A Comparative Study on Life Table Characteristics of Two Strains of *Aedes albopictus* from Japan and Thailand

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Abstract: Life tables of two strains of *Aedes albopictus* originated from Nagasaki, Japan and Chiangmai, Thailand were examined in the laboratory conditions of 27℃, 75% R.H. and 16L:8D. The developmental period (egg to adult) in females of Chiangmai strain tended to be shorter than in those of Nagasaki strain. The body sizes of femals were not significantly different between the two strains. Since females of Nagasaki strain took blood meals more frequently and produced more eggs per blood meal than those of Chiangmai strain, a marked difference was observed in m_x-curve between the two strains. l_x-curve of females in the two strains were similar and no significant differences were observed in the longevity of the females. Nagasaki strain showed larger values of the net reproductive rate and the intrinsic rate of increase, and longer mean generation time than Chiangmai strain.

Key words: Life table, *Aedes albopictus*, Nagasaki strain, Chiangmai Strain

INTRODUCTION

It is thought that *Aedes albopictus* have originated in southeast Asia and has extended their geographic distribution in recent years. The potential public health importance of this species in the continental United States has become greater since the initial infestation was discovered in Texas in 1985, because of its competence as a vector for many arboviruses and higher cold tolerance than *Ae. aegypti* (Rai, 1991). To estimate the colonizing ability of this species, experimental studies have been made on their ecological characteristics such as the photoperiodic response, the overwintering ability, and the competitive ability (Hawley *et al.*, 1989; Ho *et al.*, 1989; Black *et al.*, 1989; Washburn and Hartmann, 1992; Rai, 1991). Although the demographic aspects of this species is also important to understand their ecological adaptation to various environments, only a few studies have been made on the capacity for increase and life table characteristics (Chan, 1971; Chen and Huang, 1988; Hawley, 1988).

The life table characteristics of two strains of *Ae. albopictus* from Japan and Thailand were studied comparatively in the present study.

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MATERIALS AND METHODS

Two strains of *Aedes albopictus* used in the experiments were collected in Nagasaki, Japan and Chiangmai, Thailand. The first generation of each strain was used in the experiment. All experiments were carried out under laboratory conditions of 27℃, 75% R.H. and 16 L:8D.

To examine the developmental period from hatch to adult emergence, 25 hatched larvae of each strain were reared in a plastic cup (8 cm in diameter and 4 cm in depth) with 100 ml of water and 30 mg of larval food. A mixture of powdered mouse pellet and dry yeast (1:1) were used as the larval food. Larval skins in the cup were collected every day and the head width was measured for the body size of larvae. Pupal skins were also collected from the cup and the width of the 8th abdominal segment was measured for the adult body size.

Age specific fertility (m_x) and survival rate (l_x) were examined using 50 pairs of newly emerging adults. The adults were divided into two cohorts and kept seperately in two adult cages (20×20×30 cm) with cotton pad soaked with a 3% sugar solution. A mouse was placed for 30 min every 2 days as a blood source and the number of engorged females was counted. A plastic cup (8 cm in diameter and 4 cm in depth) with 100 ml of water was placed into the cage as an oviposition site. A piece of filter paper was attached to the inside wall of the plastic cup. The numbers of eggs on water surface and on the filter paper and dead adults were counted every 2 days as a rule.

The results of the two cohorts were pooled to construct a life table. Survival rate (l_x) was calculated as the proportion of mosquitoes alive at day x. Age specific fertility (m_x) is the mean number of female progeny produced by a female of age x. The values of m_x were calculated as follows. The number of female progeny produced by females of age x was estimated by the number of eggs observed at day x multiplied by sex ratio of 0.5. The value was divided by the interval of observation to get the number of female progeny per day. Dividing this value by the number of surviving females at day x gave the value of m_x. Assuming survival rate of 1.0 during larval development, the net reproductive rate (R_o) and the intrinsic rate of increase (r_m) were calculated in the same way as Walter and Hacker (1974).

RESULTS AND DISCUSSION

The body sizes of larvae and pupae of the two strains were shown in Table 1. Although the differences observed in the 2nd instar larvae and male pupae were significant at 1% level (*t*-test), both strains produced nearly equal size of female adults under this experimental condition. The developmental periods from egg to adult were calculated in Table 2. Males of Chiangmai strain had the shortest developmental period of 6.4 days, whereas females of Nagasaki strain had significantly longer developmental period of 8.7 days ($p<0.05$, Turkey-Kramer Method, Sokal and Rohlf, 1981). Both sexes of Nagasaki strain showed longer developmental period than Chiangmai strain, though the differences were not significant. The body size and developmental period of mosquitoes depend on the rearing condition

Table 1. Body size** of larvae and pupae (± sd) of two strains of *Aedes albopictus* from Nagasaki, Japan and Chiangmai, Thailand.

Stage	Strain		t-value
	Chiangmai	Nagasaki	
1st	17.6±1.5	17.5±1.2	0.31
2nd	23.6±1.6	24.9±1.2	2.95*
3rd	36.0±1.5	36.2±1.9	0.35
4th	48.0±2.7	48.4±2.3	0.47
Pupa (♂)	49.7±1.7	46.6±2.6	3.01*
(♀)	53.8±2.7	54.6±1.1	0.67

*significant at 1% level. **in unit (1mm=64 units).

Table 2. Developmental period from egg to adult in days (± sd) of two strains of *Ae. albopictus* from Nagasaki, Japan and Chiangmai, Thailand.

	Strain	
	Chiangmai	Nagasaki
males	$6.4^{a} \pm 0.5$	$7.5^{ab} \pm 1.8$
females	$7.5^{ab} \pm 1.4$	$8.7^{b} \pm 2.3$

Means with the same letter were not significantly different at 5% level (Turkey-Kramer method, Sokal and Rohlf, 1981).

Table 3. Population parameters of two strains of *Ae. albopictus* from Nagasaki, Japan and Chiangmai, Thailand.

	Strain	
	Chiangmai	Nagasaki
Longevity in days	(♂) $16.9^{b} \pm 10.1$ (♀) $30.0^{a} \pm 15.8$	$28.7^{a} \pm 12.8$ $31.7^{a} \pm 16.3$
Number of blood meals per female	2.6	3.3
Number of eggs per blood meal	28.2	52.2
Number of eggs per female	73.5	173.2
Net reproductive rate (R_o)	34.9	81.9
Mean generation time in days (T)	26.1	30.0
Intrinsic rate of increase (r_m)	0.182	0.193

Means with the same letter were not significantly different at 5% level (Turkey-Kramer method, Sokal and Rohlf, 1981).

of larvae such as the density and the amount of larval food (Wada, 1965; Barbosa *et al.*, 1972; Mori, 1979; Takagi and Narayan, 1992). The body sizes of larvae and adults of the two strains have to be compared under the different conditions of density and food amount in the future studies.

l_x and m_x curves of the two strains are shown in Fig. 1. l_x curves of the females of the two strains were similar and no significant differences were observed in longevity (Table 3). Males of Chiangmai strain had significantly shorter longevity than those of Nagasaki strain. Higher capacity of reproduction was suggested in Nagasaki strain than in Chiangmai strain. The total number of eggs oviposited by females of Nagasaki strain (8,661 eggs) was larger than that of Chiangmai strain (3,529 eggs). The proportions of eggs oviposited on the water surface were 33% and 40% in Nagasaki and Chiangmai strains, respectively. The difference between the two strains was highly significant at 0.1% level (Gadj=55.07, Test of independence using the G-Statistics, Sokal and Rohlf, 1981). Number of blood meal per female was calculated from the total number of engorged females divided by the initial number of females. Nagasaki strain had more blood meals (3.3) than Chiangmai strain (2.6). Number of eggs per blood meal in Nagasaki strain was 1.85 times larger than that of Chiangmai strain. As the results, number of eggs per female and the net reproductive rate (R_o) of Nagasaki strain were higher than those of Chiangmai strain. The mean generation time was shorter in Chiangmai strain and the intrinsic rate of increase (r_m) was higher in Nagasaki strain. Using *Ae. albopictus* collected from Taiwan, Chen and Huang (1988) reported shorter mean generation time, higher R_o and r_m than the present study. Large variations in life table

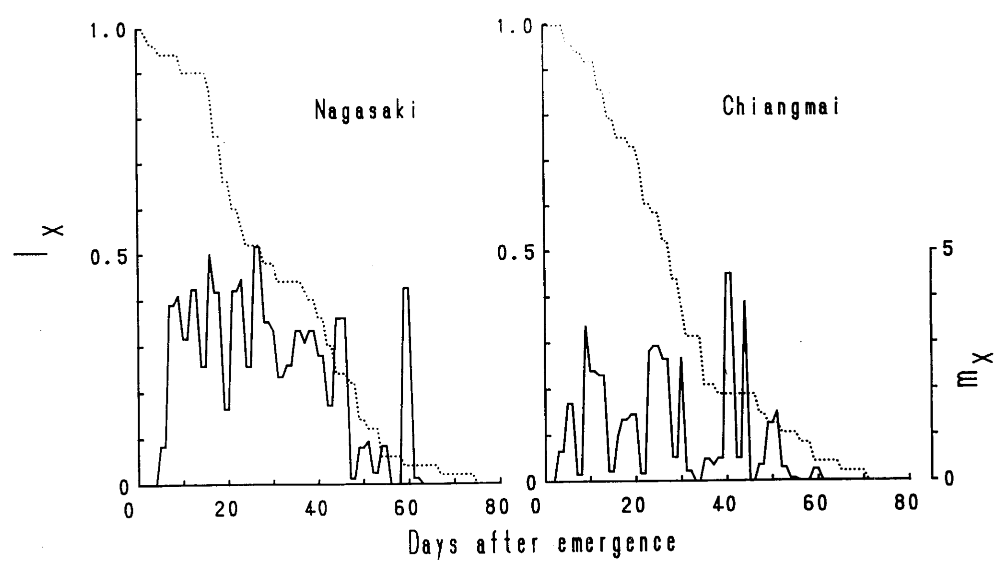

Fig. 1. l_x (dotted lines) and m_x (solid lines) curves of the two strains of *Aedes albopictus* observed under the laboratory conditions of 27℃, 75% R. H and 16L:8D.

characteristics have been observed among different strains of *Ae. aegypti* (Lansdowne and Hacker, 1975; Hacker *et al.*, 1977), *Culex pipiens quinquefasciatus* (Walter and Hacker, 1974; Suleman and Reisen, 1979), and *Cx. tritaeniorhynchus* (Reisen *et al.*, 1979). Because variations in ecological characteristics of *Ae. albopictus* among different geographic strains have been reported about cold hardiness (Hawley *et al.*, 1989), competitive ability (Block *et al.*, 1989; Ho *et al.*, 1989), and oviposition pattern and hatch rate (Mogi, 1982), a wide variation in life table characteristics is expected and more comparative studies will be needed to understand the ecological adaptation of this species.

References

1) Barbosa, P., Peters, T. M. and Greenough, N. C. (1972): Overcrowding of mosquito populations: responses of larval *Aedes aegypti* to stress. Env. Entomol., 1, 89−93.
2) Black Ⅳ, W. C., Rai, K. S., Turco, B. J. and Arroyo, D. C. (1989): Laboratory study of competition between United States strains of *Aedes albopictus* and *Aedes aegypti* (Diptera: Culicidae). J. Med. Entomol., 26, 260−271.
3) Chan, K. L. (1971): Life table studies of *Aedes albopictus* (Skuse). pp.131−144. *In* Sterility principles for insect control or eradication. International Atomic Energy Agency, Vienna.
4) Chen, C. and Huang, C. (1988): Ecological studies on *Aedes aegypti* and *Ae. albopictus* Ⅰ. Comparison of development threshold and life tables. Yushania 5, 1−15. (in Chinese with English summary)
5) Hacker, C. S., Ling, W., Hsi, B. P. and Crovello, T. J. (1977): An application of mathematical modeling to the study of reproductive adaptations in the yellow fever mosquito, *Aedes aegypti.* J. Med. Entomol., 13, 485−492.
6) Hawley, W. A. (1988): The biology of *Aedes albopictus*. J. Am. Mosq. Control Assoc., 4 (suppl., 1), 1−39.
7) Hawley, W. A., Pumpuni, C. B., Brady, R. H. and Craig, Jr., G. B. (1989): Overwintering survival of *Aedes albopictus* (Diptera: Culicidae) eggs in Indiana. J. Med. Entomol., 26, 122−129.
8) Ho, B. C., Ewert, A. and Chew, L. (1989): Interspecific cmpetition among *Aedes aegypti, Ae. albopictus,* and *Ae. triseriatus* (Diptera: Culicidae): Larval development in mixed cultures. J. Med. Entomol., 26, 615−623.
9) Lansdowne, C. and Hacker, C. S. (1975): The effect of fluctuating temperature and humidity on the adult life table characteristics of five strains of *Aedes aegypti.* J. Med. Entomol., 6, 723−733.
10) Mogi, M. (1982): Variation in oviposition, hatch rate and setal morphology in laboratory strains of *Aedes albopictus.* Mosq. News 42, 196−201.
11) Mori, A. (1979): Effects of larval density and nutrition on some attributes of immature and adult *Aedes albopictus.* Trop. Med., 21, 85−103.
12) Rai, K. S. (1991): *Aedes albopictus* in the Americas. Ann. Rev. Entomol., 36, 459−484.
13) Reisen, W. K., Siddiqui, T. F., Aslam, Y. and Malik, G. M. (1979): Geographic variation among the life table characteristics of *Culex tritaeniorhynchus* from Asia. Ann. Entomol. Soc. Am., 72, 700−709.
14) Sokal, R. R. and Rohlf, F. J. (1981): Biometry, 2nd ed. 859pp., Freeman, San Francisco.
15) Suleman, M. and Reisen, W. K. (1979): *Culex quinquefasciatus* Say: life table characteristics of adults reared from wild-caught pupae from north west frontier province, Pakistan. Mosq. News 39, 756−762.
16) Takagi, M. and Narayan, D. (1992): A laboratory experiment on the larval development of *Aedes polynesiensis* under different rearing conditions. Trop. Med., 34 (1), 1−8.

17) Wada, Y. (1965): Effect of larval density on the development of *Aedes aegypti* (L.) and the size of adults. Quaest. Entomol., 1, 223−249.

18) Walter, N. M. and Hacker, C. S. (1974): Variation in life table characteristics among three geographic strains of *Culex pipiens quinquefasciatus.* J. Med. Entomol., 5, 541−550.

19) Washburn, J. O. and Hartmann, E. U. (1992): Could *Aedes albopictus* (Diptera: Culicidae) become established in California tree holes? J. Med. Entomol., 29, 995−1005.