Foot and Mouth Disease: Mathematical Study of the Foot and Mouth Outbreak

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Abstract

The use of vaccination and culling is shown in figure 4. Numerical and qualitative tools such as MATLAB’s built-in ode solver will be used.

The Non-dimensionalised form of SIR model

A simple model for an epidemic like Foot and Mouth is the S-I-R model. SIR Model is one of the most common and classic method for modelling the infectious disease. This SIR model was created by Kermack and McKendrick in 1927. This model breaks down the population into 3 categories:

- Susceptible
- Infected
- Recovered

\[ S(t) + I(t) + R(t) = S_0 \]

History

Foot-and-mouth disease (FMD) is a severe, highly contagious, viral disease of cattle and swine. It also affects sheep, goats, deer, and other cloven-hoofed ruminants. The virus responsible for the disease is a picornavirus, RNA-containing viruses of the family Picornaviridae, to humans and other animals, and including the poliovirus and the rhinovirus that cause the common cold the prototype member of the genus Aphthovirus. In the family Picornaviridae, which includes foot and mouth disease viruses and aphthoviruses. A virus. Infection occurred when the virus particle is taken into a cell of the host. The cell is then forced to manufacture thousands of copies of the virus, and eventually bursts, releasing the new particles in the World. The virus is highly variable, which limits the effectiveness of vaccination. There are seven known types and more than 60 subtypes of FMD virus. Immunity to one type does not protect an animal against other types.

The virus can cause a high fever for two or three days, followed by blisters inside the mouth and on the feet that may rupture and cause lameness. Foot-and-mouth disease or hoof-and-mouth disease (Aphthae equina) is an infectious and sometimes fatal viral disease that affects cloven-hoofed animals. The outbreak can occur when:

- Animals carrying the virus are introduced into susceptible herds.
- Contaminated feed or water is used to feed or water susceptible animals.
- Infectious feeds or feed silages or feed contained in the virus.
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FMD is one of the most difficult animal infections to control. Because FMD can be found in all regions and countries from all infected animals, including captive animals, milk, milk, milk, and semen. Pigs, in particular, pose large quantities of aerosolized virus. Animals can shed FMD for up to four days before the onset of symptoms. Also, the virus can so quickly, vaccination isn’t always effective. This disease could spread rapidly to all sections of the country by routine livestock movements unless it was detected early and eradicated immediately. If FMD were to spread unchecked, the economic impact could reach billions of dollars in the first year. Deer and other susceptible wildlife populations could become infected and potentially serve as a source for reintroduction of livestock.

In this project, I explored the Foot and Mouth disease research done by Trevor Wood, using numerical technique. In this project, I explored the Foot and Mouth disease research done by Trevor Wood, using numerical technique.

Infectives

The figure 4 above shows the interaction between the virus and vaccination, and culling.

R0 = 3 vs .5

\[ R_0 \text{ is a reproduction rate of the virus. Naturally, if the reproduction rate is bigger than 1, then there will be epidemic.} \]

R0 = 3, then there will be no epidemic

R0 = 1, then there will be epidemic.

The following graph shows the interaction between the virus and vaccination, and culling.

The figure 1 of each set shows the graph when no culling or vaccination is used.

The figure 2 is when high level of vaccination is used.

The figure 3 is when high level of culling and vaccination is used.

The figure 4 shows the use of vaccination and culling.

Conclusions

There are some limitations to this model. There is inoculation period when the animals can infect others, but show no symptom. It is impossible to call at the desired speed and it is impossible to know the number of the infected animals at any given moment. These graphs showed that culling and vaccination leaves the greatest number of the susceptible animals. Also, this model assumes the perfect mixing of susceptible and infected animals but in reality, this is not the case. The mathematical model used does not take into account the age structure (homogeneous population) and geographical distributions. These graphs show the differences in high vaccination, high culling, and using both methods. It is apparent that some amount of vaccination before the outbreak may help to prevent the epidemic, and if the epidemic is current, the most effective way to contain the epidemic will be the swift culling of infected animals. The vaccination of non-infected animals during the epidemic is current, will not be as effective. These models neglect factors that may be important to the way epidemic spread. Euler’s method is a first-order numerical procedure for solving ordinary differential equations with a given initial value. It serves as the basis to construct more accurate numerical techniques. It also suffers from stability problems. For this reason, higher order methods should be used to solve the system of ordinary differential equations. A comparison is made between approximate solutions obtained using Euler’s and Runge- Kutta methods.

References and Acknowledgments