

## INFLUENCE OF THREE CONSTANT AND TWO RHYTHMICALLY FLUCTUATING TEMPERATURE REGIMES ON THE LIFE-TABLE PARAMETERS OF BROWN LACEWING *SYMPHEROBIUS FALLAX*

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**ABSTRACT:-** Brown lacewing (*Symphorobius fallax*), characterized by good adult longevity, high fecundity, and fast development rates are important predators in many agricultural systems. Life tables of *S. fallax* were constructed at 20°C, 24°C, 28°C and rhythmically fluctuating temperature regimes from 16°C to 24°C and 24°C to 32°C. Studies were carried out describing survival, reproduction and development of *S fallax*. Survival was positively temperature dependent. Sex ratio was not affected by constant temperatures from 20 to 28°C; however this ratio was affected by rhythmically fluctuating temperatures. The female proportion increased in 24°-32°C regimes. The development could not take place at 16°C and 32°C constant temperatures. But in rhythmically fluctuating temperature regimes development of stages took place.

*Key Words: Mealy Bug; Life Table; Sex Ratio; Rhythmically Fluctuating Temperature; UK.*

### INTRODUCTION

Life-tables describe survival, reproduction and development of a species. A life-table contains the basic information needed to study population changes and rates of increase or decrease. They determine the probability of an individual of a certain age surviving, and the average number of off springs produced by a given age female. Birch (1948) defined the intrinsic rate of increase ( $r_m$ ) as the rate of increase per head under specified physical conditions, in an unlimited environment where the effect of an increase in population density does not need to be considered. Further it is a basic parameter of an insect population that depends upon its fecundity, longevity and speed of development which, in a population, are reflected by birth and death

rates. According to Barlow (1962) the intrinsic rate of increase of a species must generally be such that the species is able to maintain its numbers in the environment in which it lives and that a balance is achieved between its rate of increase and its food supply. Messenger (1964) used  $r_m$  as an index of the rate of population growth, response to temperature and potential effectiveness. Laughlin (1965) has argued that seasonal populations with non-overlapping generations never attain rates of growth corresponding to  $r_m$  values. He therefore proposed  $r_c$  (capacity for increase) as the appropriate index of population growth potential for seasonal organisms with non-overlapping generations. Bosch and Messenger (1973) stated that the life-table for cohorts or populations are merely schedules of births and

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deaths caused by various factors and that the intrinsic birth and death rates of a population may be determined in the laboratory under various conditions of food quality, temperature, humidity and photoperiod. The key life history traits are daily fecundity, the age at first reproduction, the time of the first reproduction, the interaction of reproductive efforts with adult mortality and any variation in these traits among an individual's progeny (Stearn, 1976). The intrinsic rate of increase is an important parameter in considering the growth potential of a population under given conditions of climate and food. It aids in devising inductive strategies for the management of insect populations (Southwood, 1978). Jervis and Copland (1996) reviewed the use of life-table analysis both by ecologists and by biological control workers. They indicated that, when faced with a choice of candidate parasitoid species in a biological control programme, and in the absence of other criteria, the selection would be for the species with the greatest value for the intrinsic rate of natural increase. The later could also be used by ecologists and pest management scientists for comparing the effects of other parameters, e.g., temperature and host plants on the biology of a species (Dent, 1997).

## MATERIALS AND METHOD

The experiments were conducted in the Department of Environment, Wye College, University of London, UK. To start the experiments, uniform aged adults were required. For this purpose 50 brown lacewing adults from the main culture were

collected carefully with the help of an aspirator and released into a 27cm x 15cm x 10 cm plastic box which contained potatoes infested with longtailed mealybug (*Pseudococcus longispinus*) and kept at 26°C and 65% r.h. in an incubator. This box was made from clear plastic with two circular holes (7 cm dia) covered with fine mesh cloth to provide ventilation. The lacewings were kept in this box for 24h for egg laying on infested potatoes and were then removed carefully with the help of an aspirator and placed into a second box along with new infested potatoes. This process continued for five days after which the surviving adults were returned to their original cage in the main culture. The lacewing eggs infested boxes were left in the incubator at 26°C for eggs to develop into adults. The boxes were examined daily and emerging adult brown lacewings were collected and recorded on a daily basis.

On emergence, a few adults were studied under a binocular stereo-microscope to determine morphological differences between male and female. A distinction was seen in the colour and shape of the apex of the abdomen. The females have a darker pigmentation around this area, along with two distinct black circular areas at the tip, whereas males are lighter in pigmentation and have only one black spot. Once these features were recognized, emerging adults could be divided into males and females.

To determine pre-oviposition, oviposition, post-oviposition periods and daily fecundity, ten pairs were selected from newly emerged lacewing adults and each pair was introduced separately into a 250 ml

glass jar covered with muslin cloth which contained one potato infested with *P. longispinus*. The pair was removed from the jar after 24h and introduced to a new jar of the same kind. This continued until the death of the female. Any male which died during this period was replaced with a male of the same age from the males reserved for this purpose.

Each potato infested with lacewing eggs was carefully removed from the jar and observed under a binocular stereo-microscope to count the number of eggs laid. The lacewing eggs were laid singly without any stalk. They were oval, ends more bluntly rounded, covered with minute raised granules, white in colour, turning to pale cream afterwards. These eggs were removed with great care with a moistened camel hair brush and placed on a filter paper in a (4.5 cm dia) Petridish. A moistened cotton bud was also placed in the Petridish to save the eggs from desiccation. The Petridishes were placed back in the incubator and observed daily. On hatching, the newly emerged larvae were transferred singly to glass vials of 5cm x 1cm and fed daily with second stage *P. longispinus*. The complete development of each larva until adult emergence was studied in these vials. The information required for the construction of life-tables, i.e. female development period, female proportion in the sex ratio, age specific daily fecundity and survival, were obtained from the individuals completing their life cycles in the vials. The development was studied at five different constant temperatures i.e. 16°C, 20°C, 24°C, 28°C and 32°C at 65% r.h. under a continuous light regime of 7.5 watts

m<sup>-2</sup> in incubators. Since there was no survival after the first instar at 16°C and 32°C, the data after the first instar could not be recorded however studies were conducted on two rhythmically fluctuating temperature regimes: 16°C - 24°C and 24°C - 32°C for 12h each at continuous photoperiod.

The data obtained were statistically analyzed with one-way ANOVA. The data for sex ratio were analyzed through the chi-square test at  $P \leq 0.05$ . The males and females were compared by using t-test at 5% level.

Life-tables for *S. fallax* were constructed by determining the mean age of the cohort ( $\bar{x}$ ), the fractions of the initial population still alive at the end of each age interval ( $l_x$ ) and the mean number ( $m_x$ ) of female progeny produced per day per female still alive at age  $x$ .

Once the value of  $l_x$  and  $m_x$  are tabulated, the following population parameters can be calculated (Messenger, 1964).

Gross reproductive rate (GRR) is the mean total number of female eggs produced by a female over its life-time ( $GRR = \sum m_x l_x$ ), measured in females/ female per generation.

Net reproductive rate ( $R_0$ ) is the number of times the population will multiply per generation ( $R_0 = \sum l_x m_x$ ), measured in females/ female per generation.

Finite capacity for increase ( $\lambda$ ) is the number of times the population will multiply itself per unit of time ( $\lambda = \text{antilog}_e r_m$ ), measured in females/ female per day. Hence the finite rate

of increase ( $r$ ) is the natural antilogarithm of the intrinsic rate of increase. Therefore, any statement about the rate of increase of a population is incomplete without reference to the age distribution of that population, unless every female in it happens to be producing offspring at the same rate at all ages, and at the same time is exposed to a similar chance of dying at all ages (Birch, 1948).

Mean generation time (T): The relation between numbers and time in a population growing exponentially is given by  $N_T = N_0 e^{rT}$ , when T is the mean length of the generation, and then from the definition of net reproductive rate  $N_T / N_0 = R_0$ , hence  $R_0 = e^{rT}$  and  $T = \log_e R_0 / r_m$ , measured in days. It follows that an accurate estimate of the mean length of the generation cannot be obtained until the value of  $r_m$  is known. Therefore, for estimation purposes T may be calculated as  $T = \sum x.l_x.m_x / \sum l_x.m_x$ .

The comparison of two or more populations by means of their net reproductive rates may be quite misleading unless the mean length of the generation is the same.

Doubling time (DT) is the time required for a given population to double its number ( $DT = \log_e 2 / r_m$ ) measured in days.

Capacity for increase ( $r_c$ ) is an approximation of  $r_m$ . It is calculated as follows:

$r_c = \log_e R_0 / T_c$ , where  $T_c$  is the cohort generation time, defined as mean age of maternal parents in the cohort at birth of the female offspring,

$$T_c = \sum x.l_x.m_x / R_0$$

All these parameters can be calculated using a simple program for which a QBASIC version is given (Jervis and Copland, 1996). The data required are age-specific survival and age specific fecundity, which are scored for each day.

## RESULTS AND DISCUSSION

The intrinsic rate of increase integrates the effects of all existing mortality and fecundity into a single value which could be used to compare the reproductive potential of entomophagous insects under different ecological conditions. This parameter can also be used to compare different species under the same ecological conditions (Dent, 1997). The age at which maximum fecundity occurs is more important in determining the intrinsic rate of increase than total fecundity (Barlow, 1962). The life-table data of predators at different temperatures give an important information for pest management (Ali and Rizvi, 2007).

### Effect of Three Constant Temperatures and a Continuous Photo Period on The Life-Table Parameters of *S. fallax*

Temperature has a marked effect on the biology of *S. fallax*. Increasing temperature shortened the development period and the net reproductive rate increased about four fold between 20°C and 28°C (Table 1). Generation time increased at 20°C. A positive relationship between the intrinsic rate of increase and the finite capacity of increase was also noted with temperature (Table 1).

Table 1. Life-table parameters of *S. fallax* at three constant temperature and a continuous photoperiod

Life -table parameter	20°C	24°C	28°C
Gross Reproductive rate (GRR) Female/female per generation	22.4400	19.0620	21.816
Net reproductive rate ( $R_0$ ) Female/female per generation	2.6254	5.9854	8.7920
Capacity for increase ( $r_c$ )	0.0185	0.0447	0.0662
Intrinsic rate of increase ( $r_m$ )	0.0185	0.0448	0.0693
Cohort generation time ( $T_c$ ) days	52.1744	39.9710	31.4125
Generation time (T) days	52.1442	39.9407	31.3611
Finite capacity for increase ( $\lambda$ ) Female/female per day	1.0186	1.0458	1.0717
Doubling time (DT) days.	37.4442	15.4721	9.9997

#### Age-Specific Survival and Fecundity of *S. fallax* at Three Constant Temperatures and a Continuous Photoperiod

The survival rate after adult emergence was the maximum at 28°C (Table 2). A sharp decrease in survival was observed on 8th day after emergence at 28°C. Similar trend was observed by Ali and Rizvi (2009) whilst studying life table parameters of *Menochilus sexmaculatus*. Egg laying started 3 days after emergence at all three temperatures (Table 2). The pattern of age-specific fecundity was similar at all the three temperatures. The number of eggs laid increased with age, reached a maximum and started declining. Egg laying stopped a few days before death. This post-oviposition period varied from 2 to 7 days at all three temperatures (Table 2). During present studies, temperature was found to have the greatest effect on the life-table parameters of *S. fallax*. The net reproductive rate, capacity for increase, and intrinsic rate of increase were least at lower temperatures (Table 1). These results are in agreement with Barlow

(1962) who found that temperature influenced the intrinsic rate of increase by changing developmental time, survival rate, and fecundity rate of *Myzus persicae* (Sulzer) and *Macrosiphum euphorbiae* (Thomas) (Aphididae). When the finite rate of increase ( $\lambda$ ) of a population is less than unity ( $r_m$  is negative), the death rate exceeds the birth-rate and population eventually becomes extinct (Birch, 1948), something which did not occur in present case at any temperature regimes. Cocuzza et al. (1997) observed that the values of the intrinsic rate of increase of *Orius laevigatus* (Fieber) and *O. albidipennis* (Reuter) (Heteroptera: Anthocoridae) decreased at low (15°C) as well as at high temperatures (35°C). In present studies, the net reproductive rate and the intrinsic rate of increase of *S. fallax* also decreased at lower temperatures (Table 1). A similar effect of high temperature on net reproductive rate and intrinsic rate of increase of castor whitefly *Trialeurodes ricini* Misra (Homoptera: Aleyrodidae) was noted by Shishehbor and Brennan (1996).

Table 2. Age-specific survival and fecundity of adult *S. fallax* at three constant Temperatures and continuous photoperiod

S. No.	20°C			24°C			28°C		
	Mean age	Age specific survival	Age specific fecundity	Mean age	Age specific survival	Age specific fecundity	Mean age	Age specific survival	Age specific fecundity
	$x$	$l_x$	$m_x$	$x$	$l_x$	$m_x$	$x$	$l_x$	$m_x$
1	45.92	0.117	0.000	34.57	0.314	0.000	27.4	0.404	0.000
2	46.92	0.117	0.000	35.57	0.314	0.000	28.4	0.404	0.000
3	47.92	0.117	0.000	36.57	0.314	0.000	29.4	0.404	2.322
4	48.92	0.117	0.900	37.57	0.314	0.972	30.4	0.404	5.562
5	49.92	0.117	2.790	38.57	0.314	3.618	31.4	0.404	6.480
6	50.92	0.117	4.365	39.57	0.314	5.886	32.4	0.404	4.806
7	51.92	0.117	5.265	40.57	0.314	4.914	33.4	0.404	2.106
8	52.92	0.117	4.230	41.57	0.314	2.700	34.4	0.364	0.540
9	53.92	0.117	2.430	42.57	0.314	0.918	35.4	0.283	0.000
10	54.92	0.117	1.305	43.57	0.314	0.054	36.4	0.162	0.000
11	55.92	0.117	0.585	44.57	0.314	0.000	-	-	-
12	56.92	0.117	0.315	45.57	0.157	0.000	-	-	-
13	57.92	0.117	0.225	56.57	0.031	0.000	-	-	-
14	58.92	0.117	0.000	-	-	-	-	-	-
15	59.92	0.094	0.000	-	-	-	-	-	-
16	60.92	0.059	0.000	-	-	-	-	-	-
17	61.92	0.012	0.000	-	-	-	-	-	-

Effect of Two Rhythmically Temperature Regimes and Continuous Photoperiods on the Life-Table Parameters of *S. fallax*

The life history parameters are usually calculated on the basis of laboratory studies but in nature the conditions are varied by diurnal fluctuations. Temperature has a marked effect on the biology of *S. fallax* (Table 3). At 15°C and 32°C, there was no survival but when incorporated in rhythmically

fluctuating regimes the brown lace wing survived. High difference in the life-table parameters, i.e. gross reproductive rate, net reproductive rate, capacity for increase and intrinsic rate of increase was noted among the two regimes (Table 3). All parameters were lower between 16°C and 24°C than between 24°C and 32°C regime. The doubling time from 16°C to 24°C was negative showing that the population will diminish to the half after 173.56 days.

Table 3. Life-table parameters of *S. fallax* at two rhythmically fluctuating temperature regimes and continuous photoperiod

Life-table parameter	16°C -24°C	24°C-32°C
Gross reproductive rate (GRR) Female/female per generation	13.572	22.538
Net reproductive rate (R <sub>0</sub> ) Female/female per generation	0.814	4.394
Capacity for increase (r <sub>c</sub> )	0.00399	3.426
Intrinsic rate of increase (r <sub>m</sub> )	0.00399	3.428
Cohort generation time (T <sub>c</sub> ) days	51.405	43.208
Generation time (T) days	51.432	43.182
Finite capacity for increase (λ) Female/female per day	0.996	1.034
Doubling time (DT) days.	-173.562	20.217

Age-Specific Survival and Fecundity of *S. fallax* at Two Rhythmically Fluctuating Temperatures Regimes and Continuous Photoperiod

The survival rate after adult emergence was the maximum from 24° to 32°C (Table 4). The survivorship was constant after adult emergence at both the regimes. A decrease in survival was observed 13

Table 4. Age-specific survival and fecundity of adult *S. fallax* at two rhythmically fluctuating temperature regimes and continuous photoperiod

S. No.	16°C - 24°C			24°C - 32°C		
	Mean age (days)	Age specific survival	Age specific fecundity	Mean age (days)	Age specific survival	Age specific fecundity
	$x$	$l_x$	$m_x$	$x$	$l_x$	$m_x$
1	35.9	0.060	0.000	35.9	0.195	0.000
2	36.9	0.060	0.000	36.9	0.195	0.000
3	37.9	0.060	0.000	38.9	0.195	0.000
4	38.9	0.060	0.000	39.9	0.195	0.000
5	39.9	0.060	0.000	40.9	0.195	0.000
6	40.9	0.060	0.000	41.9	0.195	1.416
7	41.9	0.060	0.000	42.9	0.195	4.956
8	42.9	0.060	0.000	43.9	0.195	6.313
9	43.9	0.060	0.117	44.9	0.195	6.018
10	44.9	0.060	0.390	45.9	0.195	2.773
11	45.9	0.060	0.468	46.9	0.195	1.062
12	46.9	0.060	0.741	47.9	0.195	0.000
13	47.9	0.060	1.131	48.9	0.176	0.000
14	48.9	0.060	1.248	49.9	0.098	0.000
15	49.9	0.060	1.521	38.9	0.039	0.000
16	50.9	0.060	1.521	-	-	-
17	51.9	0.060	1.365	-	-	-
18	52.9	0.060	1.131	-	-	-
19	53.9	0.060	1.053	-	-	-
20	54.9	0.060	0.858	-	-	-
21	55.9	0.060	0.858	-	-	-
22	56.9	0.060	0.507	-	-	-
23	57.9	0.060	0.312	-	-	-
24	58.9	0.060	0.156	-	-	-
25	59.9	0.060	0.195	-	-	-
26	60.9	0.060	0.000	-	-	-
27	61.9	0.060	0.000	-	-	-
28	62.9	0.060	0.000	-	-	-
29	63.9	0.060	0.000	-	-	-
30	64.9	0.060	0.000	-	-	-
31	65.9	0.036	0.000	-	-	-
32	66.9	0.018	0.000	-	-	-

days after emergence from 24 °C to 32 °C. Egg laying started 5 and 8 days after emergence at the two temperature regimes (Table 4). The oviposition period was longer at 16°C-24°C than at 24°C-32°C. The number of eggs laid increased with age, reached a maximum and started declining. Egg laying stopped a few days before death. This post-oviposition period varied from 4 to 7 days in both the regimes (Table 4).

Messenger (1964) found rhythmically fluctuating temperature stimulated more rapid development of the aphid to cause development to proceed to completion at lower temperatures and to enhance greatly aphid fecundity and longevity as compared with effects of constant conditions. Present results showed almost similar trend. *S. fallax* could not survive at 16 and 32 constant temperatures but in fluctuation temperature condition it survived.

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