Household Distribution of Dengue Epidemic of the Flooding Area

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***Abstract*—Dengue disease is transmitted to human by biting of infected *Aedes* mosquitoes. From dengue data in Bangkok, Thailand, we found that there is the high rate of dengue cases when there is the flood in Bangkok. The movement of human and the flying of mosquitoes are always happen. Thus, the above three factors effect to the transmission of dengue disease. In this paper, we formulate the dynamical network model and the behaviors of solutions to our model are shown for the different set of parameters. The simulation outputs are shown to introduce the way for reduce the dengue outbreak.**

***Index Terms*—Aedes mosquito, flood, dengue, movement dynamical equations.**

I. Introduction

DENGUE disease is considered to be the most tropical disease in Thailand. Four serotypes of this disease are denoted as DEN-1, DEN-2, DEN-3 and DEN-4.Dengue disease is classified into three types: Dengue Fever(DF), DengueHemorrhagic Fever(DHF) and Dengue Shock Syndrome(DSS).Dengue virus is transmitted from person to person by biting of infected female *Aedes* mosquitoes. *Aedes albopictus* and *Aedes polynesiensis,* members of *Aedesscutellaris complex* have also been incriminated as secondary vectors [1].The appropriated temperature of dengue transmission is above 20^0 C, and it never transmit virus at 16 ^{0}C. The changed season is effected to dengue transmission. Dengue transmission is always decreasingwith the approach of cold temperatures. The person can produce life-long immunity of dengue virus to that infected serotype when he/she is infected with dengue virus for the first time but only partial protection to the other three serotypes. Transmission of dengue virus from an infected human to a mosquito is determined by the magnitude and duration of viremia in the human host. Person with high viremia provides a higher infectious dose of virus to feeding mosquito. This normally leads to a greater percentage of feeding mosquitoes becoming infected. Some mosquito vectors may however become infectious when there is only a very low level of virus in the blood [1,2]. The dengue virus epidemic in Australia ceased as the temperature dropped to 14-15 ^{0}C at the beginning of winter. Temperature may also effect the maturation of mosquitoes, higher temperature producing smaller females which are forced to take more blood meals to obtain the protein needed for egg production[3]. The temperature and humidity are influence to the extrinsic incubation period of the mosquitoes and is an important variable in causing epidemic transmission [4]. The extrinsic incubation period of the mosquito in the low temperature is greater than that in the high temperature [5]. If the climate is too cold, the development of virus is slow then the mosquitoes can not survive long enough to become infectious [6]. The mosquitoes never recover from the infection since their infective period ends with their death [2].Because 2011 is the year which has many flooding areas in Bangkok, then we compare 2 years between 2010 and 2011 to see the distribution of dengue cases. We compare the data of dengue cases in Bangkok, Thailand for each area between year 2010 and 2011. We can see that the flooding effect to the transmission of dengue virus as shown in fig.1 [7].

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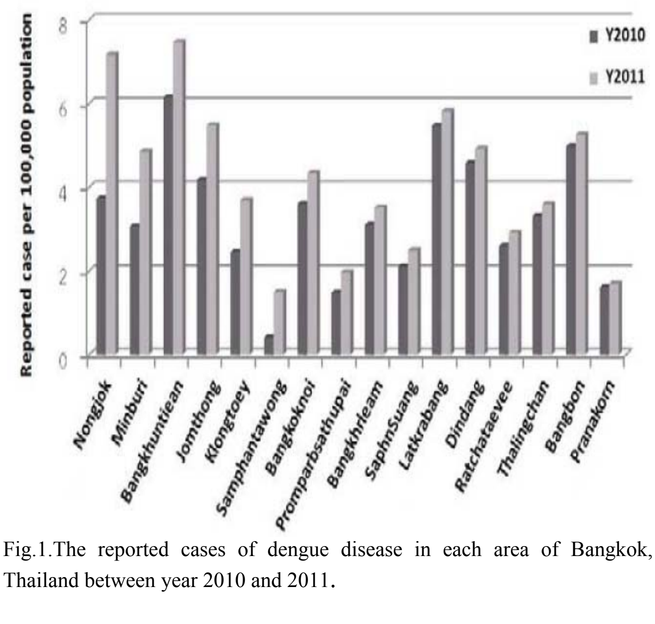

Fig.1.The reported cases of dengue disease in each area of Bangkok, Thailand between year 2010 and 2011.

Esteva and Vargas [8] formulated the mathematical model of dengue disease in 1998. They considered the transmission of dengue disease between human and mosquito. The total human and vector population have constant sizes. In 2008, the dynamical model of dengue disease is considered with the incubation of dengue virus [9]. In this paper, we consider the dynamical equations of dengue disease considering the traveling of human and mosquitoes with the effect of flooding.

II. DYNAMICAL MODEL

Dengue virus is transmitted between human and mosquitoes. We assume that people can move between houses. The mosquitoes can fly to any houses. In the beginning, there is only one dengue case and he/she can stay in any house. The people can travel to any house but at the ending day, he/she will come back to the house same as the beginning day. The flood effects to the transmission of dengue virus, thus the rate of flooding is considered in our model. The discrete dynamical equations can be described as the following equations:

$$\Delta Sh_{t,k} = -\varphi f_h \left(\frac{r}{r_{\max}}\right) Iv_{t,k} Sh_{t,k} + w\left(\frac{r}{r_{\max}}\right) Rh_{t,k}$$

$$\Delta Ih_{t,k} = \varphi f_h \left(\frac{r}{r_{\max}}\right) Iv_{t,k} Sh_{t,k} - aIh_{t,k}$$

$$\Delta Rh_{t,k} = aIh_{t,k} - w\left(\frac{r}{r_{\max}}\right) Rh_{t,k}$$

$$\Delta Sv_{t,k} = -\varphi f_v \left(\frac{r}{r_{\max}}\right) Ih_{t,k} Sv_{t,k} - \mu_v Sv_{t,k}$$

$$\Delta Iv_{t,k} = \varphi f_v \left(\frac{r}{r_{\max}}\right) Ih_{t,k} Sv_{t,k} - \mu_v Iv_{t,k}$$

The parameters are defined as in the following table:

TABLE I
THE DEFINITIONS OF VARIABLES/PARAMETERS IN OUR DYNAMICAL EQUATIONS.

Variable/Parameter	Definition
$Sh_{t,k}$	Number of susceptible persons of kthhouse at time t.
$Ih_{t,k}$	Number of infectious persons of kth house at time t.
$Rh_{t,k}$	Number of recovered persons of kth house at time t.
φ	Percentage of flooding.
$Sv_{t,k}$	Number of susceptible vector of kth house at time t.
$Iv_{t,k}$	Number of infectious vector of kth house at time t.
$Rv_{t,k}$	Number of recovered vector of kth house at time t.
f_h	Infectious rate of dengue virus from vector to human.
r	The distant of flying 's mosquito.
$r_{\max}$	The maximum distant of flying 's mosquito
w	The rate at which the recovered persons can become to be susceptible persons.
a	The recovery rate of human.
f_v	Infectious rate of dengue virus from human to vector.
μ_v	The death rate of vector.

Our dynamical equations are calculated by simulating the different set of parameters. The solutions are shown in the next section.

A. Analysis of our equations

We simulate the different sets of parameters. The considered parameters are Percentage of flooding (φ),Infectious rate of dengue virus from vector to human (f_h),The distant of flying 's mosquito(r) and Infectious rate of dengue virus from human to vector(f_v). The different sets of parameters are shown in the following table. The results are the total number of dengue cases from all houses.

TABLE II
THE DIFFERENT SET OF PARAMETERS IN THIS SIMULATIONS.

Parameter	Values			
φ	80%	60%	40%	20%
f_h	0.9	0.6	0.3	0.1
r	400	300	200	100
f_v	1.0	0.75	0.5	0.25

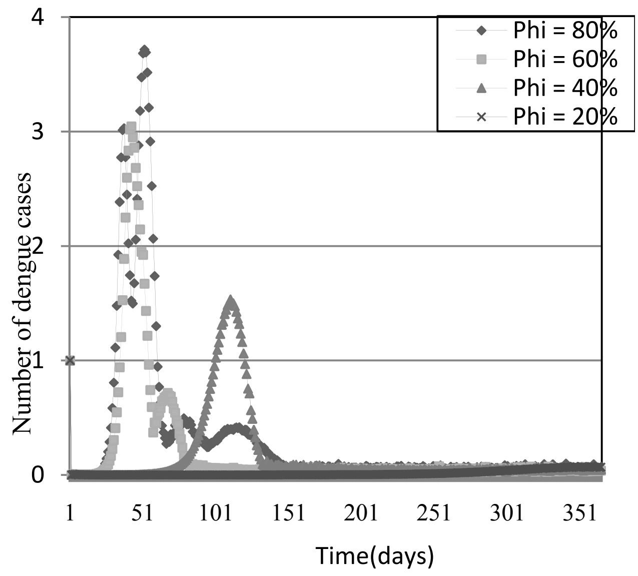

Fig.2. The number of dengue case when there is the different percentage of flooding.

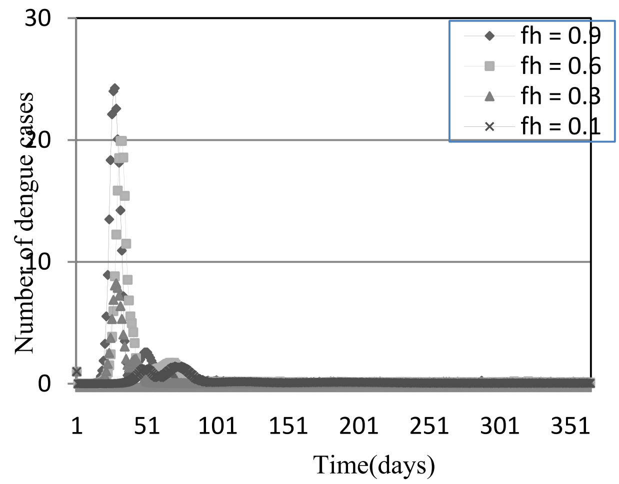

Fig.3. The number of dengue case when there is the different infectious rate of dengue virus from vector to human.

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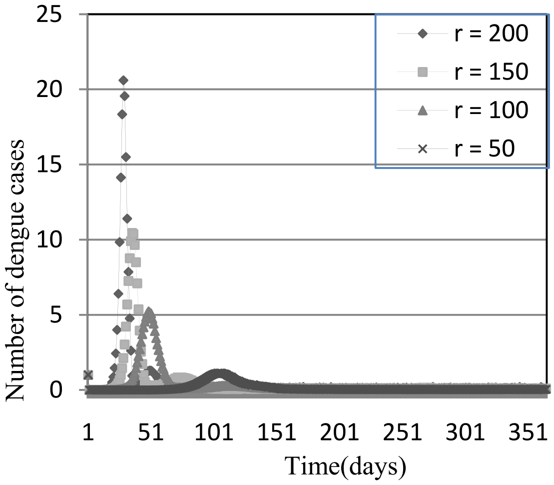

Fig.4. The number of dengue case when there is the different distant of flying‘s mosquito.

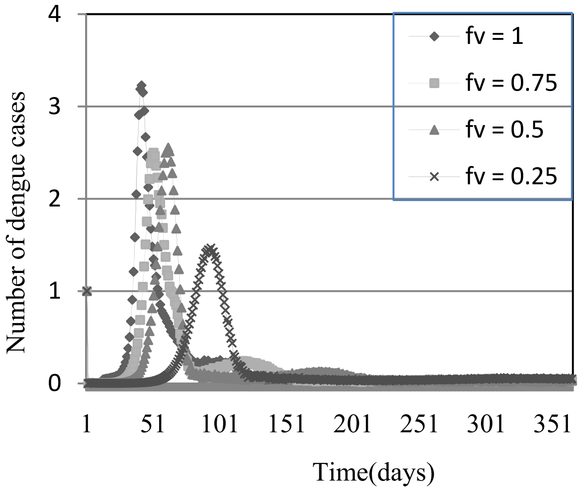

Fig.5. The number of dengue case when there is the different infectious rate of dengue virus from human to vector.

Moreover, we consider when there are the different total human and the number of houses. The results are shown in fig.6 and fig.7.

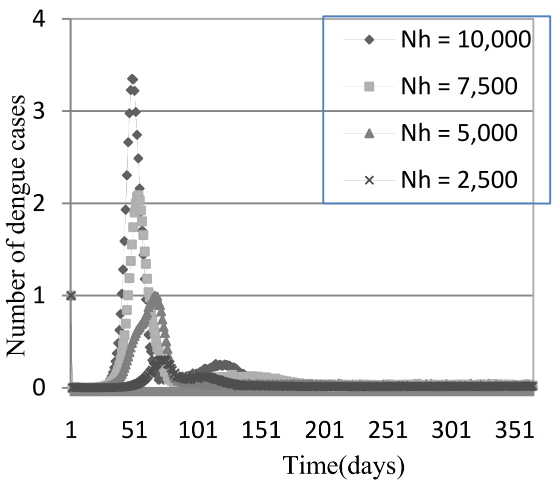

Fig.6.The number of dengue case when there is the different total number of human.

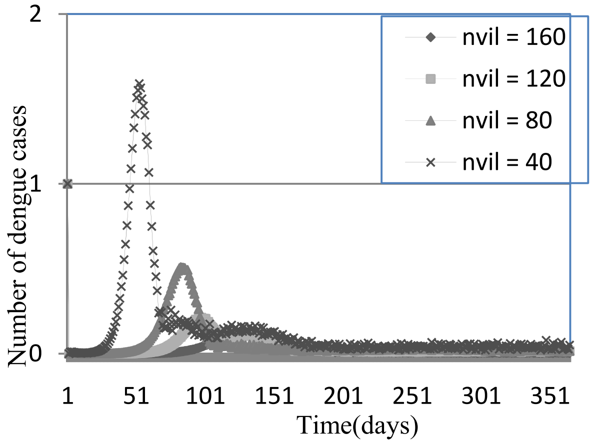

Fig.7. The number of dengue case when there is the different number of houses.

III. DISCUSSION AND CONCLUSION

In this study, we simulate the different set of parameters to see the factors effect to the transmission of this disease. From our simulations, we found that when percentage of flooding (φ), Infectious rate of dengue virus from vector to human(f_h) are increasing, The distant of flying ‘s mosquito(r) and the total human population is increasing, the infectious dengue case is increasing and the outburst time of dengue epidemic is longer. But when the number of house is increasing, the number of dengue case is decreasing and the outburst of dengue epidemic is shorter.The preliminary results of this study should suggest the factors influence to dengue transmission.

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