

**Stage specific life table of leaffolder, *Cnaphalocrocis medinalis* (Guen.) at different temperature regimes**

**Abstract**

The change in 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 adapted. 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 was decreasing with increasing temperatures as more successful development was at lower temperature regimes. Apparent mortality increased towards the higher temperature regimes as the insects are not able to 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 the most of the energy was spent in reproduction rather than for living longer time.

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

**Introduction**

IPCC in its recently released assessment report stressed that the climate change is rapid and unprecedented. 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 adapted. The change in temperature will influence the insect behavior, physiology and population dynamics of insects as they are poikilothermic. For every 10°C increase in temperature, insect metabolic rates will be doubled (2). So it is expected that the 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 slowed down as the temperature will be reaching upper threshold limit (3).

Life tables are 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 bug for all the stages have increased with increase in temperature and decreased after reaching the threshold temperature (12). Apparent mortality and survival fraction had negative relationships in case of ladybird beetle (13).

Rice leaffolder, severely damages plants by folding the leaves and ultimately leading to significant yield loss (7). Leaffolder can cause damage to leaves to the tune 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 insects 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.

### **Materials and Methods:**

Climate Control Chamber, 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 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.

### 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  $x$

### Survival fraction ( $S_x$ )

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

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

### Mortality survivor ratio (MSR)

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

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

### Indispensable mortality (IM):

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

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

### K-values:

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 (Southwood, 1978).

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

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

### Results and discussion

As expected, the survival fraction was decreasing with increasing temperatures as more successful development was at lower temperature regimes. At egg stage, 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 fifth instar and the lowest (0.71) was recorded at 34°C for fourth instar. At pupal stage, the highest (0.89) survival fraction was recorded at 28°C and 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 higher temperature regime of 34°C as the high temperature is more stressful and detrimental to the insects (19).

**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 for higher apparent mortality (Table 2). The lowest (13.10) apparent mortality for 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 fifth instar larva and the highest (29.17) was recorded at 34°C for the same. The apparent mortality for 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 (18,19,20).

**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°C and maximum (0.52) at 36°C. When the larval stages were examined, it revealed that the lowest (0.11) MSR was observed at 30°C for second instar and highest (0.41) at 34°C for fifth instar. At pupal stage, the lower (0.12) MSR ratio was observed at 28°C and 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 was 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 (19,21,22), 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 egg stage was lower (7.38) at 28°C and higher (11.38) at 34°C which indicated that the avoidable mortality was more at 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 fourth instar and higher (12.38) at 28°C for second instar larva. The higher (11.00) IM was recorded for pupal stage at 34°C and 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 (Aziz *et al.* (2013). It was also observed that the IM was remained higher for egg stage at higher temperature regimes (34.3°C). This might be due to the higher MSR for egg stage at higher temperature regimes (18,20).

**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 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 third instar and highest (0.1714) at 36°C for fourth instar. At pupal stage, higher (0.1698) K value was recorded at 34.3°C and 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 the most of the energy was spent in

reproduction rather than spending it for living longer time (13,18,23). Generally RLF tend to be K favoring at higher temperature from being r favoring at lower temperature.

## Conclusion

The survival fraction remained higher for all the stages at lower temperature regimes and drastically reduced at higher temperature regime of 34°C. The apparent mortality and Mortality Survivor Ration increased with increasing temperatures, irrespective of the stage of insect. The Indispensable Mortality was observed to be decreasing with increasing temperatures. Generally, leafhopper tend to be K favoring at higher temperature from being r favoring at lower temperature.

## References

1. Masson-Delmotte V, Zhai P, Pirani V, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis M.I, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B. (eds.). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2021.
2. Dukes JS, Pontius J, Orwig D, Garnas JRGR, Rodgers VL, Brazee N, Cooke B, Theoharides KATA, Stange EESE, Harrington R. Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict? This article is one of a selection of papers from NE Forests 2100: A Synthesis of Climate Change Impacts on Forests of the Northeastern US and Eastern Canada. Can. J. For. Res. 2009; 39: 231–248.
3. Deutsch CA., Tewksbury JJ, Tigchelaar M, Battisti DS, Merrill SC, Huey RB, Naylor RL. Increase in crop losses to insect pests in a warming climate. Science. 2018; 361: 916–919.
4. Manimanjari D, Rao S, Swathi M, Rao CAR, Vanaja M, Maheswari M. Temperature- and CO<sub>2</sub>-Dependent Life Table Parameters of *Spodoptera litura* (Noctuidae: Lepidoptera) on Sunflower and Prediction of Pest Scenarios. J. Insect Sci. 2014; 14(1): 2014, 297-303.

5. Ning S, Zhang W. and Sun Y. Development of insect life tables: comparison of two demographic methods of *Delia antiqua* (Diptera: Anthomyiidae) on different hosts. Sci Rep. 2017; 7: 4821- 4830.
6. Akkopru PE., Atlihan R., Okut H, Chi H. Demographic Assessment of Plant Cultivar Resistance to Insect Pests: A Case Study of the Dusky-Veined Walnut Aphid (Hemiptera: Callaphididae) on Five Walnut Cultivars. J. Econ. Entomol. 2015; 108(2): 1-10
7. Yang Y, Li W, Xie W. Development of *Bradysia odoriphaga* (Diptera: Sciaridae) as affected by humidity: an age–stage, two-sex, life-table study. Appl Entomol Zool. 2015; 50: 3–10.
8. Tuan S, Lee C, Chi H. Population and damage projection of *Spodoptera litura* (F.) on peanuts (*Arachis hypogaea* L.) under different conditions using the age-stage, two-sex life table. Pest manag. sci. 2014; 70(5): 805-813 .
9. Huang YB, Chi H. Age-stage, two-sex life table of *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) with a discussion on the problem of applying female age-specific life table to insect populations. Insect Sci. 2012; 19: 263–273.
10. Li W., Yang Y., Xie W., Wu Q., Xu B., Wang S., Zhu X., Wang S, Zhang, Y. Effects of Temperature on the Age-Stage, Two-Sex Life Table of *Bradysia odoriphaga* (Diptera: Sciaridae). J. Econ. Entomol. 2015; 108(1):126-134.
11. Khan J, Khan A, Ahmed N. Age and stage-specific life table parameters of *Harmonia dimidiata* (Coleoptera: Coccinellidae) fed on *Rhopalosiphum padi* (Hemiptera: Aphididae) at different temperatures. Egypt J. Biol. Pest Control. 2022; 32: 113-122.
12. Tian XY, Gao Y, Ali MY, Li XH, Hu YL, Li WB, Wang ZJ, Sh SS, Zhang JP. Impact of Temperature on Age–Stage, Two-Sex Life Table Analysis of a Chinese Population of Bean Bug, *Riptortus pedestris* (Hemiptera: Alydidae). Agriculture. 2022; 12(9):1505-1519.
13. Ali A, Rizvi PQ. Age and stage specific life-table of *Coccinella transversalis* with regards to various temperatures. Tunis. J. Plant Prot. 2009; 4: 211-219.
14. Chhavi, Srivastava A, Sharma PK. Assessment of yield losses of rice caused by paddyleaf folder, *Cnaphalocrocis medinalis* Guenee. Agric. Sci. Digest. 2017; 37: 72-74.

15. Savary S, Willocquet L, Elazegui FA, Castilla N, Teng PS. Rice pest constraints in tropical Asia: quantification of yield losses due to rice pests in a range of production situations. *Plant Dis.* 2000; 84: 357-369.
16. Waldbauer GP, Marciano AP. Rice leaf folder: Mass rearing and A proposal for screening for varietal resistance in the green house. IRRI Research paper series No 27. IRRI. 1979.
17. Iranipour S, Pakdel AK, Radjabi G. Age specific mortality and temperature dependent development of immature stages of sunn-pest, (*Eurygaster integriceps* Put.) (Het., Scutelleridae) in four constant temperatures. *Appl. Entomol. Phytopathol.* 2003; 70: 1–17.
18. Ali A, Rizvi PQ. Age and stage specific life table of *Coccinella septempunctata* (Coleoptera: Coccinellidae) at varying temperature. *World J Agric Sci.* 2010; 6(3): 268–273
19. Aziz MA, Iftkhar A, Hanif M. Life table studies of *Trilocho virescence* (bombycidae: lepidoptera) on *Ficus nitida*. *Asian J Agri Biol.* 2013; 1(1): 2-7.
20. Katsarou I, Margaritopoulos JT, Tsitsipis JA, Perdikis DC, Zarpas KD. Effect of temperature on development, growth and feeding of *Coccinella septempunctata* and *Hippodamia convergens* reared on the tobacco aphid, *Myzus persicae nicotianae*. *Bio Control.* 2005; 50: 565-588.
21. Butler GD. Development time of *Coccinella septempunctata* in relation to constant temperatures (Coleoptera: Coccinellidae). *Entomophaga.* 1982; 27: 349-353.
22. Rai MK, Ramamurthy VV, Singh PK. Biological attributes and morphometrics of *Coccinella septempunctata* (L.) (Coleoptera: Coccinellidae). *Ann. Pl. Protec. Sci.* 2002; 10: 194-197.
23. Omkar and Pervez A. Temperature dependant development and immature survival of an aphidophagous ladybeetle, *Propylea dissecta* (Mulsant). *J. Appl. Entomol.* 2004; 128: 510- 514.