# STAGE SPECIFIC LIFE TABLE OF RICE LEAFFOLDER, *Cnaphalocrocis medinalis* (Guen.) AT DIFFERENT TEMPERATURE REGIMES


## ABSTRACT

The change in air temperature will influence the insect behavior, physiology and population dynamics of insects as they are poikilothermic. Global temperature has increased by 1.09°C during 2001-2020 when compared to 1850-1900. It is projected that the temperature will further increase by 5.7°C under high emission scenario, if mitigation strategies are not adopted. Increase in temperature would affect the physiology and population dynamics of the insects. A study was undertaken to understand the effect of different temperature regimes on rice leaffolder. Survival fraction decreased with increasing temperatures as more successful development was at lower temperature regimes. Apparent mortality increased towards the higher temperature regimes as the insects cannot tolerate high temperature stress. The Mortality Survivor Ratio (MSR) revealed that the population increase would be more at higher temperature regimes as the MSR remained higher at higher temperature regimes. The Indispensable Mortality was lesser under higher temperature regimes as the number of adults emerged in the high temperature regime was less. Generally, K - values increased with increasing temperature. It indicates that the insects which happened to live under higher temperature regimes were reproduction oriented as most of the energy was spent in reproduction rather than for living longer time.



**Key words:** Climate change; Insect; Leaffolder; Life table; Rice; Temperature




## 1. INTRODUCTION

Intergovernmental Panel on Climate Change (IPCC) in its recently released assessment report stressed that climate change is rapid and unprecedented. The global temperature increased by 1.09°C during 2001-2020 when compared to 1850-1900 (1). It is projected that the temperature will increase by 5.7°C under high emission scenario, if mitigation strategies are not adopted. The change in temperature will have impact on the behavior, physiology and population dynamics of insects since they are poikilothermic. For every 10°C increase in temperature, insect metabolic rates will be doubled (2). So it is expected that insect growth and development will be accelerated under global warming situations. It is also interesting to note that the development rate of some insects in tropical climates may be slowed down as the temperature will be reaching the upper threshold limit (3).

Life tables are the best tools to assess the impact of different temperature levels as it clearly indicates the population dynamics of the insects (4). Stage specific life tables play an important role in understanding the ecological aspects of insects (5). Several scientists have used the life table for studying the impact of temperature on the population dynamics of insect pests (6,7,8,9,10). It is found that the apparent mortality was more at 16°C whereas Mortality Survivor Ratio, Survival fraction and K values were more at high temperature (11). Survival rates of bean bugs for all the stages have increased with an increase in temperature and decreased after reaching the threshold temperature (12). Apparent mortality and survival fraction had negative relationships in the case of the ladybird beetle (13).

Rice leaffolder (RLF), severely damages plants by folding the leaves and ultimately leading to significant yield loss (7). Leaffolder can cause damage to leaves to the tune of 79 per cent and yield loss may range between 11 to 37 per cent (14,15). It is understood from these that leaffolder is one of the major insect pests of rice and understanding its behavior and dynamics is important to manage the insects. It is also imperative to study its behavior with respect to different temperature regimes for understanding the effects of global warming and climate change. Hence, a study was proposed to understand the dynamics of the leaffolder at different temperature regimes by constructing stage specific life tables.

## 2. MATERIALS AND METHODS

Climate Control Chambers, where the desired level of temperature is controlled by issuing commands through the control panel was used to conduct experiments at various constant temperatures. Temperature ranges of 28.0°C, 30.0°C, 32.0°C, 34.0°C, and 36.0°C were taken into consideration for this experiment. Rice leaffolder adult was cultured using the method proposed by Waldbauer and Merciano (16). Data required for constructing the life table were collected using the methodology given by Iranipour *et al*. (17). By dividing an insect species' life cycle into discrete developmental phases (such as eggs, larvae, pupae, and adults), and then analysing the survival or mortality for each stage, temperature dependant stage specific life tables were constructed (18) by estimating the following parameters.

### 2.1. APPARENT MORTALITY

It provides information on the number of insects dying as a proportion of the total number of insects that entered that stage and was computed using the formula.

$$\text{Apparent mortality} = \frac{d_x}{l_x} \times 100$$

Where, x = Stage of the insect; $l_x$= Number surviving at the beginning of the stage x. $d_x$ = Mortality during the stage indicated in the column x

**2.2. SURVIVAL FRACTION ($S_x$)**

Stage specific survival fraction ($S_x$) of each stage was calculated using the data on apparent mortality.

$$s_x = \frac{l_x \text{of subsequent stage}}{l_x \text{of particular stage}}$$

**2.3. MORTALITY SURVIVOR RATIO (MSR)**

It is the population rise expected in each stage, if mortality has not occurred in that particular stage.

$$\text{MSR} = \frac{\text{Mortality in particular stage}}{l_x \text{of subsequent stage}}$$

**2.4. INDISPENSABLE MORTALITY (IM):**

It is the mortality which would have not occurred, if the factor causing mortality is not permitted to function.

$$\text{IM} = \text{Number of adults emerged } \times \text{MSR of particular stage}$$

**2.5. K-Values:**

An increase or decrease in population from one generation to another is dependent on K-values. It is the difference between the logarithmic values of survivor number at each stage. The values of all stages will be summed up to get generation mortality (19).

$K = K_E + K_{L1} + K_{L2} + K_{L3} + K_{L4} + K_{L5} + K_P$

Where, $K_E$, $K_{L1}$, $K_{L2}$, $K_{L3}$, $K_{L4}$, $K_{L5}$ and $K_P$ are the K - values at the egg, first instar, second instar, third instar, fourth instar, and pupal stage.

**3. RESULTS AND DISCUSSION**

As expected, the survival fraction was decreased with increasing temperatures as more successful development was at lower temperature regimes. At the egg stage, the survival fraction was higher (0.87) at 28°C and lower (0.66) at 34°C (Table 1). Among the different larval instars, highest (0.90) survival fraction was recorded at 30°C for the fifth instar and the lowest (0.71) was recorded at 34°C for the fourth instar. At pupal stage, the highest (0.89) survival fraction was recorded at 28°C and the lowest (0.68) was observed at 34°C. The survival fraction remained higher for all the stages at lower temperature regimes (28°C and 30°C) and drastically reduced at a higher temperature regime of 34°C as the high temperature is more stressful and detrimental to the insects (20). It was also reported that the survival of the different stages of the Rice leaffolder (RLF) was greatly affected at 35°C. The upper temperature threshold for survival of this species appears to lie between 30 and 35 °C (21).

**Table 1. Survival fraction of rice leaffolder at different temperature regimes**

| **Stages** | **28°C** | **30°C** | **32°C** | **34°C** |
|---|---|---|---|---|
| Egg | 0.87 | 0.86 | 0.74 | 0.66 |
| 1st Instar | 0.82 | 0.84 | 0.80 | 0.73 |
| 2nd Instar | 0.80 | 0.83 | 0.77 | 0.78 |
| 3rd Instar | 0.80 | 0.88 | 0.76 | 0.84 |
| 4th Instar | 0.83 | 0.84 | 0.77 | 0.84 |
| 5th Instar | 0.87 | 0.90 | 0.80 | 0.71 |
| Pupa | 0.89 | 0.87 | 0.84 | 0.68 |

Higher temperature regimes contributed to higher apparent mortality (Table 2). The lowest (13.10) apparent mortality for the egg stage was observed at 28°C, whereas it was highest (34.25) at 34°C. When the comparison was made between larval instars, it showed that the lowest (10.14) apparent mortality was observed at 30°C for the fifth instar larva and the highest (29.17) was recorded at 34°C for the same. The apparent mortality for the pupal stage was observed to be lowest (10.91) at 28°C and highest (32.35) at 34°C. Apparent mortality increased towards the higher temperature regimes as it is just opposite to survival fraction, indicating the less tolerance of insects to higher temperature regimes (18,20,22).



**Table 2. Apparent mortality of rice leaffolder at different temperature regimes**

| Stages | 28°C | 30°C | 32°C | 34°C |
|---|---|---|---|---|
| Egg | 13.10 | 13.10 | 26.01 | 34.25 |
| 1st Instar | 18.49 | 18.49 | 20.31 | 26.89 |
| 2nd Instar | 20.17 | 20.17 | 22.55 | 21.84 |
| 3rd Instar | 20.00 | 20.00 | 24.05 | 16.18 |
| 4th Instar | 17.11 | 17.11 | 23.33 | 15.79 |
| 5th Instar | 12.70 | 12.70 | 19.57 | 29.17 |
| Pupa | 10.91 | 10.91 | 16.22 | 32.35 |
| Adult | 100.00 | 100.00 | 100.00 | 100.00 |

MSR for egg stage was minimum (0.15) at 28$^{o}$C and maximum (0.52) at 36$^{o}$C. When the larval stages were examined, it revealed that the lowest (0.11) MSR was observed at 30$^{o}$C for the second instar and the highest (0.41) at 34$^{o}$C for the fifth instar. At the pupal stage, the lower (0.12) MSR ratio was observed at 28$^{o}$C and the highest (0.48) MSR was observed at 34°C (Table 3). The results revealed that the population increase would be more at higher temperature regimes as the MSR remained higher at higher temperature regimes. The increase in MSR with increasing temperatures for all the stages and it is attributed to the decrease in the survival ($l_x$) with increasing temperature (20,23,24), as the MSR was the function of the $l_x$.

**Table 3. Mortality Survivor Ratio (MSR) of rice leaffolder at different temperature regimes**

| Stages | 28°C | 30°C | 32°C | 34°C |
|---|---|---|---|---|
| Egg | 0.15 | 0.16 | 0.35 | 0.52 |
| 1st Instar | 0.23 | 0.20 | 0.25 | 0.37 |
| 2nd Instar | 0.25 | 0.20 | 0.29 | 0.28 |
| 3rd Instar | 0.25 | 0.13 | 0.32 | 0.19 |
| 4th Instar | 0.21 | 0.19 | 0.30 | 0.19 |
| 5th Instar | 0.15 | 0.11 | 0.24 | 0.41 |
| Pupa | 0.12 | 0.15 | 0.19 | 0.48 |

IM at the egg stage was lower (7.38) at 28$^{o}$C and higher (11.38) at 34°C which indicated that the avoidable mortality was more at the higher temperature, if the factor (temperature) causing mortality was not allowed to operate. Among the larval stages, the IM was recorded lower (4.31) at 34°C for the fourth instar and higher (12.38) at 28°C for the second instar larva. The higher (11.00) IM was recorded for the pupal stage at 34°C and the lower (6.00) was recorded at both 28°C and 32°C (Table 4). As the number of adults emerged was less under higher temperature regimes, naturally the IM was lesser under higher temperature regimes as it was the function of the number of adults emerged (20). It was also observed that the IM remained higher for the egg stage at higher temperature regimes (34.3°C). This might be due to the higher MSR for the egg stage at higher temperature regimes (18,22).

**Table 4. Indispensable Mortality of rice leaffolder at different temperature regimes**

| **Stages** | **28°C** | **30°C** | **32°C** | **34°C** |
|---|---|---|---|---|
| Egg | 7.38 | 8.87 | 10.90 | 11.98 |
| 1st Instar | 11.12 | 10.61 | 7.90 | 8.46 |
| 2nd Instar | 12.38 | 11.03 | 9.03 | 6.43 |
| 3rd Instar | 12.25 | 7.24 | 9.82 | 4.44 |
| 4th Instar | 10.11 | 10.17 | 9.43 | 4.31 |
| 5th Instar | 7.13 | 6.10 | 7.54 | 9.47 |
| Pupa | 6.00 | 8.00 | 6.00 | 11.00 |

**Table 5. K values of rice leaffolder at different temperature regimes**

| **Stages** | **28°C** | **30°C** | **32°C** | **34°C** |
|---|---|---|---|---|
| Egg | 0.0610 | 0.1308 | 0.1308 | 0.1821 |
| 1st Instar | 0.0888 | 0.0986 | 0.0986 | 0.1360 |
| 2nd Instar | 0.0978 | 0.1110 | 0.1110 | 0.1070 |
| 3rd Instar | 0.0969 | 0.1195 | 0.1195 | 0.0766 |
| 4th Instar | 0.0815 | 0.1154 | 0.1154 | 0.0746 |
| 5th Instar | 0.0590 | 0.0946 | 0.0946 | 0.1498 |
| Pupa | 0.0502 | 0.0768 | 0.0768 | 0.1698 |
| Average | 0.0764 | 0.0658 | 0.1067 | 0.1280 |

Generally, K - values increased with increasing temperature. The K value for the egg stage was recorded lower (0.0610) at 28°C and higher (0.2150) at 36°C. During the larval instars, the lowest (0.0547) K value was recorded at 30°C for the third instar and highest (0.1714) at 36°C for the fourth instar. At the pupal stage, a higher (0.1698) K value was recorded at 34.3°C and a lower (0.0502) was observed at 28.3°C (Table 5). It revealed that the insects which happened to live under higher temperature regimes were reproduction oriented as most of the energy was spent in reproduction rather than spending it for living longer time (13,18,25). Generally RLF tends to be K favoring at a higher temperature rather than r favoring at a lower temperature.

**Conclusion**

The survival fraction remained higher for all the stages at lower temperature regimes and drastically reduced at a higher temperature regime of 34°C. The apparent mortality and Mortality Survivor Ratio increased with increasing temperatures, irrespective of the stage of an insect. The Indispensable Mortality was observed to be decreasing with increasing temperatures. Generally, leaffolder tends to be K favoring at higher temperature rather than r favoring at a lower temperature.



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