The Effect of Transformation Rate in Hantavirus Infection Model

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Abstract: Hantaviruses are severe viruses that were namely based on infected mice found near Korea's Hantaan River. These viruses are carried by rodents such as birds and mice without harming the hosts themselves, but can cause fatal diseases to human. A model showing the spread of Hantavirus infection through rodents namely as AK model has been proposed by Abramson and Kenkre. Many studies have investigated the model but none look into the effect of changes in the parameter of AK model. In this paper, we investigate the effect of small changes of transformation rate to the number of infected mice in the AK model. The birth rate, natural death rate and carrying capacity are considered as fixed with values 1, 0.5 and 20 respectively. The Rungge-Kutta 4th order method has been applied to solve the AK model with changes in transformation rate by using Matlab programming. The results show that the small changes in transformation rate will lead to the changes in the number of infected mice.

Keywords: Abramson-Kenkre Model, Hantavirus, Transformation rate

1. Introduction

Hantaviruses are severe viruses that were namely based on infected mice found near Korea's Hantaan River. These viruses are carried by rodents such as birds and mice without harming the hosts themselves, but can cause fatal diseases to human.Hantavirus is very dangerous as it can easily be transferred. When human disturbed the area where rodents live and nest, the virus will be spread to the air. Sometimes, human get the virus by touching the feces, then swiping their nose or by touching the wound on human's body.Hemorrhagic fever with renal syndrome (HFRS) and Hantavirus Pulmonary Syndrome (HPS)are diseases that are caused by Hantavirus. These fatal diseases have no cure or vaccines. As humans can get infected just by breathing in the virus through the air, they should not be in direct contact with the feces, urine or saliva of infected rodents (Yusof, Ismail & Ali, 2010).

After the discovery of this uncured virus, many researchers have proposed studies about Hantavirus. In 2001, a study on the spread of Hantavirus was first done by Abramson and Kenkre (2001). They have developed a simple mathematical framework to address their observation known as Abramson–Kenkre(AK) model as shown in Figure 1. Then, many studies have been conducted to understand the ecology and epidemiology of the virus. The AK model analyzes spatio-temporal patterns in the spread of Hantavirus infection using differential equation system. It shows that there is no relation between carrying capacityand susceptible miceor infected mice.

In 2003, Abramson, Kenkre, Yates and Permenterextended their study to analyze the travelling waves of the Hantavirus infection.Next,Giuggioli, Abramson, Kenkre, Suzan, Marce and Yates (2005) discussed on the diffusion and home range parameters added to AK model and they discovered the exact value for rodent's population in Panama. By 2007, Kenkre, Giuggioli, Abramson and Camelo-Neto studied the AK model based on adult and itinerant juvenile mice. Later, Yusof et al. (2010) incorporated several types of population harvesting process into AK model andresult shows that when abundant resources are available, the infection might be subsided but uncontrollable.

Mohamad, Abd Nassir and Ramli (2012) found that there is a relation between the values of carrying capacityand susceptible miceor infected mice when the data changed.

According to Mohamad et al. (2012) as the carrying capacity changing, it will affect the values of susceptible miceor infected mice. Although there are many studies investigating the AK model, none look into the effect of changes in the parameter of AK model. This research is conducted to analyze the effect of small changes in the rate of transformation to the number of infected mice represent in AK model. The birth rate, natural death rate and carrying capacity are considered fixed with transformation rate changes from 0 to 0.2. The pattern of changes in the number of infected mice is analyzed.

2. Methodology

In this paper, we used the AK model with equation as below:

$$\frac{dM_s}{dt} = bM - cM_s - \frac{M_s M}{K} - aM_s M_i$$
$$\frac{dM_i}{dt} = -cM_i - \frac{M_i M}{K} + aM_s M_i \quad (1)$$

The definition of parameter in AK model is given as follows:

M	Total population ($M = M_s + M_i$)
M_s	Susceptible mice
M_i	Infected mice
a	Rate of transformation from susceptible to infected; due to fight when the population is over crowded
b	The birth of mice; given that mice are born susceptible
c	The death rate for natural reason; given that the rodent not infected by the virus in their body
K	Carrying capacity; the resource used by mice for the survival such as food and shelter
$-\frac{M_i M}{K}$	The limitation process of population growth

Matlab Programming has been used to generate the results. The AK model in equation (1) is solved by Rungge-Kutta 4th Order Method which has advantages of high order local truncation error. Based on AK model, the value of$b$ = 1, c = 0.5 and K = 20 were considered as fixed values. Next, various values of $a$wereapplied for this research to analyze the patent of changes. The values of a that we use are 0, 0.025, 0.05, 0.1, 0.125, 0.15, 0.175 and 0.2.

The Matlab programming codes that were usedin M.File and Command window are given as follows:

M. File:

```
function m=mice(t,y)
a=0.05;
b=1;
c=0.5;
k=20;
M=16;
```

```
m=[b*M-c*y(1)-((M*y(1))/k)-a*y(1)*y(2);-c*y(2)-
((M*y(2))/k)+a*y(1)*y(2)];
```

Command Window:

```
tspan=[0 20];
y0=[15 1];
[t,y]=ode45(@mice,tspan,y0);
plot(t,y)
```

3. Result and Discussion

The numerical experiments on AK model have been conducted and the result has been analyzed with the initial condition: M_s = 15 and M_i = 1.Figure 1 shows the graphs obtained when the values of a are 0, 0.025, 0.05, 0.075 and 0.1. By the slight changes in a, the results obtained is not significant. When the rate of transformation is reduced to 0, it means that there is no transmission from susceptible mice to infected mice. As time goes by, the number of infected mice dropped to zero and the mice die not because of the virus but they die because of other reasons such as competition of space and food.

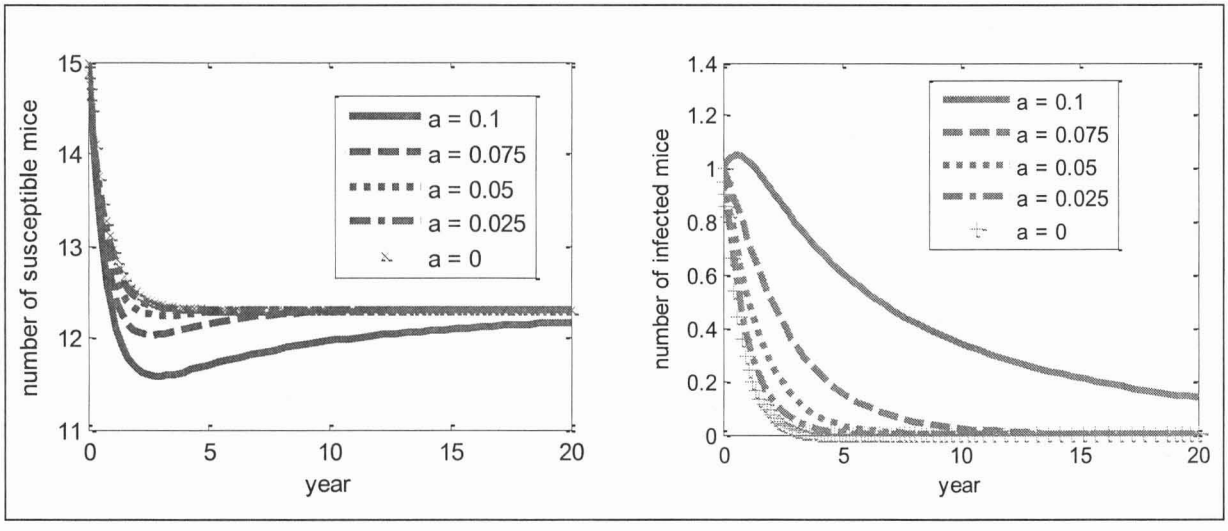

Fig. 1 The number of susceptible mice(Ms) and infected mice(Mi) for a = [0, 0.1]

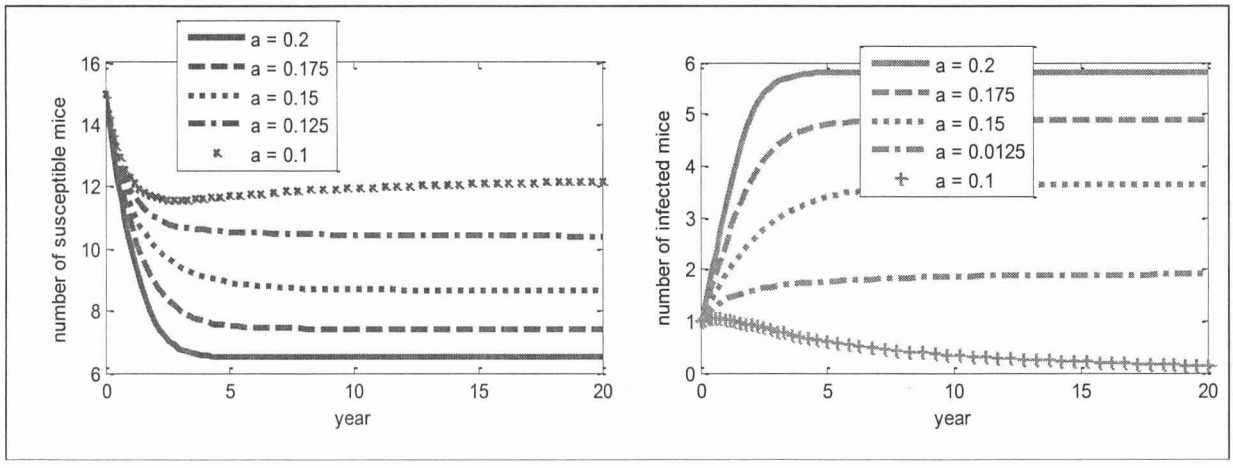

Fig. 2 The number of susceptible mice (Ms) and infected mice (Mi) for a = [0.1, 0.2]

Figure 2 shows the graphs obtained when the values of a are 0.1, 0.125, 0.15, 0.175 and 0.2. By the slight changes in a, the results obtained are significant. The number of infected mice increased rapidly when a greater than 0.1 while the number of susceptible mice decreased. This situation happened because when the rate of transformation increased, it means the transmission of the virus from the infected mice spread faster.

4. Conclusion

Generally, this research is conducted to analyze the results obtained when various values of transformation rate (a)are used. From the results, the changes in a will also lead to the changes in number of infected mice. However, there are differences between the results produced if $a$isless than 0.1 and $a$is greater than 0.1.If the rate of transformation is higher, the number of infected mice increased and when the rate of transformation is less than 0.1, the number of infected mice is smaller. In conclusion, we can say that the rate of transformation rate is proportional to the number of infected mice.

5. References

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