Journal of Experimental Biology and Agricultural Sciences, June - 2025; Volume – 13(3) page 355 – 363

Journal of Experimental Biology and Agricultural Sciences

http://www.jebas.org

ISSN No. 2320 – 8694

Life Table and Demographic Parameters of *Helopeltis theivora* Waterhouse (Hemiptera: Miridae)

Shovon Kumar Paul[1,2], Nur Azura Adam[1,3*], Syari Jamian[1], Anis Syahirah Mokhtar[1]

[1]Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[2]Entomology Division, Bangladesh Tea Research Institute, Bangladesh Tea Board, Sreemangal-3210, Moulvibazar, Bangladesh
[3]Southeast Asian Regional Center for Graduate Study and Research in Agriculture, Los Baños, Laguna, Philippines

Received – March 09, 2025; Revision – June 03, 2025; Accepted – June 20, 2025
Available Online – July 15, 2025

DOI: http://dx.doi.org/10.18006/2025.13(3).355.363

KEYWORDS

Tea

Helopeltis theivora

Life table

Survivorship

Demographic parameters

Cohorts

ABSTRACT

Helopeltis theivora is a significant pest of tea, causing economic losses through direct feeding damage to tender shoots in various tea-growing regions of Asia, including Malaysia. Understanding the population dynamics of this pest through life table analysis and demographic parameters is essential for identifying critical stages in its life cycle that influence population growth. Therefore, this study aimed to construct life tables and demographic parameters to assess the population dynamics of *H. theivora* on tea shoots. The experiment was conducted under controlled laboratory conditions at a temperature of 25 ± 1°C, a relative humidity of 70 ± 5%, and a 12:12 h light-dark photoperiod, using three cohorts of *H. theivora*, each consisting of 103, 105, and 113 one-day-old eggs. Observations were recorded daily on survival, mortality, and fecundity for each cohort to construct age-specific life tables and determine key demographic parameters. The life table analysis revealed that *H. theivora* exhibited a Type III survivorship curve, characterized by high mortality during the early developmental stages. The first instar nymphs experienced the highest mortality rate (22.47%), corresponding to a K-value of 0.111, indicating that this stage is crucial for managing the *H. theivora* population. Life expectancy (ex) for *H. theivora* decreased gradually as the individuals grew and developed. Overall, 40.81% of individuals reached adulthood, with a female-biased sex ratio of 1.0:0.92 (female to male). Female emergence began on day 23, while the last female died on day 69. Oviposition commenced on day 27 and continued until day 65, with a peak in egg-laying observed between days 34 and 45, accounting for 58.32% of the total egg production. On average, a female lived for 38.60 ± 1.60 days and laid approximately 160.47 ± 16.33 eggs during her lifetime. Demographic analysis revealed a high reproductive potential,

* Corresponding author
E-mail: nur_azura@upm.edu.my (Nur Azura Adam)

Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

with a net reproductive rate (R_0) of 29.56 female offspring per female per generation, a mean generation time (Tc) of 38.68 days, an intrinsic rate of natural increase (r_m) of 0.09 offspring per female per day, a finite rate of increase (λ) of 1.09 female offspring per female per day, and a population doubling time (DT) of 7.92 days. The results of this study indicate that management strategies should be implemented during the early nymphal stages, particularly during the first instar, to suppress the *H. theivora* population effectively.

1 Introduction

Helopeltis theivora Waterhouse (Hemiptera: Miridae), commonly known as the tea mosquito bug, is a polyphagous insect pest that causes significant economic losses in both yield and quality in tea-growing regions of tropical and subtropical Asia, including Malaysia (Bharathi et al. 2024; Naskar et al. 2025). The adults and nymphs of this pest feed by sucking cell sap from young leaves, tender stems, and buds, which are critical for tea production (Borthakur and Bora 2023; Yao et al. 2025). Infested shoots develop numerous sucking spots, causing them to curl, dry out, and turn black. In severe cases of infestation, the bushes may cease to produce new shoots, and affected areas can remain without new growth for weeks (Yao et al. 2025). Crop loss due to this pest can range from 10% to 50%, with the risk of total crop loss if timely and effective management strategies are not implemented (Borthakur and Bora 2023; Das et al. 2024). Tea is one of *H. theivora's* preferred host plants; however, this pest is also known to damage various economically important plants, including coffee, cocoa, cashew, acacia, pepper, and camphor. Additionally, it can complete its life cycle on various weed species that serve as alternative hosts (Bharathi et al. 2024; Yao et al. 2025).

Life tables are valuable resources for studying the growth, survival, and reproductive behaviours of insect species (Zhang et al. 2023; Liu et al. 2025). While life tables and demographics are related, they are not identical. Demographic studies focus on the quantitative aspects of populations, specifically the relationships between population growth, resilience, and mobility (Zhai et al. 2025). Therefore, life tables and demographic parameters are critical for identifying the leading causes of high mortality rates in populations (Chen et al. 2025; Zhai et al. 2025). Moreover, these parameters are vital for developing ecological pest management strategies by integrating various biological factors such as development, survival, and fecundity to assess their collective impact on population growth (Ribeiro et al. 2022; Pelli et al. 2023; Chen et al. 2025). Ecologists typically use two forms of life tables: age-specific and time-specific. The age-specific, or horizontal, life table tracks a real cohort of individuals of the same age from birth to death. In contrast, the time-specific, or vertical, life table involves periodic sampling of a population under the assumption of a stable age structure, with vital rates inferred using mathematical models (Gómez 2023).

Despite the economic significance of *H. theivora* as a major pest in Malaysian tea production, comprehensive life table studies on this species remain limited. In contrast, life table analyses of *Helopeltis* species have been conducted on various host plants in other countries (Izzati et al. 2023; Jakkoksung et al. 2023; Zhai et al. 2025), providing valuable demographic insights that have directly informed pest control strategies. Consequently, the absence of life table data for *H. theivora* in Malaysian tea plantations represents a significant research gap. This study aims to develop a life table and analyze the demographic parameters of *H. theivora*. The findings will help bridge existing knowledge gaps and contribute to improved pest management practices for *H. theivora* in the tea ecosystem.

2 Materials and Methods

2.1 Construction of life table

The life table was created by adapting and modifying procedures from Izzati et al. (2023) and Liu et al. (2025) based on survivorship and fecundity studies from three cohorts. A cohort refers to individuals of the same species that are born or hatched during the same period and are subsequently observed throughout their entire lifespan (Jayanth et al. 2025; Liu et al. 2025). This cohort serves as a standardized unit for demographic analysis, enabling precise estimation of vital population parameters. The cohort method is particularly valuable for species with discrete generations and is widely utilized in entomological studies to inform population modeling and pest management strategies (Gomez 2023; Pelli et al. 2023). The experiments were conducted in the Insectary of the Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, under conditions of 25°C ± 1°C temperature and 70% ± 5% relative humidity, with a 12:12-hour photoperiod from June to October 2020.

2.1.1 Survivorship study

Three cohorts of one-day-old eggs, comprising 103, 105, and 113 eggs, were used to investigate the survivorship of *H. theivora* from egg to adult. The eggs were sourced from a stock culture maintained in the insectary. Tea shoots bearing the eggs were placed into water-filled glass vials (28 ml), with approximately 10-15 eggs per rearing cage, measuring 29 x 19 x 18 cm. Each cage was properly labeled with the date of the first-day egg, cohort number, and the total number of eggs. Once the first instar nymphs emerged, they were provided with fresh tea shoots. The tea shoots were replaced daily throughout the observation period, and the nymphs were fed until they matured into adults. The survival and mortality rates of eggs, nymphs, and adults were monitored and recorded daily. Observations and counts were conducted using a magnifying glass for the eggs and all nymphal stages. For adults, the observation process was done with the naked eye, as their size is easily visible.

2.1.2 Fecundity study and adult longevity

The fecundity study involved fifteen pairs of one-day-old adult *H. theivora*, with each cohort consisting of five pairs. Each pair of adult males and females was housed in a cage measuring 30 x 30 x 44 cm, which contained tea shoots placed in a glass vial filled with water, serving as both oviposition sites and food for the adults. The shoots with eggs were collected daily and counted using a magnifying glass. Fresh tea shoots were provided every day as oviposition sites for the female *H. theivora*. The eggs deposited by each female were counted and recorded daily until the individual died. The study documented the adult longevity of both males and females, as well as the pre-oviposition, oviposition, fecundity, and post-oviposition durations for the females of *H. theivora*.

2.2 Data analysis

Three cohorts (three replications) were utilized to record the survival and mortality rates of eggs, nymphs, and adults of *H. theivora*. Additionally, the following parameters were assessed for five pairs (five replications) from each cohort: adult longevity, pre-oviposition period, oviposition period, fecundity, and post-oviposition period. A paired t-test was conducted using SAS version 9.4 to compare adult longevity between males and females.

Table 1 Formula and definition of different demographic and life table parameters

Parameter	Definition	Formula	Reference
x	The age interval is measured in days or developmental stages.		Roseli et al. (2019)
l_x	The percentage of individuals alive at the start of a given age interval is denoted by the fraction of individuals still alive during that interval		Chen et al. (2024)
L_x	The mean number of individuals alive between age x and x+1	$(l_x + l_{x+1})/2$	Mohamed et al. (2019)
d_x	The total number of dead individuals in a specific age interval x		Mohamed et al. (2019)
100_{qx}	The percentage of apparent mortality	$(d_x/l_x)100$	Roseli et al. (2019)
S_x	The rate of survival in a specific developmental stage		Chen et al. (2024)
T_x	The total number of individuals that are still alive at age x and beyond	$L_x + L_{x+1} \ldots L_{x+n}$	Izzati et al. (2023)
e_x	Individuals life expectancy of at age x	T_x/l_x	Izzati et al. (2023)
m_x	The average number of female eggs laid per female at age x		Izzati et al. (2023)
R_o	Net reproductive rate	$\sum l_x m_x$	Chen et al. (2024)
T_c	Mean generation time in days- the time between the birth of an individual and the birth of its offspring	$\sum x l_x m_x / \sum l_x m_x$	Chen et al. (2024)
r_m	The intrinsic rate of natural increase	lnR_o/T_c	Chen et al. (2024)
λ	Finite rate of increase, the number of female offspring per female per day	e^{rm}	Chen et al. (2024)
DT	The population doubling time is the time it takes for a population to double in size	$ln2/r_m$	Ribeiro et al. (2022)
GRR	The gross reproduction rate, representing the theoretical natality rate of a female organism over its lifespan	$\sum m_x$	Izzati et al. (2023)
Pre-oviposition period	The time from the final molt to the first egg-laying		Roseli et al. (2019)
Oviposition period	Duration from the first reproduction to the last reproduction.		Mohamed et al. (2019)
Post-oviposition period	The time from the final reproductive event to the individual's death.		Roseli et al. (2019)
Fecundity	Total number of eggs laid by females during their lifetime.		Mohamed et al. (2019)
Daily reproduction	The average daily production of eggs over a female's lifetime		Roseli et al. (2019)
Female longevity	The lifespan of a female		Mohamed et al. (2019)
Male longevity	The lifespan of a male		Mohamed et al. (2019)

The other parameters, including pre-oviposition, oviposition, post-oviposition periods, and fecundity, were analyzed to calculate the arithmetic mean and standard error (SE). Daily survival, mortality, and fecundity data from each cohort were collected to determine the life table parameters and population age structures. Data analysis was performed using Microsoft Excel 2019. The symbols, formulas, and definitions used for the life table parameters and other calculations are summarized in Table 1, which serves as a reference for interpreting the results.

3 Results

3.1 Age-specific survival life table for *H. theivora*

Figure 1 illustrates the survivorship pattern of *H. theivora* across three separate cohorts reared on tea shoots. The results revealed consistent trends in developmental success and stage-specific mortality for this insect. The survivorship curve (lx) showed a steep decline during the early life stages, followed by a more gradual reduction as the individuals aged. This pattern indicates a Type III survivorship, characterized by high early-stage mortality, with survival probabilities stabilizing for those individuals that progress beyond the initial vulnerable stages. Egg hatchability was high across all cohorts, ranging from 80.95% to 85.84%, with first-instar nymphs emerging on day 8 in all groups. Adult emergence rates varied among cohorts, with 35.24% to 45.13% of individuals reaching adulthood, and sex ratios ranging from 1:0.85 to 1:0.96 (female: male). The first instar consistently exhibited the highest mortality rate across all cohorts, ranging from 17.65% to 27.06%, followed by the egg and second instar stages. Mortality progressively decreased in the later instars, with the fifth instar exhibiting the lowest mortality rates, ranging from 5.13% to 8.51%. Adult female emergence began between days 23 and 24, with the last recorded adult female death occurring between days 60 and 69.

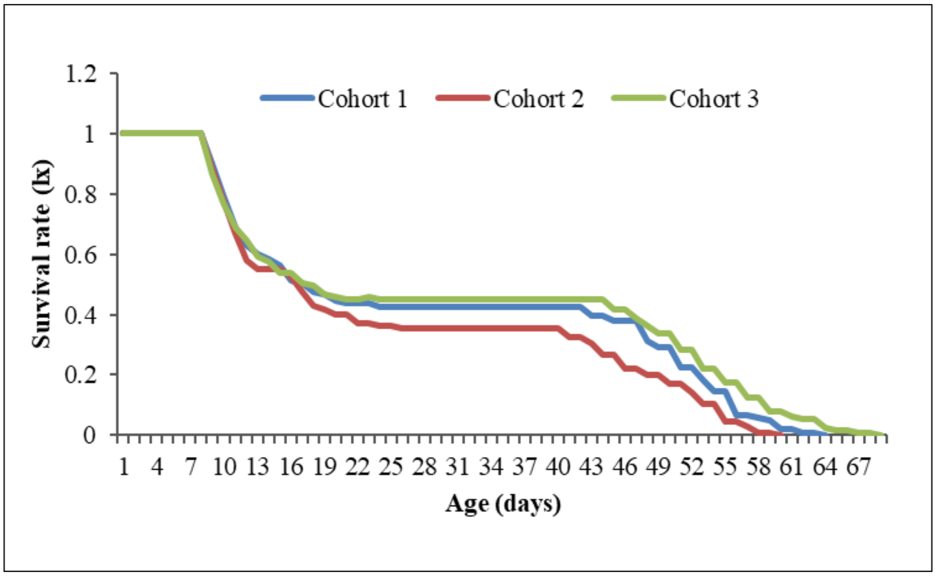

Figure 1 Survival curves for three cohorts of *H. theivora* cultured on tea shoots.

Table 2 Stage-specific pooled life table of *H. theivora*

Growth Stage (x)	lx	Lx	dx	100qx	Sx	Tx	ex	K-value
Egg	321	294.00	54	16.82	83.18	1228.50	4.179	0.080
Nymph								
1st instar	267	237.00	60	22.47	77.53	934.50	3.943	0.111
2nd instar	207	189.00	36	17.39	82.61	697.50	3.690	0.083
3rd instar	171	161.50	19	11.11	88.89	508.50	3.149	0.051
4th instar	152	146.00	12	7.89	92.11	347.00	2.377	0.036
5th instar	140	135.50	9	6.43	93.57	201.00	1.483	0.029
Adult	131	65.50						

Adult sex ratio (Female: Male) = 1.0:0.92

Table 2 presents pooled data from a life table study of *H. theivora*, focusing on three cohorts reared on tea shoots. Out of 267 eggs hatched, there was a progressive reduction in survival rates through various developmental stages. Ultimately, 40.81% of the individuals reached the adult stage, comprising 63 males and 68 females, resulting in an average sex ratio of 1.0:0.92 (Female: Male). The first instar nymph exhibited the highest stage-specific mortality at 22.47%, along with the largest K-value of 0.111, indicating it is the most vulnerable stage. This was followed by the second instar, with a mortality rate of 17.39% (K = 0.083), and the egg stage, at 16.82% (K = 0.080). Subsequent stages showed lower mortality rates and corresponding K-values. Notably, the fifth instar had the lowest mortality rate at 6.43% (K = 0.029). These findings emphasize the first instar as the most critical stage affecting population dynamics, making it a key target for pest management interventions.

3.2 Age-specific fecundity table for *H. theivora*

Figure 2 illustrates the age-specific survival (l_x) and fecundity (m_x) patterns of *H. theivora* plotted against age in days. The l_x curve shows a gradual decline over time, reaching nearly zero by day 67. The m_x curve begins on day 27 and continues until day 65, indicating the reproductive activity of adult females. Female emergence initially occurred on day 23, with the last recorded mortality on day 69. Oviposition began on day 27, just four days after females started emerging, and continued until day 65. The peak egg-laying activity was observed between days 34 and 45, accounting for 58.32% of the total fecundity. In contrast, the lowest oviposition rate (2.88%) was recorded between days 60 and 66. These findings suggest that females exhibit a concentrated reproductive effort early in the oviposition period, followed by a gradual decline in fecundity as they age.

Table 3 presents key demographic parameters that quantify the population growth potential of *H. theivora*. The gross reproduction rate (GRR) is estimated to be 82.05 offspring per female per generation, indicating a high reproductive potential. The net reproduction rate (R_0) is 29.56 female offspring per female per generation, reflecting a substantial potential for population increase. The mean generation time (T_c) is calculated to be 38.68 days, representing the average interval between generations. The intrinsic rate of natural increase (r_m) is 0.09 offspring per female

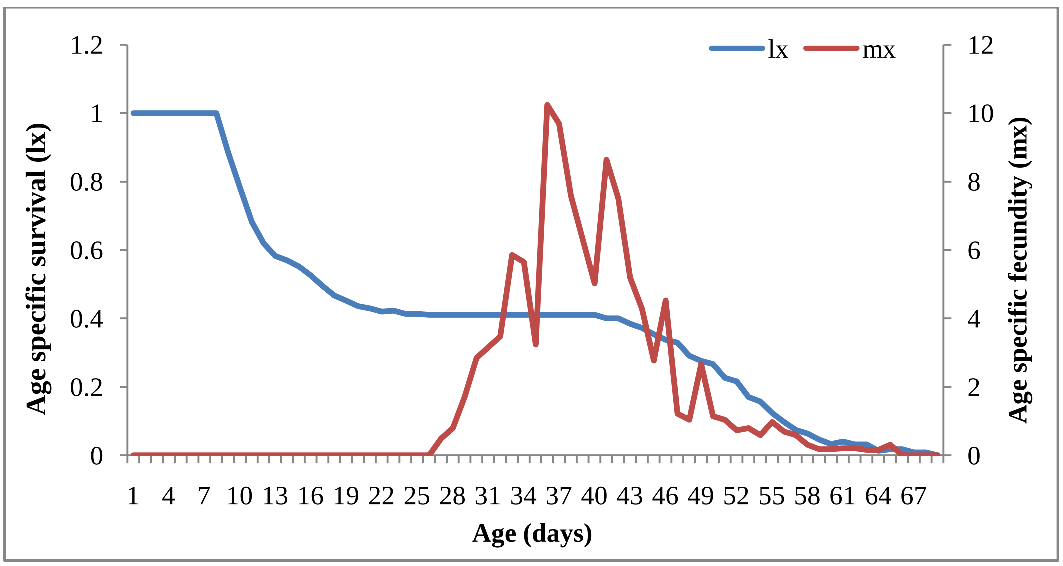

Figure 2 Daily age-specific survival (l_x) and fecundity (m_x) of female *H. theivora*

Table 3 Population growth parameters of *H. theivora*

Parameter	Values
Gross reproduction rate (GRR) (offspring per female per generation)	82.05
Net reproduction rate (R_o) (female offspring per female per generation)	29.56
Mean generation time (T_c) (days)	38.68
The intrinsic rate of natural increase (r_m) (offspring per female per day)	0.09
Finite rate of increase (λ) (female offspring/female/day)	1.09
Doubling time (DT) (days)	7.92

Table 4 Adult longevity, oviposition period, and fecundity of *H. theivora*

Parameter	Mean ± SE
Pre-oviposition period (days)	4.40 ± 0.21
Oviposition period (days)	29.87 ± 1.16
Post-oviposition period (days)	3.60 ± 0.13
Male longevity (days)	30.33 ± 1.18b
Female longevity (days)	38.60 ± 1.60a
Daily eggs (eggs/female/day)	5.31 ± 0.42
Fecundity (eggs/female)	160.47 ± 16.33

Means with the same letters are not significantly different at P>0.05

per day, signifying positive population growth ($r_m > 0$) under ideal conditions. Correspondingly, the finite rate of increase (λ) is 1.09 female offspring per female per day, indicating the growth factor per unit of time. The doubling time (DT) is calculated to be 7.92 days, meaning the population could double in size in just over a week under suitable conditions. These demographic parameters collectively highlight the high reproductive potential and rapid population growth of *H. theivora* when environmental conditions are favorable.

3.3 Fecundity, adult longevity, pre-oviposition period, and oviposition period of *H. theivora*

Table 4 presents a detailed analysis of the reproductive characteristics and longevity of *H. theivora* under controlled laboratory conditions. The pre-oviposition period was recorded at an average of 4.40 ± 0.21 days, indicating a relatively short phase preceding reproductive activity. The oviposition period, on the other hand, was significantly longer, averaging 29.87 ± 1.16 days, which suggests that females remained reproductively active for a considerable duration. The post-oviposition period was brief, with a mean duration of 3.60 ± 0.13 days, marking the final stage of the female life cycle when egg-laying ceases. Longevity analysis showed a significant difference ($T = 4.37$; $df = 14$; $P < 0.05$) between the sexes. Females had a longer lifespan, averaging 38.60 ± 1.60 days, compared to males, who lived an average of 30.33 ± 1.18 days. This difference suggests that females have the potential for extended reproductive activity. Additionally, the mean daily oviposition rate was recorded at 5.31 ± 0.42 eggs per female, resulting in an overall fecundity of 160.47 ± 16.33 eggs per female throughout the reproductive period.

4 Discussion

In this study, higher mortality rates were observed during the early developmental stages of *H. theivora*, which gradually declined in later stages until all individuals eventually died. Analysis of the survivorship curves for the three cohorts indicates that *H. theivora* exhibits a Type III survivorship pattern. This finding aligns with the classification proposed by Campbell et al. (2025) and Izzati et al. (2023), who noted that a Type III survivorship curve typically indicates a higher mortality rate during the early stages of an insect's life cycle. Similar survivorship patterns have been documented in previous life table studies of *H. theivora* on tea (Roy et al., 2015) and swamp weed (Srikumar et al., 2016), which supports the current findings.

The sex ratio is a crucial biological parameter for assessing population growth rates, and the present study revealed a female-biased trend. A predominance of females enhances reproductive output and accelerates population growth (Simanjuntak et al. 2022; Izzati et al. 2023). The estimated stable age distribution (Lx) values for different growth stages of *H. theivora* in this study are comparable to those reported by Simanjuntak et al. (2022), who provided Lx values for *H. bradyi* across various life stages: eggs, 1st, 2nd, 3rd, 4th, 5th instar nymphs, and adults were 283.0, 230.5, 185.0, 154.5, 126.0, 112.0, and 55.0, respectively. In this investigation, life expectancy (ex) values decreased as the age of individuals increased. This trend is consistent with the findings of Campbell et al. (2025) and Izzati et al. (2023), who noted that ex values progressively declined with age in laboratory experiments under non-stress conditions.

In the present study, the first instar nymph of *H. theivora* recorded the highest K-value, indicating their critical role in population regulation. The high mortality observed at this stage may be attributed to physiological vulnerabilities and developmental instability common to early nymphal instars (Simanjuntak et al. 2022; Izzati et al. 2023). Additionally, the daily handling and counting required for survival assessments may have caused mechanical injury and stress, further increasing mortality rates during this stage (Simanjuntak et al. 2022). Inadequate laboratory ventilation, which hinders gas and heat exchange, may also contribute to the high mortality rates in the early instar stages (Mohamed et al. 2019). Conversely, the fifth instar nymph exhibited the lowest K-value, likely due to its larger size and superior physical and physiological capabilities compared to earlier instars. Roseli et al. (2019) reported that advanced instars possess better adaptive abilities. Furthermore, Laveaga et al. (2023) observed reduced mortality in later instars of the spotted lanternfly (Hemiptera: Fulgoridae), supporting the observed pattern in *H. theivora*. Thus, the results suggest that the first instar nymph is the optimal stage for effectively managing the *H. theivora* population.

The present study found that female insects exhibited a distinct oviposition pattern, with most eggs laid during the early oviposition period and a notable decline in fecundity in later stages. This pattern aligns with the findings of Bharathi et al. (2024) and Serrana et al. (2022), who noted that increased egg-laying during the early adult phase promotes rapid population expansion. In contrast, the reduction in fecundity during the senescent stage may help maintain population stability under suboptimal environmental conditions.

The demographic parameters reported in this study are consistent with those identified by Izzati et al. (2023) for *H. bradyi*, where the gross reproductive rate (GRR) was 88.0 offspring per female per generation, the net reproductive rate (R_0) was 19.70 female offspring per female per generation, the intrinsic rate of increase (r_m) was 0.02 offspring per female per day, the generation time (Tc) was 39.50 days, and the doubling time (DT) was 40.49 days. In contrast, the current study observed a higher r_m value of 0.09, indicating a greater potential for population increase under favorable conditions. This finding supports the work of Roseli et al. (2019), who emphasized that higher r_m values are indicative of faster population growth. The Tc value of 38.68 days found in this study closely corresponds to that of Izzati et al. (2023), which reported a value of 39.50 days. A shorter Tc value facilitates earlier reproduction, thereby accelerating population build-up (Simanjuntak et al. 2022).

Additionally, the low DT value of 7.92 days calculated for *H. theivora* in this study suggests a rapid population doubling time, which enhances the GRR and R_0 values, contributing to overall population growth. The r_m value is influenced by multiple factors, including generation time, fecundity, and survival rates (Simanjuntak et al. 2022; Izzati et al. 2023). Therefore, the observed variation in demographic parameters between this study and previous research may be attributed to differences in reproductive characteristics among populations.

The durations of pre-oviposition, oviposition, and post-oviposition for *H. theivora* recorded in this study agree with the findings of Roy et al. (2015), who reported that the pre-oviposition duration ranges from 2 to 5 days, while the oviposition duration varies from 24 to 36.8 days. The post-oviposition period in the current study was slightly lower than that reported by Srikumar and Bhat (2013) for *H. antonii* on Singapore cherry (4.38 ± 1.51 days, with a range of 3-7 days) but higher than that documented by Simanjuntak et al. (2022) for *H. bradyi* on cucumber (2.55 ± 0.80 days). These differences may be attributed to interspecific variation, differences in host plants, and variations in laboratory-rearing conditions.

In terms of adult longevity, female *H. theivora* exhibited significantly longer lifespans than males, corroborating the findings of Antony et al. (2018) in tea and Thube et al. (2019) in cocoa, where female-biased longevity was similarly documented. The fecundity data collected in this investigation are comparable to those of Roy et al. (2015), who recorded approximately 220 eggs per female, with a daily oviposition rate ranging from 4 to 10 eggs. Previous research has established that the reproductive parameters of herbivorous insects, such as female longevity, pre-oviposition, fecundity, and post-oviposition periods, are influenced by environmental factors, including temperature, relative humidity, and host plant availability (Susanto et al. 2024).

Conclusion

The study revealed that the population of *H. theivora* follows a Type III survivorship curve, characterized by significant mortality during the early life stages and comparatively lower mortality in later stages. Among all life stages, the first instar nymph exhibited the highest K-value, marking it as a critical stage for mortality and population regulation in *H. theivora*. Female oviposition activity was particularly pronounced during the early reproductive period, contributing to a rapid increase in population size. The demographic parameters further confirmed the species' high reproductive potential, with a rapid population growth rate indicated by an r_m of 0.09 offspring per female per day, an R_0 of 29.56 female offspring per female per generation, and a generation time (DT) of 7.92 days. These findings highlight the necessity of implementing control strategies that focus on the early nymphal instars, especially the first instar, to effectively manage the population growth of *H. theivora* in tea plantations. Future research should investigate the effects of abiotic factors, such as temperature fluctuations, and biotic factors, including natural enemies, on *H. theivora* demography to refine predictive models and enhance pest control measures.

Acknowledgment

The authors express their gratitude to the National Agricultural Technology Program, Phase II (NATP-2), Bangladesh Agricultural Research Council (BARC), Dhaka, Bangladesh, for providing financial support. Special thanks are extended to the Bangladesh Tea Research Institute**,** the Bangladesh Tea Board, and the Ministry of Commerce of the People's Republic of Bangladesh for their collaboration and support. The authors also acknowledge the Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, Selangor, Malaysia, for providing laboratory facilities and other valuable resources to carry out this work.

Conflict of Interest

The authors declare that no conflicts of interest are associated with this work.

Authors Contributions

NAA was responsible for the experimental design, supervision of the research work, data analysis, and manuscript revision. SKP conducted the research, analyzed the data, and prepared the initial manuscript draft for his PhD thesis. SJ and ASM, as co-supervisors of SKP, provided partial supervision and guidance during the research process.

Ethical Clearance

The research on insect species presented in the article does not need ethical approval.

References

Antony, A., Srikumar, K. K., & Radhakrishnan, B. (2018). Comparative biology of *Helopeltis theivora* Waterhouse (Heteroptera: Miridae) on *Psidium cattleianum* (Myrtales: Myrtaceae) and *Camellia sinensis* (Ericales: Theaceae). *Entomon*, *43*(20), 143–145.

Bharathi, N. S., Rabesh, T., & Sujatha, K. (2024). Courtship behavior and ecology of mating in tea mosquito bug, *Helopeltis theivora* Waterhouse (Hemiptera: Miridae). *Mysore Journal of Agricultural Sciences*, *58*(3), 316-324. https://doi.org/10.1186/s41936-022-00297-4

Borthakur, S., & Bora, D. (2023). Identification of chemical cues of *Camellia sinensis* (Ericales: Theaceae) and alternate host plants for preference by tea mosquito bug *Helopeltis theivora* (Hemiptera: Miridae). *International Journal of Science and Research Archive*, *8*(1), 710–719. https://doi.org/10.30574/ijsra.2023.8.1.0123

Campbell, G. R., Hall, T., & Hyslop, E. J. (2025). The life history and mosquito consumption dynamics of *Notonecta indica* (Hemiptera: Notonectidae) in eastern Jamaica. *Journal of Insect Science*, *25*(1), 15. https://doi.org/10.1093/jisesa/ieaf013

Chen, Q., Zhang, J., Tian, Y., Li, J., Ning, W., Chen, G., & Zhang, X. (2024). Evaluating the effects of short-term low temperature on the growth and development of *Trichopria drosophilae* based on the age–stage two-sex life table. *Parasites & Vectors*, *17*(1), 418. https://doi.org/10.1186/s13071-024-06480-6

Chen, Z., Luo, Y., Wang, L., Sun, D., Wang, Y., et al. (2025). Advancements in life tables applied to integrated pest management with an emphasis on two-sex life tables. *Insects*, *16*(3), 261. https://doi.org/10.3390/ insects16030261

Das, R., Roy, S., Handique, G., Chakraborti, D., Naskar, S., Chakraborty, K., & Babu, A. (2024). Decoding defenses: biochemical insights into insecticide resistance in tea mosquito bug, *Helopeltis theivora* Waterhouse (Hemiptera: Miridae) from tea plantations of Eastern India. *Crop Protection*, *184*, 106802. https://doi.org/10.1016/j.cropro.2024.106802

Gómez, V. (2023). Demographic features of two cohorts of tadpoles of the Lesser Snouted Treefrog (*Scinaxnasicus*) (Anura: Hylidae) from ponds in northern Argentina. *Herpetology Notes*, *16*, 75-81.

Izzati, D. N., Witjaksono, W., & Harjaka, T. (2023) Population demographics of *Helopeltis bradyi* Waterhouse (Hemiptera: Miridae) from three different locations. *Jurnal Perlindungan Tanaman Indonesia*, *27*(2), 58-66.https://doi.org/10.22146/ jpti.84515

Jakkoksung, A., Attasopa, K., Chiu, C. I., & Chanbang, Y. (2023). Life cycle and damage patterns of tea mosquito bug (*Helopeltis theivora* Waterhouse), a newly recorded pest on arabica coffee in northern Thailand. *Chiang Mai Journal of Science*, *50*(5), 1-10. https://doi.org/10.12982/cmjs.2023.047

Jayanth, B. V., Lakshmi, K. S., Rajareddy, G., Udaykumar, E., & Paul, B. (2025). Life history traits and feeding efficiency of generalist predator, *Geocoris ochropterus* Fieber against *Spodoptera frugiperda* (JE Smith) with stage-specific estimates of its population and predation rates. *Phytoparasitica*, *53*(3), 1-17. https://doi.org/10.1007/s12600-025-01268-5

Laveaga, E., Hoover, K., & Acevedo, F. E. (2023). Life history traits of spotted lanternfly (Hemiptera: Fulgoridae) when feeding on grapevines and tree of heaven. *Frontiers in Insect Science*, *3*, 1091332. https://doi.org/10.3389/finsc.2023.1091332

Liu, Q., Wang, L. L., Zhou, Y., He, S. Y., Lin, C. J., et al. (2025). Integrating temperature-dependent demography, predation rate, and computer simulation for using *Arma custos* as a biological control agent against *Ectropis grisescens*. *Entomologia Generalis*, *45*(2), 431-439. https://doi.org/10.1127/entomologia/2025/3221

Mohamed, S., Roseli, M., Sajili, M. H., & Adam, N. A. (2019). Life table and demographic parameters of *Bactrocera dorsalis* reared on mango (*Mangifera indica* L.). *Bioscience Research*, *16*(SI), 311–318.

Naskar, S., Hazra, A., Ghosh, S., Das, R., Babu, A., et al. (2025). Understanding genotypic diversity of tea mosquito bug, *Helopeltis theivora* Waterhouse (Heteroptera: Miridae) populations identified for insecticide susceptibility and resistance. *The Nucleus*, 1-13. https://doi.org/10.1007/s13237-025-00541-6

Pelli, A., Pimenta, P. C., & Pelli, P. M. (2023). Population parameters and dynamic life table of stick-insect *Cladomorphus phyllinus* Gray, 1835 (Phasmatidae, Cladomorphinae). *Ecology & Environmental Sciences*, *8*(4), 143-146. https://doi.org/10.15406/ mojes.2023.08.00284

Ribeiro, L. K., Lara, C. A. D., Coelho Junior, A., Ferreira, P. S. F., Resende, J. T. V. D., Bento, J. M. S., & Nardi, C. (2022). Morphology of immature stages, biological parameters and life table of *Microtechnites bractatus* (Hemiptera: Miridae) on different host plants. *Revista Brasileira de Entomologia*, *66*(3), e20220016.https://doi.org/10.1590/1806-9665-rbent-2022-0016

Roseli, M., Adam, N. A., Lau, W. H., & Yaakop, S. (2019). Life table and demographic parameters of rice leaffolder, *Cnaphalocrocis medinalis* Guenee (Lepidoptera: Pyralidae). *Serangga*, *24*(2), 49–59. http://dx.doi.org/10.37231/jab.2021.12.1.245

Roy, S., Muraleedharan, N., Mukhapadhyay, A., & Handique, G. (2015). The tea mosquito bug, *Helopeltis theivora* Waterhouse (Heteroptera: Miridae): its status, biology, ecology and management in tea plantations. *International Journal of Pest Management*, *61*(3), 179–197. https://doi.org/10.1080/09670874.2015.1030002

Serrana, J. M., Ormenita, L. A. C., Almarinez, B. J. M., Watanabe, K., Barrion, A. T., & Amalin, D. M. (2022). Life history and host plant assessment of the cacao mirid bug *Helopeltis bakeri* Poppius (Hemiptera: Miridae). *PhytopSarasitica*, *50*(1), 1-12. https://doi.org/10.1007/s12600-021-00957-1

Simanjuntak, R. G., Harjaka, T., & Wijonarko, A. (2022). Biology and demography of *Helopeltis bradyi* Waterhouse (Hemiptera: Miridae) reared on cucumbers. *Jurnal Perlindungan Tanaman Indonesia*, *26*(1), 13–20. https://doi.org/10.22146/jpti.71761

Srikumar, K. K., & Bhat, P. S. (2013). Biology and feeding behaviour of *Helopeltis antonii* (Hemiptera: Miridae) on Singapore cherry (*Muntingia calabura*) - a refuge host. *Journal of Entomological Research*, *37*(1), 11–16.

Srikumar, K. K., Kumar, B. S., & Radhakrishnan, B. (2016). Biology of two mirids, *Helopeltis theivora* and *Pachypeltis maesarum* (Hemiptera: Miridae), on the Swamp weed, *Ludwigia peruviana*. *Journal of the Kansas Entomological Society*, *89*(4), 306–314. https://doi.org/10.2317/0022-8567-89.4.306

Susanto, A., Setiawati, W., Muharam, A., Udiarto, B. K., Suganda, T., & Putri, S. N. S. (2024). Fitness and survival of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on maize in West Java, Indonesia. *Sains Malaysiana*, *53*(9), 3085-3095. http://doi.org/10.17576/jsm-2024-5309-14

Thube, S. H., Mahapatro, G. K., Mohan, C., Pandian, T. P. R., Apshara, E., & Jose, C. T. (2019). Biology, feeding and oviposition preference of *Helopeltis theivora*, with notes on the differential distribution of species of the tea mosquito bug species complex across elevations. *Animal Biology*, *70*(1), 67–79. https://doi.org/10.1163/15707563-20191083

Yao, Q., Lin, Y-Z., Qin, S., Lin, Z. F., & Ji, X. C. (2025) Characterization of feeding damage by tea mosquito bug, *Helopeltis theivora* Waterhouse (Hemiptera: Miridae) on Hainan Dayezhong tea cultivar. *Frontiers in Plant Science*, *15*, 1529535. https://doi.org/10.3389/fpls.2024.1529535

Zhang, Q. Y., Zhang, Y. L., Quandahor, P., Gou, Y. P., Li, C. C., Zhang, K. X., & Liu, C. Z. (2023). Oviposition preference and age-stage, two-sex life table analysis of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on different maize varieties. *Insects*, *14*(5), 413. https://doi.org/ 10.3390/insects14050413

Zhai, Y., Zeng, X., Wei, D., Jiang, X., Long, X., et al. (2025). Exploring the life cycle of *Bactrocera latifrons*: adetailed age-stage, two-sex life table. *Insects*, *16*(2), 132. https://doi.org/ 10.3390/insects16020132