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Life Table and Population Parameter of *Sogatella furcifera* (Horvath) (Homoptera: Delphacidae) on Rice

[1]S.S. Win, [2]R. Muhamad, [2]Z.A.M. Ahmad and [2]N.A. Adam
[1]Plant Protection Entomology Division, Department of Agriculture,
Myanmar Agriculture Service, Yangon, Myanmar
[2]Department of Plant Protection, Faculty of Agriculture,
Universiti Putra Malaysia, 43400 UPM, Serdang Selangor, Malaysia

Abstract: Survivorship and fertility of the White Backed Plant Hopper (WBPH), *Sogatella furcifera* were assessed under laboratory conditions in Myanmar. A pair of five days old WBPH was released into a wooden cage covered with wire mesh sieve. Thirty days old rice plant in a pot was placed on the floor of the wooden cage. The single sex method was applied in the life table study. Life tables and population parameters were constructed based on unlimited food supply and a natural enemies-free environment. Results showed that the highest mortality occurred in the immature stages, especially in the first and second instars. The life table analysis showed that population densities of *S. furcifera* decreased gradually. The proportion of male to female observed was 1:0.88. The females could live for a maximum of 12 days. The trend of oviposition showed a peak at about the 10th day of the female life span. The mean number of eggs produced per female was 8.75. The intrinsic rate of increase (r_m) was 0.06999 per female per day and daily finite of increase (λ) was 1.0255 per female per day, with a mean generation time (T) of 34.97 days. The net reproductive rate (Ro) of the population was 9.2732. The population Doubling Time (DT) was within 10.88 days. It could be concluded that the survivorship curve reflected a modest rate of mortality during the early life stages and a gradual reduction when approaching adulthood. All the surviving nymphs underwent four moults. The life table showed that about 37.26% of *S. furcifera* eggs successfully emerged as adults and high mortality occurred during the early immature stages. This type of survivorship is commonly classified as type II.

Key words: Life table, *Sogatella furcifera*, plant hopper, rice

INTRODUCTION

Pests and disease problems are major constraints for increasing rice production. Insect pests including plant hoppers can cause serious damage to rice crop. One such example is the White Backed Plant Hopper (WBPH), *Sogatella furcifera* (Horvath) which has become a serious threat to rice production throughout South and South East Asia since the early 1970's. Loss of crop yield due to WBPH is estimated at between 10 to 30%. Serious damage usually occurs during the early stages of plant growth with symptoms of hopper burns due to intensive sucking by the insect (Dale, 1994).

The construction of life tables is an important tool for understanding the population dynamics of an insect. The basic life table construction is one of the most important conceptual and analytical tools in entomological research. Age-specific life table serves as a framework for organizing dates on mortality and natality and also provides detailed transparent descriptions of the actual properties of a cohort. It generates simple summary statistics such as life expectancy and natility rate and also has a basic form that can be expanded, condensed, or modified for analyzing different types of data such as mortality by some factors (Carey, 2001). Analysis of life tables is the most suitable method to account for natality and reproduction of a population (Begon and Mortimer, 1981; Price, 1997). Deevey (1947) reported that life table is a concise summary statement for every interval of age, the number of deaths (d_x), the number surviving at the beginning of age class x (l_x), the rate of mortality (q_x) and the expectation of life remaining for individuals of age x (e_x). The table also includes numbers living between age x and x+1, i.e., the age structure (L_x). In such studies, development times and survival rates of each stage, longevity of adults and the daily fecundity of females are recorded for every individual (Chi, 1988). Therefore, the aims of this study was to construct the life tables of *S. furcifera* fed on rice plants for demographic analysis and to determine the survivorship and rate of increase of the plant hopper.

Corresponding Author: Rita Muhamad, Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor DE, Malaysia Tel: 60389467244 Fax: 60386560698

MATERIALS AND METHODS

The insects used for the experiments were obtained by culturing in the Laboratory. The experiments were conducted in the laboratory and in a smallholder pesticide free rice field in Hmaw Be, Upper Myanmar. The rice plants were grown in a pot. Five seeds of rice were placed in each pot (10 cm diameter×5 cm in length). The soil was provided up to the height of 13 cm prior to seeding. The excess seedlings were thinned out 15 days after seeding. One or two seedlings were left in each pot. Manawthukha rice variety was selected for in this experiment. The single sex method was applied in the life table study (Southwood, 1978). A wooden cage (length 34 cm× breadth 34 cm×height 61 cm) covered with wire mesh sieve on each site was constructed and a pair of five days old WBPH was released into the wooden cage. Thirty days old rice plant in a pot was placed on the floor of the wooden cage.

The construction of the life tables followed the procedure described by Southwood (1978). In order to construct the age-specific life table, 27 females and 23 males were paired in the field into 5 cages. The adult hoppers were taken out from the wooden cage three days after releasing. Data of the survival rate of eggs, 1st to 5th nymphal instar and adults were recorded daily for calculations. The mortality rates of all nymphal and adult stages were also recorded. Total numbers of eggs laid were recorded until all the released plant hopper females died. Data analysis was carried out following the single sex method and the life table was then constructed using the following parameters:

- X : The pivotal age for the age class in units of time (days)
- l_x : The number of surviving individual at the beginning of age class x
- L_x : The number of individual alive between age x and x+1
- d_x : The number dying during the age interval x
- $100q_x$: Percent apparent mortality
- S_x : Survival rate within stage
- T_x : Total number of age x units beyond the age x
- e_x : Life expectancy for individual of age x
- m_x : Age specific fertility, the number of living females born per female in each interval class
- Ro : Net reproductive rate, equal to the sum of the l_x m_x products, or $Ro = \Sigma\, l_x\, m_x$
- T_c : Cohort generation time (in days), approximated by the following formula:

$$T_c = \Sigma\, X l_x\, m_x / \Sigma\, l_x\, m_x$$

- r_c : Innate capacity for increase, calculated by, $r_c = \ln Ro/T_c$
- r_m : The maximum population growth, the intrinsic rate of natural increase or the innate capacity for increase, calculated by iteration of Euler's equation:

$$\Sigma\, e^{-rm.x}\, l_x\, m_x = 1$$

- T : The corrected generation time, $T = \ln Ro/ r_m$
- λ : The finite rate of increase, number of female offspring per female per day, calculated by:

$$\lambda = e^r\, m$$

- DT : Doubling time, the number of days required by a population to double, calculated by:

$$DT = \ln 2/ r_m$$

- b : Intrinsic birth rate, $1/\Sigma\, e^{-r}\, m^x\, l_x$
- d : Intrinsic death rate, $b - r_m$

To estimate the population parameters of *S. furcifera*, three sets of data from different cohorts were obtained on different dates (7 July, 20 July and 25 July 2007)

RESULTS

Age-specific survival life table: The survivorship (l_x) of *S. furcifera* for three different cohorts (Fig. 1a-c) in general shows similar pattern with high mortality occurring during nymphal growth particularly in the early instar which gradually decreases throughout the life span. The first emerging adults occurred on days 22, 23, 22 and the maximum life spans (from hatching egg to death of adult) were 33, 36, 36 days for cohorts 1, 2 and 3, respectively. The patterns of survivorship observed indicated that the young immature stage is susceptible to physical disruptions and unsuitable food quality. This survivorship curve reflected a modest rate of mortality during the early life stages and a gradual reduction when approaching adulthood. The population assumed a near type II diagonal survivorship curve following the classification of Speight *et al.* (1999).

Table 1 shows the pooled life table concerning mortality, the description of one pathway of population change. All the surviving nymphs underwent four moults. The life table showed that about 37.26% of 378 *S. furcifera* eggs successfully emerged as adults and high mortality

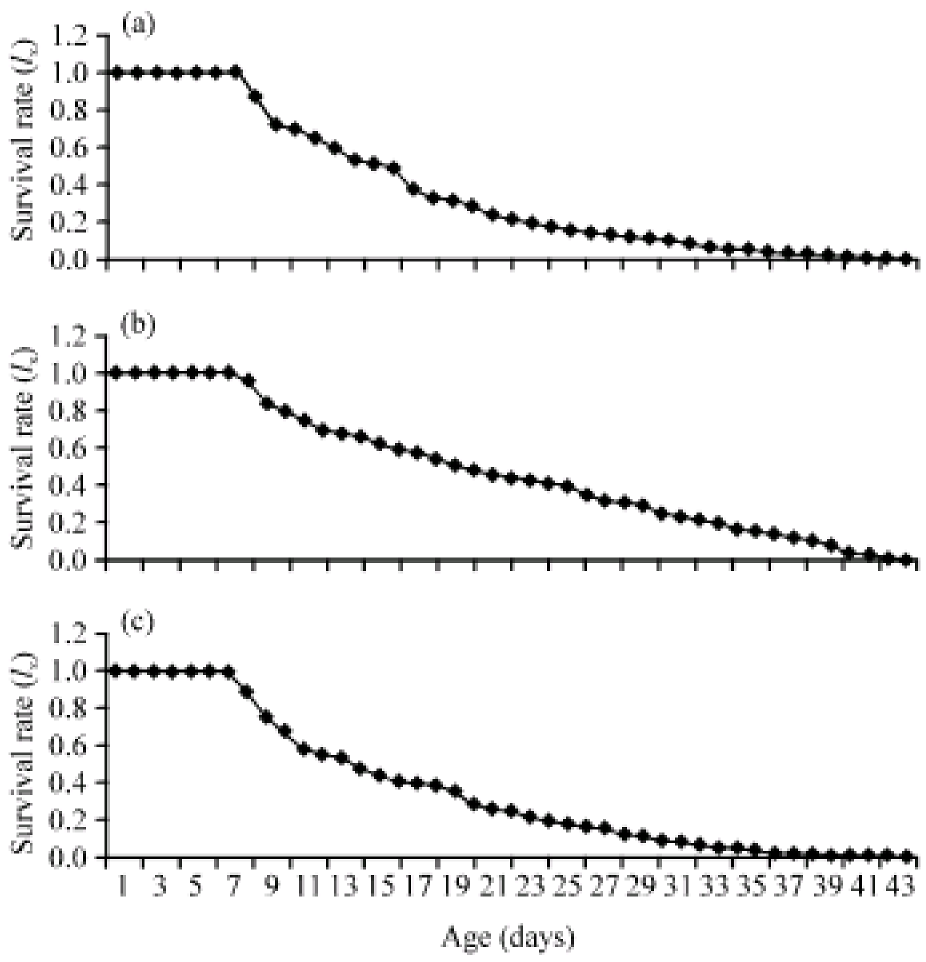

Fig. 1: (a-c) Patterns of survivorship curve (l_x) of *S. furcifera* for three different cohorts

Table 1: Pooled life table of *S. furcifera* on rice

Age (days)	I_x	L_x	d_x	$100q_x$	S_x	T_x	e_x
Egg	378	360	36	9.52	90.48	1345	2.56
Nymph							
Instar 1	342	295	94	27.48	72.51	985	2.88
Instar 2	248	223	50	20.16	79.84	690	2.78
Instar 3	198	175	47	23.74	76.26	467	2.36
Instar 4	151	132	39	25.83	74.17	292	1.93
Instar 5	112	108	8	7.14	92.86	160	1.43
Adult	104	52					

X: Developmental stage (days), I_x: No. entering stage, L_x: No. a live between stage x and x+1, d_x: No. dying in stages, $100q_x$: Percent apparent mortality, S_x: Survival rate within stage, T_x: Total number of age x units beyond the age x, e_x: Life expectancy

occurred during the early immature stages. This type of survivorship is commonly found in most insect species (Begon and Mortimer, 1981).

Age-specific fertility life table: The age-specific survival and fecundity of *S. furcifera* females were shown in Fig. 2 and the detailed data in Table 2. The first female emerged on day 23 and the first death on day 30. The survival of the immature stage from egg to adult emergence was 0.92. The proportion of male and female recorded was 0.506:0.494 (Table 2). The last females died on the 42nd day. On average the females could be alive for a maximum of 35 days. Females started laying eggs from the 29th day or about 6 days from their first emergence. The numbers of eggs deposited were low in the early period and higher during the final period of their life span. The highest numbers of eggs were laid at 34 days of age with the number of eggs per female being 9.

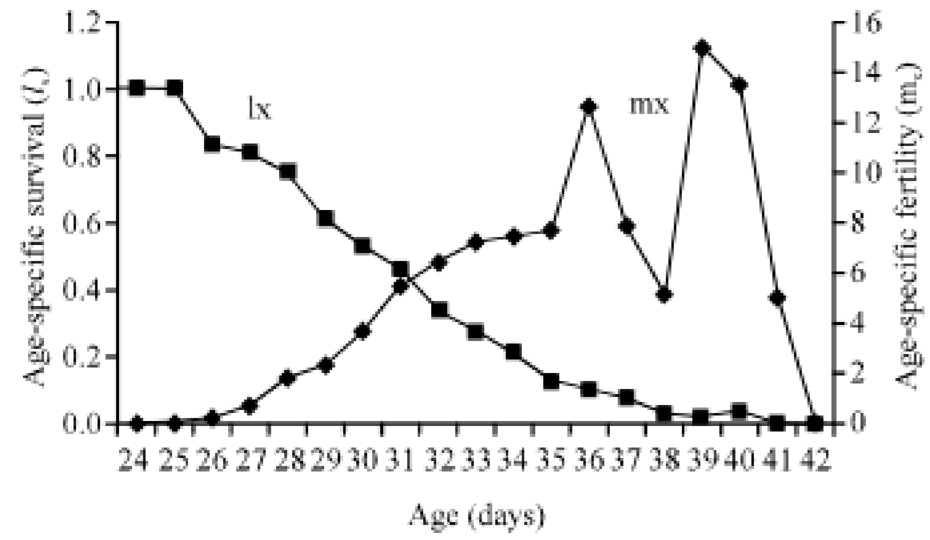

Fig. 2: Daily age- specific survival (l_x) and fecundity (m_x) of *S. furcifera* females fed on rice

Table 2: Age-specific survival and fecundity table of *S. furcifera* fed on rice

Age (days) x	l_x	Egg per female	m_x^a	$l_x m_x$	$x l_x m_x$	$e^{-r_m x}$ ($l_x m_x$)
1	1					
2	1					
3	1					
4	1					
5	1					
6	1					
7	1					
8	1					
9	1					
10	1					
11	1					
12	1					
13	1					
14	1					
15	1					
16	1					
17	1					
18	1					
19	1					
20	1					
21	1					
22	1					
23	1					
24	1					
25	1					
26	0.834100	0.22857	0.12046	0.10047	2.61231	0.01632
27	0.810100	0.69697	0.36730	0.29755	8.03391	0.04507
28	0.752500	1.80645	0.95200	0.71638	20.05864	0.10119
29	0.610200	2.33333	1.22967	0.75034	21.75994	0.09883
30	0.530100	3.68000	1.93936	1.02805	30.84164	0.12627
31	0.463500	5.47826	2.88704	1.33814	41.48248	0.15326
32	0.340200	6.42857	3.38786	1.15255	36.88157	0.12309
33	0.275400	7.25000	3.82075	1.05223	34.72374	0.10479
34	0.213400	7.46667	3.93493	0.83971	28.55030	0.07798
35	0.125100	7.71429	4.06543	0.50859	17.80048	0.04404
36	0.102400	12.66667	6.67533	0.68355	24.60795	0.05520
37	0.077500	7.87500	4.15013	0.32163	11.90048	0.02422
38	0.027778	5.14286	2.71029	0.07529	2.86086	0.00529
39	0.018519	15.00000	7.90500	0.14639	5.70917	0.00958
40	0.036200	13.50000	7.11450	0.25754	10.30180	0.01572
41	0.001800	5.00000	2.63500	0.00474	0.19446	0.00027
42	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
Total			53.89504	9.27318	324.33333	1.00114

The population and reproductive parameters of *S. furcifera* females are summarized in Table 3. The intrinsic rate of natural increase (r_m) of *S. furcifera* was

Table 3: Population and reproductive parameters of *S. furcifera* fed on rice

Parameters	Formula	Values
Approximate generation time (T_c) (days)	$\Sigma l_x m_x x / \Sigma l_x m_x$	34.97000
Corrected generation time (T) (days)	ln Ro/r_m	31.86100
Innate capacity for increase (r_c)	ln Ro/Tc	0.06368
Intrinsic rate of natural increase (r_m)	$\Sigma e^{-r_m x} l_x m_x = 1$	0.06990
Finite rate of increase (λ)	e^r	1.08000
Doubling time (DT) (days)	ln 2/r	10.88000
Intrinsic birth rate (b)	$1/\Sigma e^{-r_m x} l_x$	1.17000
Intrinsic death rate (d)	b-r_m	1.10600
Gross reproduction rate	Σm_x	53.89500
Net reproduction rate (Ro)	$\Sigma l_x m_x$	9.27320

0.0699 per female per day and the daily finite rate of increase (λ) was 1.08 female offsprings per female per day. The mean generation time (T_c) was 31.86 while the net reproduction rates (R_0) of the population was 9.27. The Doubling Times (DT) was within 10.88 days. The r_m, T_c and DT are useful indices of population growth under a given set of crop growing conditions.

DISCUSSION

The survivorship (l_x) of *S. furcifera* (Fig. 1) showed that higher mortality was found during the nymphal growth stages particularly in the early stages. The population densities subsequently decreased gradually through out the life span during this study period. Velasco and Walter (1993) reported that survival of insects, growth of nymphs and reproductive phase were highly influenced by food quality. The pattern of survivorship of *S. furcifera* observed indicated that the nymphal stages were susceptible to poor food and nutrition quality. It was also influenced by the density dependent factor of food change during captivity for *S. furcifera*. Affects by variations in food sources on population parameters were observed in *Earias vitella* fed on different host plants (Satpute *et al*., 2005), *Diaphorina citri* fed on four different host plants (Tsai and Liu, 2000) and *Orius albidipennis* fed on various arthropod preys (Chyzik *et al*., 1995). The survivorship curve for *S. furcifera* was also classified as type II following that of Speight *et al.* (1999) and Schowalter (2006) since it was very poor for the nymphal immature stages but much higher for the older individuals. The experiments in this study were conducted in July 2006 coinciding with rainy season which could influence the mortality of the early nymphal stages of *S. furcifera.* Schowater (2006) reported that insect populations are highly sensitive to changes in abiotic conditions, such as temperature, rainfall and relative humidity. Any changes in parameters could affect the growth of insects and their survival.

The pooled life tables (Table 3) showed that the population changes according to the death and birth rates. The mortality of eggs of *S. furcifera* recorded was 9.52%. The mean net reproductive rate (R_0) of *S. furcifera* was 9.27. According to Birch (1948) the comparison of two or more populations by their net reproductive rate (R_0) might be misleading unless the mean values of the generation time are the same.

The intrinsic rate of increase r_m, mean generation time T_c and Doubling Time (DT) of the population were useful indices of population growth under a given set of growing conditions. Longevity, reproductive rate, growth rate and population fluctuation could be influenced by their food sources (host plants or host preys) and also by environmental conditions such as temperature (Ellers-Kirk and Fleischer, 2006). If the tested host plants are different, the results of the population parameters will be varied. Life tables giving data on the r_m of a particular species provide insight into the characteristic life patterns of different species (Satpute *et al*., 2005). There is a range of innate capacity for individual of a population (Gill *et al*., 1989).

The values of the population parameters may be varied according to field and laboratory conditions. It appears that the survival of different stages of plant hoppers under field conditions and laboratory conditions (testing in cages) may be varied due to more stress during life span of the plant hoppers released in the cages. Such variations have been known to cause some effect on population parameters of *Acalymma vittatum* (Coleoptera: Chrysomelidae) fed on cucurbits (Ellers-Kirk and Fleischer, 2006) and *Nasonovia ribisnigri* (Homoptera: Aphididae) fed on lettuce (Diaz and Fereres, 2005). Environmental conditions such as temperature, relative humidity, wind speed, solar radiation and the overall microclimate are expected to vary considerably between field and caged conditions.

CONCLUSION

The survivorship curve reflected a modest rate of mortality during the early life stages and a gradual reduction when approaching adulthood. All the surviving nymphs underwent four moults. The life table showed that about 37.26% of *S. furcifera* eggs successfully emerged as adults and high mortality occurred during the early immature stages. This type of survivorship is commonly classified as type II.

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