



Life Table Studies of *Helicoverpa Armigera* Hubner: A Review on Recent Works Done in India

Banna Ushasri¹, Arup Kumar Sarma^{2*}, Surashmi Bhattacharyya³, Hiranya DevaNath²

¹Department of Entomology, Assam Agricultural University, Jorhat-785013, Assam, India

²AAU-Zonal Research Station, Assam Agricultural University, Nagaon-782002, Assam, India

³BNCA, Assam Agricultural University, Biswanath Chariali-784176, Assam, India

Article history

Received : January 20, 2025

Revised : March 9, 2025

Accepted : April 12, 2025

Published : April 15, 2025

*Correspondence

Name: Dr. Arup Kumar Sarma
arup.sarma@aau.ac.in

License and copyright



Copyright: © 2025 by the authors. **Open-access** publication under the terms and conditions of the **Creative Commons Attribution-ShareAlike 4.0 International (CC BY-SA)** license

E-ISSN and DOI

E-ISSN: 3026-2461

DOI: [10.25077/aijent.3.1.10-18.2025](https://doi.org/10.25077/aijent.3.1.10-18.2025)

ABSTRACT

For demographic studies of organisms, life tables are one of the most appropriate tools that help in presenting the patterns of birth, death, survival of progeny and also the life expectancy. Life tables can be constructed based on the sexes in relation to the ecological drivers that include both biotic and abiotic factors. *Helicoverpa armigera* is a highly destructive pest affecting the major food crops such as pulses, fruit crops, oilseeds etc. all over the world. In India it is cosmopolitan. The estimated yield loss in India is about nearly 38%. An attempt has been made here to review the information generated in some recent works regarding the population studies of this polyphagous pest and its management in India.

Keywords: Generation time, *Helicoverpa armigera*, life table, population, reproductive rate.

INTRODUCTION

Helicoverpa armigera Hubner commonly called as the American bollworm, Gram pod borer, fruit borer etc. is a highly polyphagous (Naseri, 2014; Fathipouret al., 2019, Das, 2014; Subramanian and Mohankumar, 2006; Jallow and Zalucki, 1996; Talekaret al., 2006), multivoltine, migratory (Drake, 1991) and economically important pest (Atashi et al., 2021) known to feed on 181 host plants. It is a

major pest of many crops in Asia, Europe, Oceania, Africa and including Brazil (Asghar et al., 2022; Riaz, 2021) with wide geographical distribution (Zalucki and Furlong, 2005). More than 172 species belonging to 40 families and 200 species belonging to 30 families were reported in Australia and china, respectively (Zalucki et al. 1994; Liu, 1934; Xu et al., 1958). Caterpillar is the feeding stage and estimated to be causing nearly 40-50 % (in chick pea)

(Rai et al., 2003) at times up to 100% (Vaishampayan, 1980) yield loss directly by feeding flower buds, fruits and seeds (Cunningham and Zalucki, 2014; Rajapakse and Walter, 2007; Jha et al., 2014) which causes circular bore holes (Garcia, 2006; Safuraie-Parizi, 2014, Perkins et al., 2008, Perkins et al., 2009). *H. armigera* in its larval stage can devour 25-30 pods (Singh and Ali, 2005). The estimated yield loss in India is nearly 38%. Adult moths have great capacity of flight and can travel up to 1000km enabling the pest to disperse in wide range of geographic areas (Basavaraj et al., 2018; Dalal and Arora, 2021).

Life tables are one of the most common tools to describe the biology of insect species and their response to environmental conditions (Rossini et al., 2024). It provides information related to the population of the organism with regards to the age specific details. These life tables includes the data pertaining to natality, mortality, fecundity, age, developmental periods, total number of female off springs given by the female parent and number of females produced by individual female in a day which helps in understanding the dynamics of insect population. In many cases these life table depends on mortality of the cohort and hence can also be referred to as mortality tables.

Population parameters serve as bioclimatic parameters and as indicators of the rate of population growth in determining the potential of a pest population in its expansion over an area under certain circumstances (Deb and Bharpoda, 2016).

Life table includes critical demographic variables, rendering it as a suitable tool for studying the changes associated (Razmjou et al., 2014) and control of pest populations (Southwood, 2000; Harcourt, 1969). These demographic variables include assessing the dynamics of colonizing or species invasion, chances of extinction, predicting the evolution history and pest outbreaks. Demographic information also helps in formulating population models and comprehending the link between growth and survival of the various life phases, as

well as interactions between insect pests and their ecological factors.

Life tables can be categorized into two types: 1) Generation or cohort life tables, 2) Period or current life table. Generation or cohort life table depends on the rate of death of individuals in the actual cohort and studies them for the period between birth and death. Hence these are suitable for organisms having short life span. Period or current life table actually represents the rate of deaths of hypothetical cohort rather than the actual cohort for a short period of time (Islam et al., 2019). The life table studies, that identify the most susceptible stage of the insects in their life cycle, have been regarded as one of the most critical instruments in pest management as well as one of the most essential ways for understanding changes in population of species. 1st and 2nd instar larvae are most susceptible stage leading to mortality in *H. armigera* (Reddy et al., 2004). In order to gain better insight into the diversity of pest demography, it is essential that such ecological life graphs be created for *H. armigera* in a variety of circumstances so as to measure their mortality rates from different causes during an entire generation within its natural habitat (Damanpreet, 2022).

Terms included under life table studies (Deb and Bharpoda, 2016; Farrokhi et al., 2017; Howe, 1971):

Age or stage: It represents specific life stages like egg, larva, pupa, adult or age intervals. It is useful for insects with distinct developmental stages.

Survival rate: The proportion of the original cohort surviving to the start of stage x , i.e., $l_x = \frac{n_x}{n_0}$ Where, n_0 is the initial number of individuals. n_x is the number of individuals alive at the start of stage

Fecundity (m_x): The average number of offspring produced per individual during stage, x .

Net Reproductive Rate (R₀)

The net reproductive rate (R₀) is the average number of offspring produced by an individual over its lifetime. In, $R_0 = \sum l_x m_x$

indicates a population growth; indicates a population decline.

$R_0 > 1$ indicates a population growth;

$R_0 < 1$ indicates a population decline.

Generation Time (T)

During the birth of female progeny, the average age of the mother at that time in a cohort is referred to as generation time.

$$T = \frac{\sum x l_x m_x}{\sum l_x m_x}$$

Innate Capacity For Increase In Number (r)

The rate at which the population grows per individual per unit time: $r \approx \ln(R_0)/T$.

Finite Rate Of Natural Increase (λ)

The number of female off-springs given birth by a female parent per day is finite rate of increase. It was given as (Birch, 1948).

$$\lambda = \text{Antilog}_e r$$

Analysis of key mortality factors: The method of key factors analysis developed by Varley and Gradwell (1963 and 1965) was used to detect density relationship of mortality factors. By this method, the killing power (K) of such mortality factors in each age group was estimated as the difference between the logarithms of population density before and after its action

Life Table Analysis On Different Hosts Under Various Conditions

Basavaraj et al. (2018) conducted a study on *Helicoverpa armigera* and developed life table based on age specific fecundity. From their study they had given that the pre ovipositional period ranges from 36th-39th day where females started egg laying on 40th day which continued to 48th day. On 10th day after female emergence first mortality was observed.

Maximum birthrate by female per day (m_x) 89.17 was on 43rd day. Minimum birthrate by female per day (m_x) 9.15 females per female in the life cycle was on 48th day. The net reproduction rate (R₀) and average generation time (T) was 281.011 and 41.40 days, respectively. The innate capacity was 0.13 and finite rate of the increase in number was 1.14 females per female per day. When the stable age pattern of *H. armigera* was studied early life stages egg, larvae accounts for maximum stability of age pattern.

In a life table study of fruit borer infestation in tomato, *H. armigera* exhibited pre-ovipositional period at 44th and 45th day of pivotal age where female moths started laying eggs after pre-ovipositional age i.e. after 45th days and limited to 54th day pivotal age with 0.72 and 0.11 female survival values (l_x), respectively. Highest number of progeny by the females (m_x) 45.55 was observed on 50th pivotal day. The net reproductive rate (R₀) was 160.53 having average generation time (T) of 49.03 days. The intrinsic rate of increase (r) i.e. number of females per female per day recorded was 0.1045 with finite rate of increase 1.34 females/female/day (λ). Adults contributed least and the early immature stages contributed comparatively high for stable population. With increase in age the life expectancy decreased from 14.07 to 2.83 days for egg stage to adult, respectively (Deb and Bharpoda, 2016).

When fertility life table of *H. armigera* in different feeds such as soybean, cotton, wheat and corn was studied, it revealed that (R₀) net reproductive rate of females was higher in larvae fed on cotton (1234) followed by soybean (755). The lower value of R₀ and in corn and wheat indicates low egg laying capacity and high mortality during reproductive stages. The innate capacity to increase (r) and finite rate of increase (λ) were highest in cotton among all the feeds with 0.91 and 2.48, respectively. The time interval between two generations (T_c) of *H. armigera* was also highest in cotton (54.6 days) (Gomes et al., 2017).

Singh and Yadav (2009) investigated the life table parameters on *H. armigera* on chick

pea pods and gave that (R_0) net reproductive rate was 332.43. The pupal, larva and egg duration were 15, 8 and 3 days, respectively. Pre-ovipositional period ranged from 36th to 38th days of pivotal age. Egg laying by the females started at 39th day and lasted up to 48th days of pivotal age. The actual capacity to increase (r) and finite rate of increase (λ) were 0.135 and 1.1459 females/female/days, respectively with mean generation time of 42.62 days. They also multiplied 332.43 times/generation on chick pea. After 34-49 days the life expectancy was reduced to 4.85 days from 14.78 days in the beginning. On 43rd day mortality of first female was recorded with $d = 0.76$. They also noticed that 99% of the immature stages were unable to reach the adult stage indicating the contribution of early egg and larval stages for the stability of population.

Study of life table of *H. armigera* when reared on *Asparagus officinalis* by Jha et al. (2012) revealed that the intrinsic rate of increase (r) was 0.1029 where finite rate of increase (λ) was 1.1083. The net reproductive rate (R_0) was 40.2 and generation time (T) was 36.7 days. *H. armigera* reared at 29°C exhibited noticeably shorter developmental period of each stage, adult longevity, pre-oviposition period and fecundity than those reared at 25°C. At 29°C 55% of 5th instar larvae developed into 6th instar while it was only 9% when reared at 25°C. The mean pre-ovipositional period of *H. armigera* was 35.36 days and 42.37 days at 29°C and 25°C, respectively.

Choudhury et al. (2012) in their study of *H. armigera* on chickpea regarding the stage specific life table noticed that the average generation time of the insect was 37 and 42 days during 1st and 2nd generations, respectively. They also observed the higher longevity period in female than male adult. The female fecundity was found to vary from 362.99 eggs/ female to 375.09 eggs/female in 1st generation and 388.90 eggs/ female to 391.18 eggs/ female during the followed generation. In 1st generation, finite and intrinsic rate of increase were given to be 1.13 females/female/day, 0.12 females/ female/ day, respectively while in 2nd

generation they were 1.12 females/female/day and 0.12 females/ female/ day, respectively.

Dhandapani and Balasubramanian (1980) studied of *H. armigera* on three different host plants bengal gram, lab-lab and redgram regarding the life table parameters. The experiment revealed red gram (80 adults) exhibited highest survival where life tables were studied from egg to adult. At the age of 42nd day in the life cycle female parent contributed highest progeny ($m_x = 81.48$) in lab-lab. The net reproductive (R_0), representing the total female-births was more (236.98) in lab-lab. The finite rate of increase (λ) is highest in lab-lab (1.150). The time duration of a generation (T) was less (38-10 days) in redgram.

In a work done in Andhra Pradesh, India on host preference of *H. armigera*, Sudarshan Raju (1993) reported Pigeon pea as the most preferred crop hosts with mean length of generation of 31.49 days, followed by tomato (34.79 days), cotton (35.46 days), and chilli (39.10 days). He also reported Corchorus as the most preferred host among the weeds under study, with mean length of generation of 34.80 days followed by Amaranthus (35.54 days) and Solanum (35.57 days). The net reproductive rate was found highest on cotton (46.72) followed by pigeonpea (43.08), tomato (37.80), Corchorus (30.28), Solanum (14.73), Amaranthus (11.78) and chilli (9.66). The population of *H. armigera* on reaching stable age-distribution comprised approximately 99 per cent of immature stages on all selective hosts.

Bisaneet al. (2009) studies on the life table of *Helicoverpa armigera* constructed for field-collected and laboratory-reared populations on chickpea and artificial diet revealed the egg stage as the most vulnerable, with the highest mortality (14.35%) in field-collected eggs and 11.11% in laboratory-reared eggs on artificial diet. Early instar larvae mortality was significant (34.55%) due to parasitization by *Eriborus argenteopilosus* (14.89%) and *Campoletis chlorideae* (8.94%), while late instar larvae and pupae showed lower mortality but were impacted by tachinid fly parasitization (13.19%) and developmental failures (12.09%).

Generation survival was higher on artificial diet (0.62) than chickpea (0.57), with late larval stages showing maximum survival.

Maity et al. (2020) conducted a study on the growth, development, survivorship, and fertility of *Helicoverpa armigera* across two generations, using age-specific survivorship and female fertility life tables under controlled laboratory conditions at $26 \pm 1^\circ\text{C}$ and $80 \pm 5\%$ RH. Larvae reared on unripe tomatoes showed survival trends where early instars (first to third) were the most vulnerable, with a consistent decline in survival observed until the 33rd day, after which no mortality occurred until the pre-oviposition stage. Life expectancy was high in early stages but declined steadily with age in both generations. Female fertility data revealed that the pre-reproductive period lasted 40.5 days, followed by a 6–7 day oviposition period, with net reproductive rates (R_0) of 133.83 and 126.22 females/female in the first and second generations, respectively. Growth and suitability indices were calculated, revealing a generation time of approximately 1.5 months.

Field life table study done by Kaneri et al. (2018) gave the following results. The mortality of adult due to malformations, younger group larvae, older group larvae, pupal stage and malformations in the adult stage was 1.68%, 0.57%, 28.75% and 4.83%, respectively, according to the life table of *H. armigera* on chickpea prepared under field conditions to examine the key mortality factors. Younger larvae were recorded with mortality of 28.75 per cent, pupal stage with 4.83 per cent and deformed adults with 1.68 per cent.

Dabhi and Patel (2007) in a study observed a 10% mortality rate during the egg stage, with larval and pupal stages experiencing 10% and 8.64% mortality, respectively. The mean generation time (T) for *Helicoverpa armigera* was 43.19 days, indicating a rapid life cycle. The intrinsic rate of increase (r_m) and finite rate of population growth (λ) were calculated as 0.1364 and 1.146 females per female per day, respectively, demonstrating the species' capability to multiply 2.5966 times per week under the given conditions. The hypothetical

second-generation (F_2) female population was projected to reach 130,928.19, highlighting a significant reproductive potential. The life expectancy of newly deposited eggs was 15.84 days, but a high mortality rate was noted within the first 5 days, emphasizing the vulnerability of early developmental stages.

Liu et al. (2004) conducted life table studies of *H. armigera* on six different hosts i.e., cotton, corn, tomato, hot pepper, tobacco and common bean. Their study revealed the survival percentage of 33.1 % in immature larvae in cotton contradicting 1.7% on hot pepper which also revealed that the though cotton bollworm can complete its life cycle in all six host plants, hot pepper and tomato were not as suitable as others as hosts. Naseri et al. (2014) investigated 13 cultivars of soybean for life table studies and revealed that the cultivar resistance against *H. armigera* varies from cultivar to cultivar where the highest net reproductive rate (R_0) of 270.1 female/female/generation in red-kidney-bean was recorded against least net reproductive rate of 177.3 female/female/generation in white kidney bean.

Sonawane et al. (2006) studied life table parameters of *H. armigera* on Bt and non Bt cotton and observed a drastic reduction in Net reproductive rate (R_0) of 47.05 in Bt against 416.84 in non Bt.

Management of *H. armigera* on the basis of life table studies:

Damanpreet et al. (2022) in their study on field life tables and key mortality factors of *H. armigera* infesting tomato reported that the important mortality factors of the pest under field conditions were fungi like *Beauveria bassiana*; *Campoletis chloridae*; HaNPV and *Bacillus thuringiensis*. They reported that the egg stage was most vulnerable having 32-91% loss during main and spring growing seasons of tomato. It was followed by early larval stage exhibiting 40.27- 44.86% loss was followed by late larval stage with 35.84–40.95% and pupal stage with 24.45–29.23% loss. Lower egg mortality rate during the main season crop was due to the lower parasitoid population. Highest was due to the increased population of parasitoids. They

also concluded that these key mortality factors cannot bring down the pest population during the main season and are effective during the spring season. Survival of generation was also high during the main season which increases the pest load for the following season. Survival was low during spring season which contributes maximum for mortality, decreases the pest load for the next season.

Kaneriet al., (2018) reported that the 20% of egg mortality was due to sterility. Mortality of younger larvae was 0.57% which was due to bacterial infection. Mortality of older instar larvae was 28.75 % where bacteria along with many factors like fungi, parasitoid Bracon spp., Tachnid maggot and NPV caused the mortality. Among all the insect life stages maximum population decline was in larval stage which was indicated by higher 'k' value was given in their study.

In cotton, *Campoletis chloridae* caused mortality of 8.19, 4.76 and 11.66 per cent in early instar larvae of *H. armigera* during third, second and first generation, respectively. Death rate of 4, 3.33 and 1.78 per cent was observed in early instar larvae of *H. armigera* due to entomopathogenic fungi in first, second and third generation, respectively. 3.07 per cent mortality in early instar larvae was observed in second generation of *H. armigera* due to HaNPV. In the first, second, and third generations, *C. chloridae* contributed to 4.5, 1.78, and 3.63 percent of the death rate of late instar larvae of *H. armigera*, respectively. In second and third generations, entomopathogenic fungi were responsible for 1.81 and 1.78 percent of the mortality of late instar *H. armigera* larvae (Rodge et al. 2019).

Jadhao et al. (2016) in their studies have seen 7.60 and 6.81 per cent larval mortality of *H. armigera* due to nuclear polyhydrosis virus and an unidentified parasitoid during its bivoltine cycle on sunflower.

- Management of the pest in the main season crop is difficult compared the spring season crop as the environmental conditions are more suitable to the pest during main season crop.

- Older larvae are susceptible to different kinds of threats which include predators-birds, parasitoids *C. chloridae*, *B. bassiana*, HaNPV.
- As these natural enemies are already present in the crop ecosystem, these natural enemy population should be strengthened enough to compete with the pest population. The potential of natural enemies can be utilized in pest control.
- The strains naturally obtained will be more compatible and effective against pest in many cases and hence they have to be identified. These identified strains can be evaluated for their effectiveness, mass produced and released in the field.
- This integration of natural control with other pest control measures helps in reducing the cost of protection and also decreases environmental hazards.

CONCLUSION

Immature stages of *H. armigera* accounts for population stability rather than the adults was revealed by many researchers in various experiments and their study on life tables. The net reproductive rate in most cases was in and around 300. The intrinsic rate of increase and finite rate of increase are <1 and >1 , respectively. It is also evident that conditions like host range, temperature regulates the developmental period of the insect. The generation time i.e. time taken to complete one generation is usually between 35-45 days. Younger larvae are more prone to bacterial infections and older larvae are susceptible to fungi, viruses, bacteria and nematode also. Hence, these natural parasitoids and predators can be exploited for use in pest management during their vulnerable stages for effective control.

REFERENCES

- Asghar, M.S., Sarwar, Z.M., Almadiy, A.A., Shami, A., El Hadi Mohamed, R.A., Ahmed, N., Waghulade, M.S., Alam, P., & Abd Al Galil, F.M. (2022). Toxicological effects of silver and zinc oxide nanoparticles on the biological and life

- table parameters of *Helicoverpa armigera* (Noctuidae: Lepidoptera). *Agriculture*, 12(10), 1744.
- Atashi, N., Shishehbor, P., Seraj, A.A., Rasekh, A., Hemmati, S.A., & Riddick, E.W. (2021). Effects of *Helicoverpa armigera* egg age on development, reproduction, and life table parameters of *Trichogramma euproctidis*. *Insects*, 12(7), 569.
- Basavaraj, K., Naik, M.I., Jagadish, K.S. & Shadakshari, Y.G., (2018). Studies on age specific fecundity life tables for *Helicoverpa armigera* Hub, on sunflower (*Helianthus annuus* L.). *Journal of Entomology and Zoological studies*, 6(2), 1364-1368.
- Birch, L., (1948). The intrinsic rate of natural increase of an insect population. *The Journal of Animal Ecology*, 17(1), 15-26.
- Bisane, K.D., Khande, D.M., Bhamare, V.K., & Katole, S.R., (2009). Life table studies of *Helicoverpa armigera* (Hübner) on chickpea. *International Journal of Plant Protection*, 2(1), 54-58.
- Choudhury, R.A., Rizvi, P.Q., & Satpute, N.S., (2012). Stage specific lifetable of *Helicoverpa armigera* (Hubner) on chickpea. *Indian Journal of Entomology*, 74(4), 310-314.
- Cunningham, J.P., & Zalucki, M.P. (2014) Understanding heliothine (Lepidoptera: Heliothinae) pests: what is a host plant? *Journal of Economic Entomology*, 107,881-896
- Dabhi, M.V. & Patel, C.C.(2007). Life expectancy of *Helicoverpa armigera* on chickpea. *SAT-eJournal*, 5, 1-2.
- Dalal, P.K., & Arora, R., (2021). Fecundity and life-table parameters of *Helicoverpa armigera* (Hübner)(Lepidoptera: Noctuidae) on tomato crop under alternating temperature regimes: Implications for pest monitoring in sub-tropical India. *International Journal of Tropical Insect Science*, 41, 2851-2865.
- Damanpreet, Ravinder, S.C., & Aggarwal, N., (2022). Field life tables and key mortality factors of *Helicoverpa armigera* infesting tomato (*Solanum lycopersicon*). *Indian Journal of Agricultural Sciences*, 92 (6), 684.
- Das, S.K. (2014). Scope and relevance of using pesticide mixtures in crop protection: a critical review. *International Journal of Environmental Science and Toxicology*, 2(5), 119-123.
- Deb, S., & Bharpoda, T. (2016). Life-table parameters of fruit borer, *Helicoverpa armigera* (Hübner) in tomato, *Lycopersicon esculentum* Mill. *The Bioscan*, 11, 9-14.
- Dhandapani, N., & Balasubramanian, M., (1980). Life table for the gram pod borer, *Heliothis armigera* Hbn. on three pulse crops. *Proceedings of Animal Sciences*, 89,575-578.
- Drake, V.A., (1991). Methods for studying adult movement in *Heliothis*. In *Heliothis: Research methods and prospects*, New York, NY: Springer New York.pp. 109-121.
- Farrokhi, M., Gharekhani, G., Iranipour, S., & Hassanpour, M., (2017). Host plant–herbivore–predator interactions in *Chrysoperla carnea* (Neuroptera: Chrysopidae) and *Myzus persicae* (Homoptera: Aphididae) on four plant species under laboratory conditions. *Journal of Economic Entomology*, 110(6), 2342-2350.
- Fathipour, Y., Sedaratian, A., Bagheri, A., & Talaei-Hassanlouei, R.(2019). Increased food utilization indices and decreased proteolytic activity in *Helicoverpa armigera* larvae fed sub-lethal *Bacillus thuringiensis*-treated diet. *Physiological Entomology*, 44(3-4), 178-186.
- Garcia, F.M.(2006). Analysis of the Spatio-temporal Distribution of *Helicoverpa armigera* Hb. in a tomato field using a Stochastic Approach. *Biosystems Engineering*, 93(3), 253-259.
- Gomes, E.S., Santos, V. & Ávila, C.J. (2017). Biology and fertility life table of *Helicoverpa armigera* (Lepidoptera: Noctuidae) in different hosts. *Entomological Science*, 20(1), 419-426.
- Harcourt, D. (1969). The development and use of life tables in the study of natural insect populations. *Annual Review of Entomology*, 14(1), 175-196.
- Howe, R.W. (1971). A parameter for expressing the suitability of an environment for

- insect development. *Journal of Stored Products Research*, 7(1), 63-65.
- Islam, A., Mondal, M.N.I., Islam, M.R., Islam, M.R., Islam, M.S., Khan, M.N., & Hoque, M.N., (2019). Techniques of life table construction: A review. *International Journal of Humanities and Education Research*, 1(2), 10-15.
- Jadhao, S.M., Shinde, P.R., Sawant, C.G., & Shetgar, S.S. (2016). Field life-tables and key mortality factors of Lepidopterous pests of sunflower. *Journal of Entomological Research*, 40(4), 387-391.
- Jallow, M.F.A., & Zalucki, M.P. (1996). Within- and between-population variation in host-plant preference and specificity in Australian *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae). *Australian Journal of Zoology*, 44(5), 503-519.
- Jha, R.K., Chi, H., & Tang, L.C. (2012). Life table of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) with a discussion on Jackknife vs. Bootstrap techniques and variations on the Euler-Lotka equation. *Formosan entomologist*, 32, 355-375.
- Jha, R.K., Tuan, S.J., Chi, H., & Tang, L.C., (2014). Life table and consumption capacity of corn earworm, *Helicoverpa armigera*, fed asparagus, *Asparagus officinalis*. *Journal of Insect Science*, 14(1), 34.
- Kaneria, P.B., Kabaria, B.B., Variya, M.V., & Bharadiya, A.M. (2018). Field life table studies of *Helicoverpa armigera* (Hubner) infesting chickpea in Saurashtra conditions, *Journal of Entomology and Zoology Studies*, 6(5), 2403-2406.
- Liu, G.S. (1934). The economical food plants of cotton bollworm, *Heliopsis obsoleta* Fab. *Insect and Plant Pathology*. 2: 708-709.
- Liu, Z., Li, D., Gong, P., & Wu, K. (2004). Life table studies of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), on different host plants. *Environmental Entomology*, 33(6), 1570-1576.
- Maity, C., Mondal, P., & Mondal, L., (2020). Studies on age specific & female fertility life tables of *Helicoverpa armigera* under controlled condition. *Journal of Entomology*, 585-591.
- Naseri, B., Golparvar, Z., Razmjou, J., & Golizadeh, A., (2014). Age-stage, two-sex life table of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on different bean cultivars. *Journal of Agricultural Science and Technology*, 16(1), 19-32.
- Perkins, L.E., Cribb, B.W., Hanan, J., & Zalucki, M.P. (2009). The role of two plant-derived volatiles in the foraging movement of 1st instar *Helicoverpa armigera* (Hübner): time to stop and smell the flowers. *Arthropod-Plant Interactions*, 3: 173-179.
- Perkins, L.E., Cribb, B.W., Hanan, J., Glaze, E., Beveridge, C. and Zalucki, M.P. (2008). Where to from here? The mechanisms enabling the movement of first instar caterpillars on whole plants using *Helicoverpa armigera* (Hübner). *Arthropod-Plant Interactions*, 2(4), 197-207.
- Rai, D., Ujagir, R., & Singh, R. K. (2003). The larval parasitization by *Campoletis chloridae* Uchida (Hymenoptera: Ichneumonidae) of *Helicoverpa armigera* (Hübner) in pure chickpea crop at Pantnagar. *Biological Control*, 17, 81-83.
- Rajapakse C.N.K., & Walter G.H. (2007) Polyphagy and primary host plants: oviposition preference versus larval performance in the lepidoteran pest *Helicoverpa armigera*. *Arthropod Plant Interact*, 1, 17-26.
- Razmjou, M., Naseri, J., Hemati, B., & Ali, S. (2014). Comparative performance of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on various host plants. *Journal of Insect Science*, 87(1), 29-37.
- Reddy, K.S., Rao, G.R., Rao, P., & Rajasekhar, P. (2004). Life table studies of the capitulum borer, *Helicoverpa armigera* (Hubner) infesting sunflower. *Journal of Entomological Research*, 28(1), 13-18.
- Riaz, S., Johnson, J.B., Ahmad, M., Fitt, G.P., & Naiker, M. (2021). A review on biological interactions and management of the cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae). *Journal of Applied Entomology*, 145, 467-498.

- Rodge, A.K., Shetgar, S.S., Sarukh, P.L., & Dalvi, V.B. (2019). Studies on field life-tables and key mortality factors of cotton bollworm *Helicoverpa armigera* (Hubner) on deshi cotton. *Journal of Entomology and Zoology Studies*, 7(6), 535-538.
- Rossini L, Contarini M, Speranza S, Mermer S, Walton V, Francis F, et al. (2024) Life tables in entomology: A discussion on tables' parameters and the importance of raw data. *PLoS ONE* 19(3): e0299598. <https://doi.org/10.1371/journal.pone.0299598>
- Safuraie-Parizi, S., Fathipour, Y., & Talebi, A.A. (2014). Evaluation of tomato cultivars to *Helicoverpa armigera* using two-sex life table parameters in laboratory. *Journal of Asia-Pacific Entomology*, 17(4), 837-844.
- Singh, R. and Ali, S., 2005. Efficacy of Bio-Pesticides in the Management of *Helicoverpa armigera*(Hüb.) in Chick pea. *Annals of Plant Protection Sciences*, 13(1), pp. 94-96.
- Singh, S.K., & Yadav, D.K. (2009). Life table and biotic potential of *Helicoverpa armigera* (hübner) on chick pea pods. *Annals of plant Protection Science*, 17(1), 90-93.
- Sonawane, J.R., Khande, D.M., Bisane, K.D., & Tayade, P.P., 2007. Life table studies of *Helicoverpa armigera* (Hübner) on Bt and non Bt cotton. *Journal of Entomological Research*, 31(1), 1-4.
- Southwood T.R.E., & Henderson P.A. (2000). *Ecological Methods*. 3rd ed. Blackwell, Oxford, UK, 575.
- Subramanian, S., & Mohankumar, S., (2006). Genetic variability of the bollworm, *Helicoverpa armigera*, occurring on different host plants. *Journal of Insect Science*, 6(1), 26.
- Sudarshan Raju, K. I. (1993). Life table of *Helicoverpa* (*Heliiothis*) *armigera* (Hubner) (Noctuidae: Lepidoptera) on common hosts of Andhra Pradesh. <http://krishikosh.egranth.ac.in/handle/1/5810053306>
- Talekar, N.S., Opena, R.T., & Hanson, P. (2006). *Helicoverpa armigera* management: a review of AVRDC's research on host plant resistance in tomato. *Crop Protection*, 25(5), 461-467.
- Vaishampayan, S.M., 1980. Seasonal abundance and activity of gram-pod borer, *Helicoverpa armigera* Hubner and its outbreak situation on gram at Jabalpur. *Indian Journal of Entomology*, 42, 433-459.
- Varley G.C., & Gradwell G.R. 1965. Interpreting winter moth population changes. *Proceedings of XII International Congress of Entomology, London*, 377-378.
- Xu, M.-X., G.-X. Zhang, & H.-F. Zhu. (1958). Research of cotton bollworm. *Acta Entomologica Sinica* 1(1), 18-29.
- Zalucki, M.P., & Furlong, M.J. (2005). Forecasting *Helicoverpa* populations in Australia: a comparison of regression based models and a bioclimatic based modelling approach. *Insect Science*, 12(1), 45-56.
- Zalucki, M.P., Murray, D.A.H., Gregg, P.C., Fitt, G.P., Twine, P.H., & Jones, C. (1994). Ecology of *Helicoverpa armigera* (Hubner) and *Heliiothis punctigera* (Wallengren) in the inland of Australia-larval sampling and host-plant relationships during winter and spring. *Australian Journal of Zoology*, 42(3), 329-346.