B-10.2 Predictive Study on the risk of dengue fever spreading due to global warming

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Total Budget for FY1996-FY1998 32,318,000 Yen (FY1998; 11,353,000 Yen)

Abstract Global warming will bring about the temperature elevation, and the habitat of vectors of tropical infectious diseases will spread into subtropical or temperate zone. The purpose of this study is to simulate the spreading of Dengue Fever(DF)/ Dengue Haemorrhagic Fever(DHF) under global warming.

(1) The relationship between DF/DHF endemicity, mosquitoes density, meteorological condition and socio-economic information were analyzed using data-set collected in southern China.

(2) From the results of field survey in Hainan, China and in Chiangmai, Thailand distribution and density of *aedine* mosquito (vectors of DF/DHF) showed seasonal variation and relation between meteorological condition, in particular temperature.

(3) From the results of laboratory experiments of *aedine* mosquito we found that growth rate and survival rate of them showed dependency on temperature condition.

Key Words Dengue Fever/ Dengue Haemorrhagic Fever, *aedine* mosquito, Temperature, Survival Rate

Introduction

Dengue Fever(DF)/ Dengue Haemorrhagic Fever(DHF) has been the most important health problem in tropical or sub-tropical areas in recent years. It is because of 1) increase of numbers of patients and expansion of endemic areas, 2) appearance of DHF and 3) the fear of expansion of endemic areas into sub-tropical or temperate zone due to global warming. *Aedes aegypti*, major vector of DF/DHF, has a habit to breed in the pot or puddle near residences and prefer to suck human blood (anthropophilic). In addition to global warming, population growth, urbanization, and deficiency of infrastructure of big cities in developing countries will bring about the increase of chance of DF/DHF infection.

Objective

The purpose of this study is to simulate the spreading of DF/DHF under global warming in Asia-Pacific region. DF/DHF is a vector-borne disease which is transmitted by *aedine* mosquito. Temperature elevation will accelerate the growth speed of larva, pupa and virus and prolong the life expectancy of adult mosquito. The change of pattern and amount of precipitation will affect the habitat of *Aedine* mosquito.

There are many factors which may play roles in DF/DHF transmission. In this study, we aimed to clarify those factors which may determine the endemics or epidemics of DF/DHF through reexamination of existing data and collection of some additional information by field survey. In order to get those basal data on DF/DHF, field survey and laboratory experiments were conducted both in China and in Thailand.

Method

1) Ecological study on DF/DHF endemics in southern China

We collected 10 years' data-set concerning DF/DHF endemicity, *aedine* mosquito density and some meteorological condition (temperature and precipitation), and socio-economical information on 60 villages in southern China (Yunnan Province, Guandong Province, Guangxi Zhuang Autonomous Region and Hainan Province). And we analyzed the relationships between DF/DHF endemicity, *aedine* mosquito density and another factors such as temperature and precipitation.

2) Experimental studies on the growth of *aedine* mosquito (vectors of DF/DHF)

(1) We carried out laboratory experiments on growth rate of *aedine* mosquito in different temperature conditions (25℃, 27℃ and 29℃) in Hainan, China.

(2) We carried out field experiments on growth rate of *aedine* mosquito in Nagasaki University, Japan.

(3) We carried out field experiments (marking-release and recapture) on survival rate of *aedine* mosquito in Japan, China and Thailand.

3) Field survey on *aedine* mosquito (vectors of DF/DHF)

Field surveys on *aedine* mosquito were conducted in several areas in Hainan, southern China and in Chiangmai, northern Thailand, and we discussed the ecology of *Ae. aegypti* and *Ae. albopictus* which are the major vectors of *DF/DHF.*

Results and discussion

1) Ecological study on DF/DHF endemics in southern China

Incidence of numbers of DF/DHF patients showed clear seasonal variations (peak in summer season) and the relation to some meteorological factors such as temperature and precipitation (Fig.1).

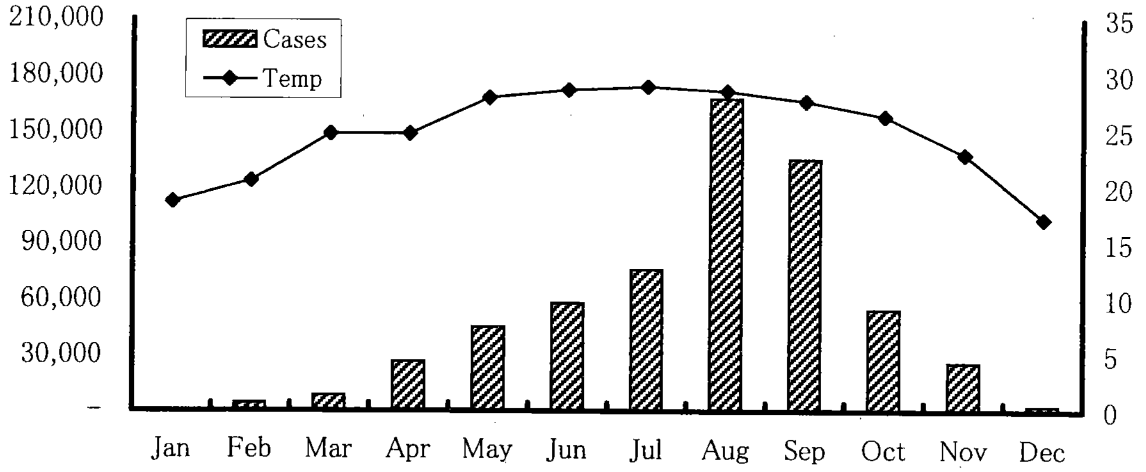
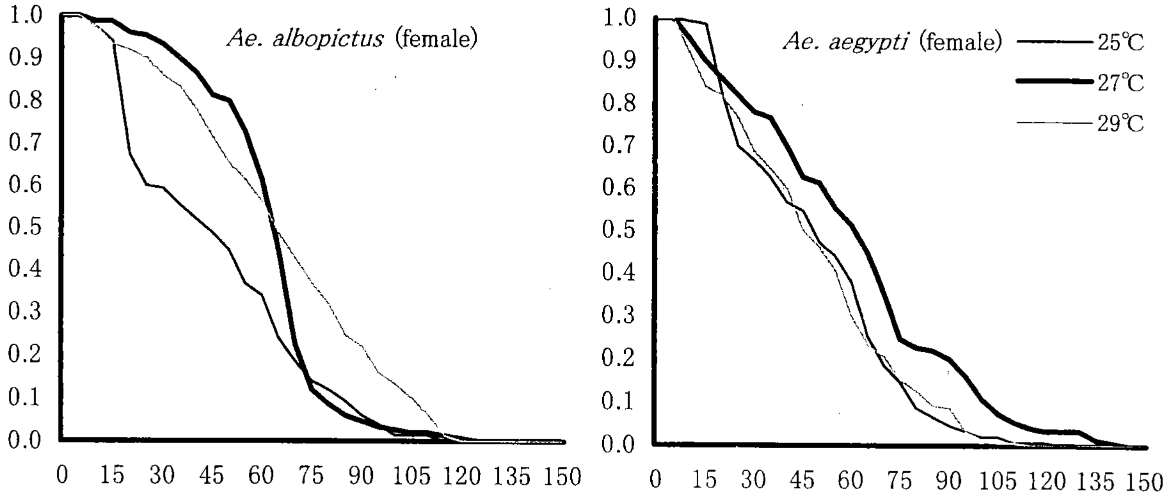


Fig.1 Monthly incidence of DF/DHF patients and average temperature (Hainan, China)

2) Experimental studies on the growth of *aedine* mosquito (vectors of DF/DHF)

(1) Growth rate (larva to pupa and pupa to adult) of *Ae. aegypti* and *Ae. albopictus* showed nearly same speed as shown in references. Growth rate, survival rate of pupa and sex ratio showed weak relation to the breeding temperature.

We found extremely high daily survival rate (long life expectancy) in both species and in both sex. Daily survival rate differed in bleeding temperature and we found highest daily survival rate (longest life expectancy) at 27℃ (Fig.2and Fig.3).



[x axis: observing days y axis: cumulative % of surviving mosquito]

Fig.2 Daily survival rate

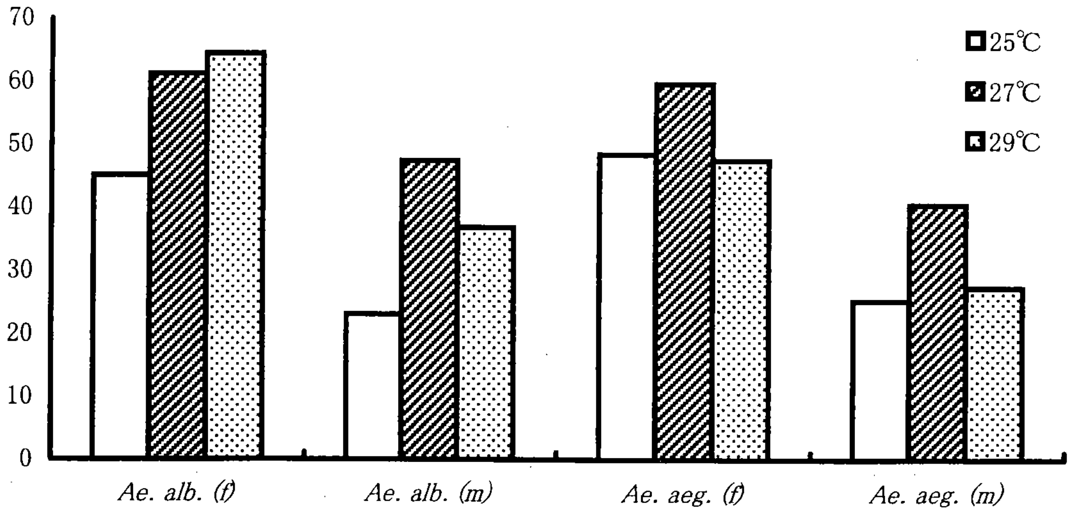


Fig.3 Life expectancy (days)

(2) In the field experiments at Nagasaki University, larva of *Ae. aegypti* and *Ae. albopictus* could not grow up to pupa in winter season (Dec. - Feb.) because of lower atmospheric temperature. In March *Ae. aegypti* could not grow up but *Ae. albopictus* had grown up very slowly (Table 1). From these results we can estimate threshold temperature for *aedine* vectors growth. Fig.4 showed the relation between development speed and atmospheric speed.

Table 1 Growth rate of *aedine* mosquito

		Ae. aegypti		Ae. Albopictus					
				strain-I		strain-N		strain-C	
date	temp. (℃)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
980107	6.1	0		0		0		0	
980202	8	0		0		0		0	
980304	9.5	0		56	48.5	45	47.2	38	48.9
980405	18	85	16.6	94	17.4	-	-	-	-
980501	20.6	88	9.4	95	11.6	74	11.3	83	12.4
980602	21.7	90	9.6	99	10.9	84	11.7	88	11.5
980715	26.5	85	7.6	93	8.1	84	8.2	84	8.5
980827	25.7	87	6.9	95	7.1	97	9	63	7.7
980929	20.4	80	8.9	97	11.2	95	11.1	65	10.3
981028	11.8	86	14	77	19.2	81	17.1	67	17.3
981203	10.4	0		0		0		0	

(a): percentage of larva succeeded to gow up to pupa
(b): number of days to grow up to pupa

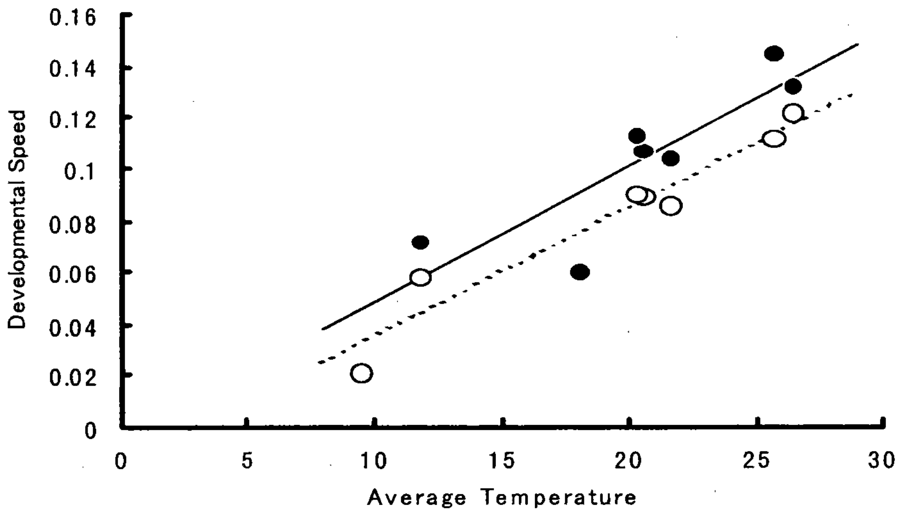


Fig.4 Relationship between temperature and developing speed
● : *Ae. aegypti*、 ○ : *Ae. albopictus*

(3) As the results of field experiments (marking-release and recapture method) we obtained followings. The number of recaptured mosquito showed highest in the next day after release and decreased gradually. Total recapture rate were very small (1-7%) except one experiment (14.7%). Daily survival rate were estimated about 0.68 to 0.82 and they showed higher estimate in summer (rainy) season. The estimated life expectancy were 2.6 to 4.2 days and they showed great discrepancy between the results estimated from laboratory experiments (Fig.5).

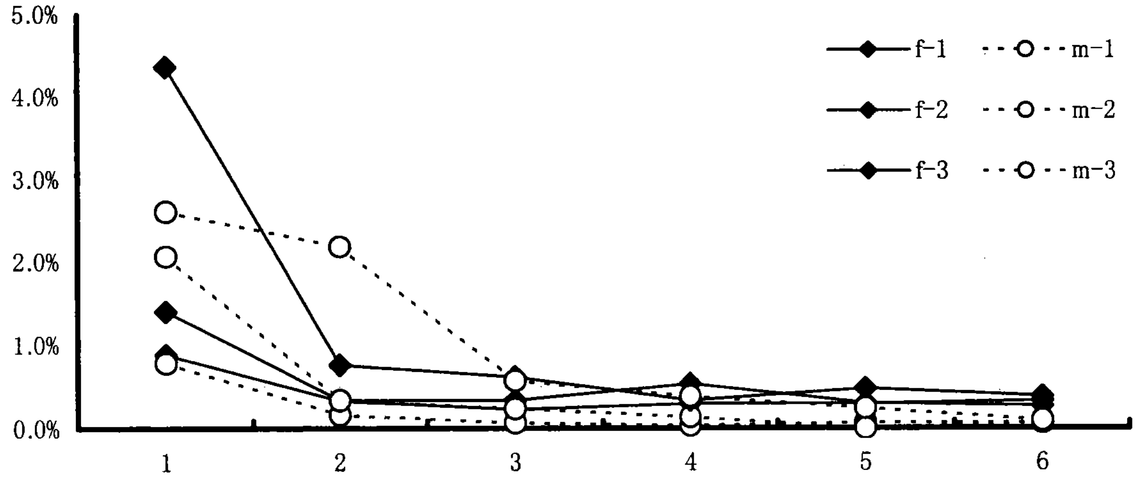


Fig.5 Daily survival rate of *Ae. aegypti* in the field experiments

[x axis: observing days y axis: % of recaptured mosquito]

3) Ecology of *Aedine* mosquito (vectors of DF/DHF)

In several areas in Hainan, southern China and in Chiangmai, northern Thailand, we conducted field surveys on the ecology of *Ae. aegypti* and *Ae. albopictus,* which are the major vectors of DF/DHF.

The situation of mosquito larva incidence was quite different in each survey area and it showed the localization even in same village. We investigated the factors which regulate the incidence of mosquito larva. We found some factors which relate to the incidence of mosquito larva but they could explain only a small part of it.

47 used tires was examined for 2 years by the weekly survey in Chiangmai, Thailand, and the seasonal changes in the incidence of *aedine* mosquito larva were analyzed in relation to the environmental factors such as water quality and temperature and light condition. Acidity, chemical oxygen demand(COD), and concentrations of NH4 and NO2 were measured every 3 weeks in the field for each tire. The number of tires with mosquito larvae showed a clear seasonal change. The number of tiers with *Ae. albopictus* was always larger than that with *Ae. aegypti*. The decrease in the number of tires with *Ae. aegypti* was observed earlier than that of *Ae. albopictus*. The number of tires with *Ae. aegypti* was large in June to August and decreased in the latter half of the rainy season, while that with *Ae. albopictus* decreased in the dry season. The water temperature was always >18℃, so that the temperature condition allowed the continuous breeding of *aedine* mosquitoes throughout the year. Significant temporal variations were observed in pH, COD, NO2 and NH4. However all the changes did not correlate with the seasonal prevalence of *Ae. aegypti* and *Ae. albopictus*. The reasons for the decline of *Ae. aegypti* population during the latter half of the rainy season was not clear in this study. More analytical study will be needed to clarify the reasons, because *Ae. aegypti* is a main vector of dengue fever in Thailand.

The incidence of *Ae. aegypti* and *Ae. albopictus*, percentage of water positive cases during the study period (% water positive), averages of water temperature, light intensity and water quality were calculated for each tire, and the relationship between the incidence of larvae and these 7 factors was analyzed by multiple regression analysis. The statistically significant factors for *Ae. aegypti* were % water positive and average light intensity, and these factors explained 30% of the observed variation in the incidence of *Ae. aegypti* among 47 tires. In *Ae. albopictus*, not only the 2 factors (% water positive and average light intensity) but also the average value of COD were significant factors, and these 3 factors explained 58.8% of the observed variation in the incidence of *Ae. albopictus*.