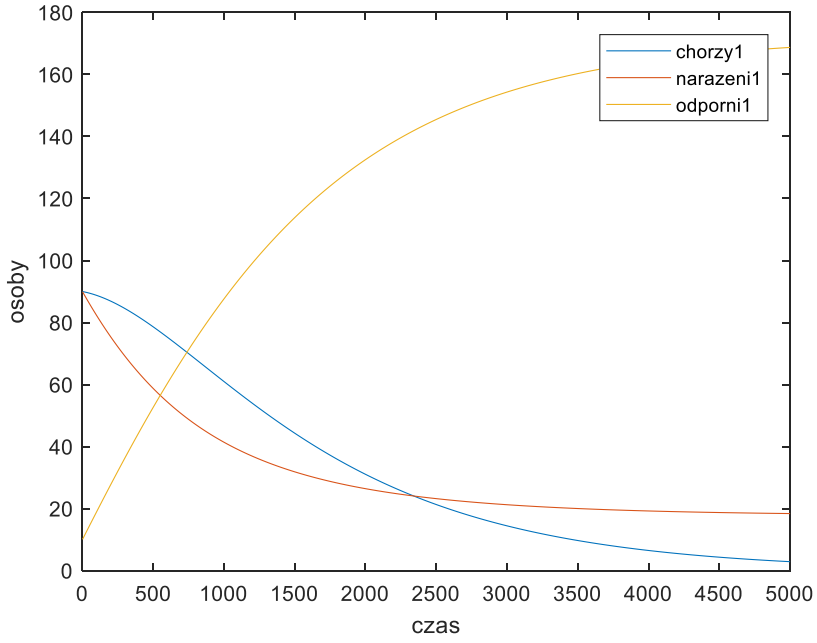
```
    ArrayList<Double> time= new ArrayList<>();

    public ArrayList<Integer> getCzas() {
        return czas;
    }

    public ArrayList<Double> getNarazeni() {
        return narazeni;
    }

    public ArrayList<Double> getChorzy() {
        return chorzy;
    }

    public ArrayList<Double> getOdporni() {return odporni; }

    public ArrayList<Double> getTime() {return time; }

    @Override
    public void init(double t0, double[] y0, double t) {

    }

    @Override
    public void handleStep(StepInterpolator interpolator, boolean isLast) throws
MaxCountExceededException {

        time.add(interpolator.getCurrentTime()*100);
        double[] x = interpolator.getInterpolatedState();
        narazeni.add(x[0]);
        chorzy.add(x[1]);
        odporni.add(x[2]);


    }
}
```

```
package Zad2;

import org.apache.commons.math3.exception.DimensionMismatchException;
import org.apache.commons.math3.exception.MaxCountExceededException;
import org.apache.commons.math3.ode.FirstOrderDifferentialEquations;

public class LotkaVolterraODE implements FirstOrderDifferentialEquations {

    private double[] params;

    public LotkaVolterraODE(double[] params){
        this.params = params;
    }

    @Override
    public int getDimension() {
        return 3;
    }




    // params={beta, gamma, N}
    //          0       1   2
    // x[0] --- x
    // x[1] --- y
```

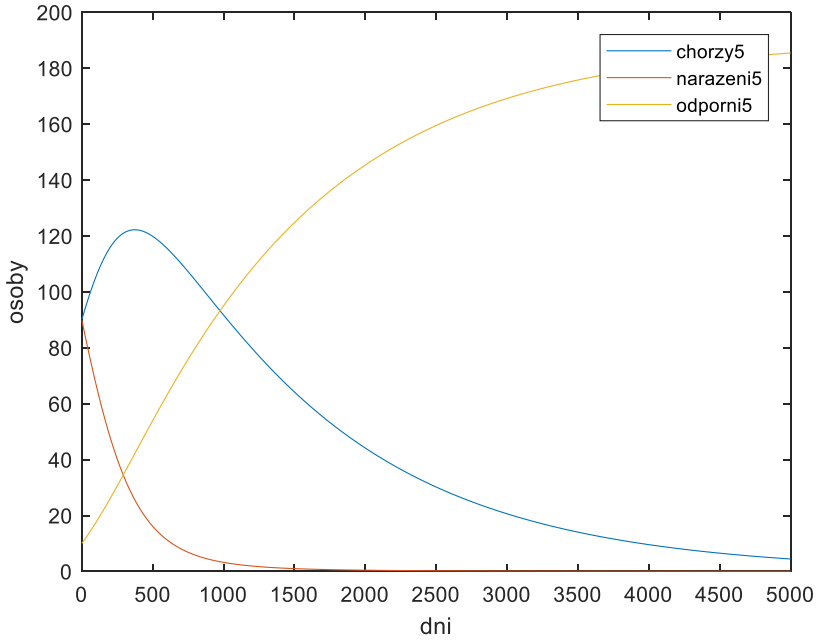
```
    // x[2] --- z

    @Override
    public void computeDerivatives(double t, double[] x, double[] dxdt) throws
MaxCountExceededException, DimensionMismatchException {
        dxdt[0]=-(params[0]/params[2])*x[0]*x[1];  //zdrowi
        dxdt[1]=(params[0]/params[2])*x[0]*x[1]- (1/params[1])*x[1];  //chorzy
        dxdt[2]=(1/params[1])*x[1];  //odporni
    }
}
```

Zad.2 wyniki

Parametry={1,10,1000} : (os/dzień, dni na wyleczenie, populacja)



Parametry={3,13,1000} :



Liczba chorych w 1 przypadku nie ma piku (myślę, że zarażanie 1 os. na dzień powinno spowodować choćby nieznaczny wzrost liczby chorych ze względu na czas zdrowienia wynoszący 10 dni), ilość zdrowych, narażonych na chorobę maleje wolniej niż w przypadku poniżej, krzywa przedstawiająca osoby odporne jest bardzo zbliżona w obu przypadkach. Zmiana pierwszego parametru na więcej niż 1 powoduje powstanie piku na krzywej chorych.

```
beta: 3.0
gamma: 13.0
dzień, w którym było najwięcej chorych: 372.0

beta: 1.0
gamma: 10.0
dzień, w którym było najwięcej chorych: 0.0
```