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The Effect of Wolbachia Introduction and Predatory in Dengue Disease Transmission

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This paper discusses a mathematical model of dengue transmission with the introduction of Wolbachia and predatory. We assume that the parameter of the birth rate and the parameter of the death rate in human and vector population are the same, the life expectancy and the biting rate decrease because of the damage of the mosquito's proboscis due the presence of Wolbachia. Numerical result shows the effect of predatory and the effect of Wolbachia is able to reduce the primary and secondary infection of dengue in human.

Keywords: Mathematical Model, *Aedes aegypti*, Predatory, Wolbachia Infection, Multi-Agent Intervention.

1. INTRODUCTION

Dengue Fever (DF) is regarded as a dangerous disease which presents in many tropical countries. The prevalence is in the increasing rate and sometime the outbreak occurs periodically. It is caused by four serotype of viruses. The viruses may result in various clinical manifestations, from an asymptomatic to a fatal one. The transmission of the disease is caused by the biting of female *Aedes aegypti* mosquitoes. To date the control of the disease transmission is regarded as still unsuccessful. The outbreaks of the disease still occur in many places of tropical countries, especially in the urban areas.

The main control of dengue transmission is done by eliminating or eradicating the mosquitoes. Many scientists have shown that the transmission of dengue fever can be reduced by using bacteria of the genus Wolbachia which is introduced into the mosquito vector.[1,3] As the effect, the life time of mosquitoes can be reduced.[5] In this paper, we discuss the effect of multiple bio—agents intervention, such as the introduction of adults of Wolbachia-infected mosquitoes and predatory to the aquatic life-stage of mosquitoes, to control the spread of dengue disease in human.

We define the introduction of wolbachia as an action to realease wolbachia infected mosquitoe to the wild. After those mosquitoes mated with the natural mosquitoes, the offsprings of the mosquitoes will have a shorter life span (larger death rate) and a lower capability of injecting their proboscis. Further, we define the predatory intervention as an action to introduce natural enemy of the larva/egg of the Aedes mosquitoes in the early life stages of the mosquitoes, e.g., by placing the Betta fishes.

The model is based on earlier work,[2,4,6] where the presence of the intervention is in the form of the modification of vector death rate and biting rate.

2. MATHEMATICAL MODEL

By referring to the work of Anggriani et al.,[4] the differential equations model for the a dengue disease transmission is given by:

$$\frac{dS_0}{dt} = \mu_h N_h - \frac{b_r \alpha_1}{N_h} S_0 V_1 - \mu_h S_0 \tag{1}$$

$$\frac{dZ_0}{dt} = \xi Z - \frac{b_r \alpha_2}{N_h} Z_0 V_1 - \mu_h Z_0 \tag{2}$$

$$\frac{dI}{dt} = \frac{b_r \alpha_1}{N_h} S_0 V_1 - (\gamma + \mu_h) I \tag{3}$$

$$\frac{dY}{dt} = \frac{b_r \alpha_2}{N_h} Z_0 V_1 - (\gamma + \mu_h) Y \tag{4}$$

$$\frac{dZ}{dt} = \gamma (I + Y) - (\mu_h + \xi) Z \tag{5}$$

$$\frac{dV_0}{dt} = \mu_v N_v - \frac{b_r \alpha_v}{N_h} V_0 I - \mu_v V_0 \tag{6}$$

$$\frac{dV_1}{dt} = \frac{b_r \alpha_v}{N_h} V_0 I - \mu_v V_1 \tag{7}$$

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