

POPULATION DYNAMICS OF THE RICE LEAF FOLDER CNAPHALOCROCIS MEDINALIS GUENEE: A LIFETABLE STUDY

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ABSTRACT

The rice leaf folder *Cnaphalocrocis medinalis* Guenee has become a major concern, causing outbreaks in various parts of India. A lifetable study was conducted to analyze the growth, survival, reproduction, and mortality of *C. medinalis*, aiming to determine the weakest lifestages and unravel its population dynamics. The study observed the highest survival rate at the fourth-instar larval stage and the lowest during the egg and first-instar larval stages. A population trend index of 5.9 was observed, indicating significant population growth.

Key words: Cnaphalocrocis medinalis, rice, lifetable, developmental stages, survival, mortality, k value, weakest lifestage, population trend index, population dynamics, IPM, larval instars, population trend index

Rice (Oryza sativa) is one of the important cereal crops in India, cultivated over an area of 46.4 m ha with a production of 130.29 mt during 2021-22 (DAC, 2023). However, rice cultivation is prone to substantial environmental stresses, with biotic stress causing 52% of annual production loss, of which 21% is caused by insects (Tenguri et al., 2023). Amongst the insect pests attacking rice, the rice leaf folder Cnaphalocrocis medinalis Guenee (Lepidoptera: Pyralidae) is a predominant defoliator and perhaps one of the most debilitating pests (Luo, 2010). From the second instar onwards, the larvae build their shelter by folding the leaf longitudinally and attaching its margins with silk strands. The larvae feed on the mesophyll tissue of the leaf, resulting in longitudinal white streaks. Even a single larva can harm multiple rice leaves, and this damage can add up and reduce photosynthesis. Ultimately, this can result in decreased crop yield. The rice leaf folder, formerly considered a minor pest, has attained major pest status, causing population outbreaks in recent decades in various parts of India (Singh et al., 2017). The infestation often lasts throughout the crop cycle, severe during the reproductive and ripening stages. Understanding the insect behavioral ecology and the various mortality factors influencing their population will enhance our abilities to effectively manage pest populations. However, studying the rice leaf folder has proven challenging due to difficulties in its laboratory breeding (Jian et al., 2012).

A lifetable is an effective tool for comprehending the growth, development, mortality, and survival of insects for ecological studies. It divides the insect life cycle into several time periods or developmental stages and provides an extensive overview of its birth, death, and dispersal under varying conditions (Schowalter, 2016). The parameters used in the lifetable help in detecting fluctuations in insect populations at various stages of development and throughout their lifecycles (Kakde et al., 2014). A cohort lifetable or an age-dependent lifetable takes account of the mortality experience of a particular cohort from its time of birth till the death of the last individual (Carey, 2001). Along with the lifetable analysis, the population trend index is invaluable for understanding, analyzing, and predicting population dynamics. Hence, a lifetable study was undertaken to elucidate the mechanisms of population change of C. *medinalis* and to determine their weakest lifestages.

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MATERIALS AND METHODS

The culture of *C. medinalis* was initiated with field collected adults and maintained at the climate control facility at the Division of Entomology, Indian Agricultural Research Institute (IARI), New Delhi, India (28°38'N, 77°09'E). The relative temperature and humidity were maintained at 27± 1°C and 70± 5% respectively. The rearing method and culture maintenance were followed as per Chintalapati et al. (2015). Study was conducted

for five generations under laboratory conditions, and the following parameters were recorded or derived for the construction of the age-specific lifetable (Southwood and Henderson, 2000; Carey, 2001). x- developmental stage of the insect; lx- No of insects living at a particular stage; dx- No of insects among lx insects which will die before reaching the next stage (x+1);100 qx- % of insects that will die before reaching the next stage; sxthe probability that an insect will survive till the next stage; Lx- the average number of insects living between stage x and x+1; Tx- total number of alive insects from stage x to x+1; ex- average life expectancy. The k value or key factor (k), a measure of mortality, was calculated using the method outlined by Ali and Rizvi (2010), where k = log(lx) - log(lx+1). Population trend index (I), which measures the potential of population growth between two consecutive generations, was calculated by following the formulae $I = G_2 / N_E$ (Padmavathi et al., 2013), where N_E is the initial number of eggs and G_2 is the expected fecundity of the next generation, which can be calculated with the equation, $G_2 = A*P_F*F_X$ (A-Number of adults; P_F- Average fecundity per female; F_x- the ratio of females). Statistical analysis was performed using (SPSS, Version 16, Sept 13, 2007). A one-way ANOVA was carried out to compare the variations among various population parameters and their means were categorized into homogenous groups and compared using Tukey's test (p=0.05).

RESULTS AND DISCUSSION

The pooled lifetable data of *C. medinalis* showed significant differences among the parameters under study (Table 1). The study showed that although 65.2% of the eggs (358.2) hatched into first instar larvae (233.6), of which only 17.6% could reach up to the adult stage (63), with the highest occurrence of death during the egg stage (124.6). The mortality was found to be highest during the egg stage (34.73%), which was on par with the

mortality of first instar larvae (26.41%), while survival was observed to be higher in the later developmental stages. The life expectancy was found to be highest at the second instar larvae (3.9), which was on par with the first (3.7), and third instar larvae (3.7). Earlier a high rate of egg mortality had been reported as a common trait (Cuthbertson et al., 2013) and among Lepidopteran insects' mortality during the early larval stages is typically significant (Soufbaf et al., 2010). Similar to the present study, Park et al. (2014) reported high egg mortality (43%); and Jian et al. (2012) and Manikandan et al. (2023) reported high early larval mortality and pupal survival while rearing C. medinalis at 27 ± 1 °C on rice leaves. The results observed by Ankit et al. (2016) are also in line with the present study in terms of egg hatching (63.45%), while higher pupation (56.66%) was reported, which might be due to the varietal difference or variation in the temperature and humidity conditions of rearing. Hasan and Ansari (2011) also reported 70-93% mortality of larval stages and only 6-29 % adult emergence in *Pieris brassicae*. Similar higher mortality during initial developmental stages was reported in Tuta absoluta by Cuthbertson et al. (2013).

The present study revealed a k value of 0.19 for the egg stage, which was on par with the k value of the first instar larvae (0.13). The k-value for the remaining developmental stages ranged between 0.06 and 0.09. K-value has been found as the key factor that determines the growth or decline of the population (Ali and Rizvi, 2010) and it allows the evaluation of mortalities at different stages of the lifecycle. A similar study conducted by Marina et al. (2019) observed a highest k value of 0.125 for the first instar larvae of *C. medinalis*, indicating the highest mortality. Ali and Rizvi (2010) and Pereira et al. (2007) also observed higher k values during the initial developmental stages of ladybird beetle and coffee leaf miner, respectively. The population trend index was observed as 5.9, which

Table 1. Stage-specific lifetable for *C. medinalis* reared on rice (pooled data)

X	lx	dx	100qx	SX	Lx	Tx	ex	k value
egg	358.2 ± 8.4^{a}	124.6 ± 6.9^{a}	34.73 ± 1.4^{a}	$0.65 \pm 0.01^{\circ}$	295.9 ± 6.3^{a}	1166.9± 41.8a	3.3 ± 0.15^{bc}	0.19± 0.01a
L1	233.6 ± 5.9^{b}	62 ± 9.9^{b}	26.41 ± 4.1^{ab}	0.74 ± 0.04^{cb}	202.6 ± 6.1^{b}	871 ± 42.3^{b}	3.7 ± 0.18^{a}	0.13 ± 0.03^{ab}
L2	$171.6 \pm 9.4^{\circ}$	$32.6 \pm 1.4^{\circ}$	19.24 ± 1.2^{bc}	0.81 ± 0.01^{ba}	$155.3 \pm 9.2^{\circ}$	$668.4 \pm 36.7^{\circ}$	3.9 ± 0.03^{a}	0.09 ± 0.01^{bc}
L3	139.0 ± 9.0^{cd}	$20.8 \pm 2.7^{\circ}$	14.7± 1.1°	0.85 ± 0.01^{a}	128.6 ± 7.8^{cd}	513.1 ± 27.6^d	3.7 ± 0.06^{ab}	0.07 ± 0.01^{c}
L4	118.2 ± 6.6^{de}	$14.8 \pm 1.6^{\circ}$	$12.3 \pm 0.9^{\circ}$	0.88 ± 0.01^{a}	110.8 ± 5.9^{de}	384.5 ± 19.9^{de}	3.3 ± 0.02^{c}	0.06 ± 0.00^{c}
L5	103.4 ± 5.2^{ef}	$17.2 \pm 0.7^{\circ}$	$16.7 \pm 0.3^{\circ}$	0.83 ± 0.0^a	94.8 ± 4.8^{ef}	273.7 ± 14.0^{ef}	2.6 ± 0.01^{d}	$0.08 \pm 0.00^{\circ}$
Pre-Pupa	$86.2 \pm 4.5^{\rm efg}$	13.4± 1.3°	$15.5 \pm 0.9^{\circ}$	0.85 ± 0.01^{a}	$79.5 \pm 4.0^{\rm f}$	178.9 ± 9.2^{fg}	2.1 ± 0.01^{e}	0.07 ± 0.01^{c}
Pupa	72.8 ± 3.6^{fg}	9.8 ± 0.4^{c}	$13.6 \pm 0.7^{\circ}$	0.86 ± 0.01^a	$67.9 \pm 3.5^{\rm f}$	99.4 ± 5.2^{gh}	$1.4 \pm 0.01^{\rm f}$	0.06 ± 0.01^{c}
Adult	63 ± 3.4^{g}	-	-	-	31.5 ± 1.7^{g}	31.5 ± 1.7^{h}	-	-
F value	165.729	61.826	16.156	15.921	147.623	162.71	88.292	15.094
p value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

indicated that the population would increase 5.9 times after one generation. A population trend index can be considered as a measure to forecast the population size, wherein an index value of >1 indicates the growth of the population, and a value of <1 points toward its suppression as opined earlier (Cui et al., 2018). Similar to our study, the population trend index study on the C. medinalis population was conducted by researchers like Jian et al. (2012) and Padmavathi et al. (2013) and both of them revealed an index value >1, which shows the potential for the buildup of the population in the upcoming generation. Life table analysis, coupled with population trend indices, provide valuable insights into the growth, survival, reproduction, and mortality patterns of the rice leaf folder population. It can aid in predicting the potential population buildup as well as in identifying the weakest lifestage for implementing targeted control measures.

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AUTHOR CONTRIBUTION STATEMENT

APS and SC conceived and designed the research. APS, SR, PT, and YY conducted experiments. APS, SC, and SR analyzed data. APS and SC wrote the manuscript. All authors read and approved the manuscript

CONFLICT OF INTEREST

No conflict of interest.

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