Indian Journal of Ecology (2024) 51(6): 1263-1267
DOI: https://doi.org/10.55362/IJE/2024/4392

Manuscript Number: 4392
NAAS Rating: 5.38

Impact of Temperature on Survival and Fecundity of *Spodoptera litura* on Capsicum

Inderpeet Kaur Boparai, Krishan Chander Sharma and Harwinder Singh Buttar

Department of Entomology, Dr. Y. S. P. University of Horticulture and Forestry, Nauni, Solan-173 230, India
E-mail: harwinder-pp@pau.edu

Abstract: The tobacco caterpillar, *Spodoptera litura* (Fab.), is a pervasive pest affecting numerous plant species. This study investigates the life fertility parameters of *S. litura* on capsicum under varying temperatures to enhance pest management strategies. With experiments conducted at the Dr. Y.S. Parmar University of Horticulture and Forestry, India, this research aims to elucidate the impact of temperature on the reproductive potential of *S. litura*. By analyzing key fertility parameters such as gross reproductive rate (GRR), net reproductive rate (R0), and intrinsic rate of increase (rm). The study assesses the optimal temperature conditions for *S. litura* reproduction. The optimal conditions for reproduction occur at 25°C, but the highest intrinsic rate of increase was recorded at 35°C, indicating accelerated population growth under higher temperatures despite a reduction in individual fecundity. These insights contribute to more precise pest control strategies by highlighting temperature's role in *S. litura* population dynamics, thereby improving Integrated Pest Management (IPM) interventions.

Keywords: Tobacco caterpillar, Life fertility parameters, Population dynamics, Insect ecology

The tobacco caterpillar, *Spodoptera litura* (Fabricius), is a highly polyphagous pest known to damage a wide range of crops, including vegetables, grains, and oilseeds, making it one of the most economically significant agricultural pests worldwide (Zakria et al 2022), affecting over 290 plant species across 99 families (Wu et al 2004). Its adaptability to various environments and host plants, coupled with its high reproductive potential, has led to increased reliance on chemical pesticides for management (Sharma et al 2018). However, the excessive use of chemical controls has resulted in pest resistance and negative environmental impacts, emphasizing the need for integrated pest management (IPM) strategies (Brar and Sharma 2017, Sharma et al 2024).

Temperature is a critical abiotic factor influencing the life cycle of insects, affecting their development, survival, and reproduction. As ectothermic organisms, *S. litura* is particularly sensitive to temperature variations, which can significantly alter its biological performance (Karmakar and Pal 2017). Studies have shown that temperature affects key life history traits such as growth rates, developmental thresholds, and fecundity (Rao and Prasad 2020, Zhong et al 2024). Elevated temperatures can enhance metabolic rates, leading to increased food consumption and faster development, while also influencing the insect's interaction with natural enemies (Islam et al 2022, Yi et al 2020). Research has demonstrated that specific temperature ranges can optimize the development and reproductive success of *S. litura*. For instance, optimal conditions promote higher survival rates and fecundity, while extreme temperatures may negatively impact these parameters (Duraimurugan 2018, Sharma et al 2018). Moreover, temperature fluctuations can influence the dynamics of pest populations and their associated predators, further complicating pest management strategies (Zhu et al 2017).

Understanding the ecological and physiological responses of *S. litura* to temperature is vital for developing effective pest management practices. Life table studies serve as valuable tools in this regard, providing insights into the dynamics of pest populations under varying environmental conditions. They allow for the evaluation of demographic parameters such as age-specific survival rates, fecundity, and population growth rates, which are essential for modeling pest behavior and predicting outbreaks (Chi and Su 2006). In light of the growing concerns surrounding climate change and its impact on agricultural systems, this study aims to examine the influence of temperature on the survival and fecundity of *S. litura* when reared on capsicum (*Capsicum* spp.). By constructing life fertility tables for *S. litura* under different temperature regimes, seek to elucidate the relationship between temperature and pest dynamics, thereby informing better management strategies to mitigate the impacts of this pest on capsicum cultivation.

MATERIAL AND METHODS

The investigations on "Studies to construct life fertility tables of *Spodoptera litura* on capsicum" were conducted Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, HP, India. The host plants used in this study included capsicum. (*var.* Solan Bharpur). Seed beds were prepared

with a 1:1 mixture of soil and farmyard manure, and eight-week-old seedlings with 3 to 4 leaves were transplanted into the field, following standard cultural practices without insecticide application. Fresh leaves from these plants were used in the study. The culture of *S. litura* was established by collecting larvae from polyhouses and open fields at the Entomological Research Farm and Vegetable Research Farm of the university. The larvae were reared in plastic jars (15 cm × 21 cm) under laboratory conditions with fresh castor leaves, which were changed twice daily. To prevent microbial infections, castor leaves were washed with dilute potassium permanganate solution, rinsed with water, and air-dried. The jars were thoroughly cleaned with detergent and air-dried. Larvae were reared for at least two generations on the same host plant species. Mature larvae ready for pupation were transferred to jars with 5 cm of moist soil to facilitate pupation. Pupae were collected and transferred to other jars for adult emergence. Newly emerged adults were paired and kept in jars for mating and egg laying, with a cotton wick soaked in 10% sucrose solution for adult feeding. The inner surfaces of the containers were lined with filter paper for egg laying. Eggs were collected every 12 hours and used in experiments.

Life fertility studies of *S. litura* were conducted on capsicum at 20, 25, 30 and 35°C. After rearing the test insect for at least one generation to negate the effects of the previous host, data on developmental stages, mortality and fertility parameters (preoviposition period, oviposition period, postoviposition period and daily egg production) were recorded. Fertility parameters, including gross reproductive rate (GRR), net reproductive rate (R0), approximate generation time (TC), innate capacity for natural increase (rc), true intrinsic rate of increase (rm), true generation time (T), finite rate of natural increase (λ), and doubling time (DT), were calculated according to methods described by Birch (1948), Howe (1953), and Watson (1964). Repeated estimates of each fertility parameter were obtained using the Jackknife procedure (Meyer et al 1986), following the methodology described by Maia et al (2000), ensuring reliable and accurate results. These fertility tables provided insights into the influence of temperature on the survival and fecundity of *S. litura*, contributing to the development of pest management strategies.

RESULTS AND DISCUSSION

Age-specific survival and fecundity parameters of *S. litura* on capsicum at different temperatures: The survival and fecundity of *S. litura* on capsicum were influenced significantly by temperature. At 20°C, the survival rate was initially high but gradually declined, with all females dying by the 73rd day (Fig. 1). Similar trend was observed at 25°C, where survival declined more rapidly, with all adults dying by the 56th day (Fig. 2). At 30°C and 35°C, the survival period was further shortened, with all adults dying by the 40th (Fig. 3) and 24th (Fig. 4) days, respectively.

The age-specific fecundity of *S. litura* on capsicum varied with temperature. At 20°C, egg laying began on the 55th day, peaking at 111.17 eggs per female, then fluctuating slightly before declining to 19.19 by the 64th day, with no eggs laid beyond the 65th day (Fig. 1). At 25°C, egg-laying started earlier and peaked at higher numbers, with a rapid decline afterward (Fig. 2). At 30°C and 35°C, peak egg production occurred even earlier, with a more condensed egg-laying period and a faster decline in fecundity (Fig. 3 and 4).

Survival rates declined more rapidly at higher temperatures, with cooler conditions at 20°C prolonging the life span. Fecundity patterns showed that peak egg laying occurred earlier and in higher numbers as temperature increased, but the duration of egg-laying was shorter, indicating a more condensed reproductive phase in warmer conditions. Population dynamics indicated that the intrinsic rate of increase (rm) and finite rate of increase (λ) were higher at elevated temperatures, leading to faster population growth. However, the net reproductive rate (R0) and gross reproductive rate (GRR) peaked at 25°C, suggesting that this temperature provides optimal conditions for the reproductive success of *S. litura.*

Fertility parameters of *Spodoptera litura* on capsicum at different temperatures: The fertility parameters of *S. litura* on capsicum exhibited significant variations across different temperatures (Table 1). At 25°C, *S. litura* showed the highest reproductive output, with the greatest gross reproductive rate (GRR) and net reproductive rate (R0), indicating that this temperature provides optimal conditions for reproduction. In contrast, the lowest GRR and R0 were recorded at 35°C, suggesting that higher temperatures negatively impact reproductive potential. Both the approximate generation time (Tc) and true generation time (T) decreased with increasing temperatures. At higher temperatures, such as 35°C, the developmental and reproductive cycles were considerably accelerated, leading to faster population turnover compared to cooler conditions (Table 1). The intrinsic rate of natural increase (rm) and innate capacity for increase (rc) also showed a positive correlation with temperature, peaking at 35°C, which suggests a significant boost in reproductive efficiency at higher temperatures. The finite rate of natural increase (λ) declined with rising temperatures, whereas the doubling time (DT) shortened, indicating a more rapid population growth at warmer temperatures. Despite lower individual fecundity at higher temperatures, the overall population growth was

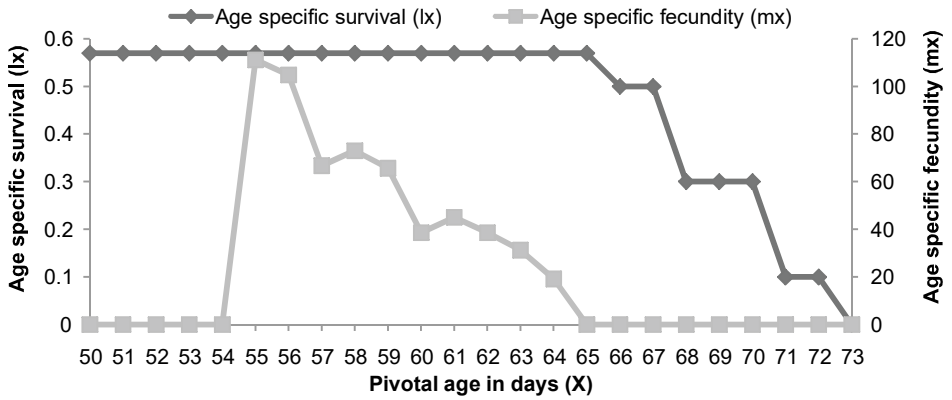

Fig. 1. Daily age-specific survival and age-specific fecundity of *S. litura* on capsicum at 20˚C

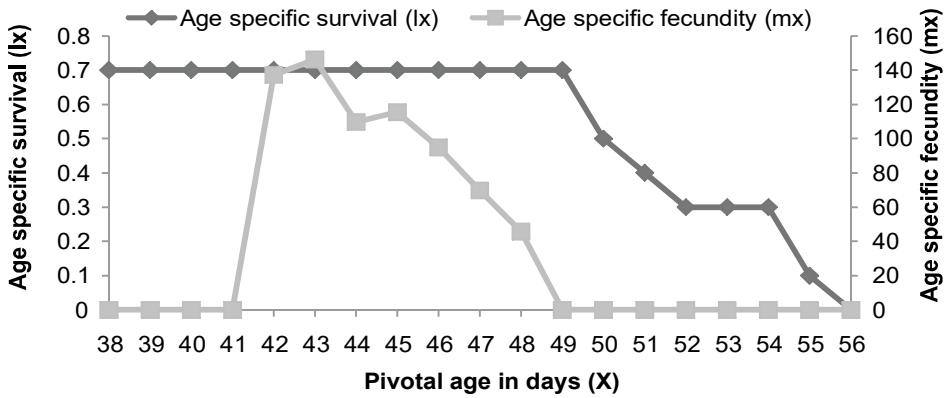

Fig. 2. Daily age-specific survival and age-specific fecundity of *Spodoptera litura* on capsicum at 25°C

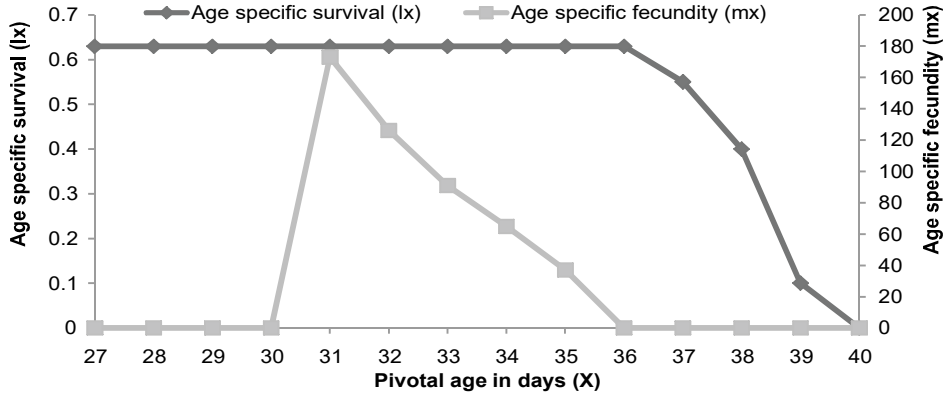

Fig. 3. Daily age-specific survival and age-specific fecundity of *Spodoptera litura* on capsicum at 30°C

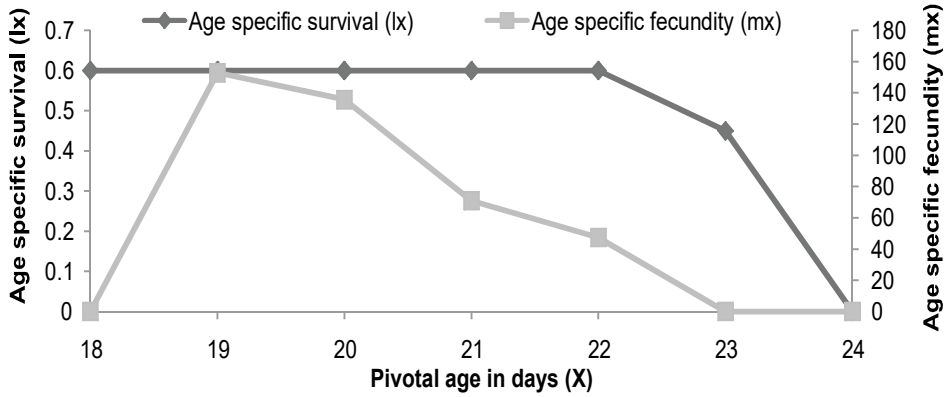

Fig. 4. Daily age-specific survival and age-specific fecundity of *Spodoptera litura* on capsicum at 35°C

accelerated due to shorter generation times (Table 1). The weekly multiplication rate (WM) also increased with temperature, showing a more rapid population expansion at 35°C.

Fertility parameters of *S. litura* on capsicum: Gross reproductive rate (GRR) was significantly higher (718.86 female eggs per female) at 25°C. It was followed by at 20 and 30°C. GRR was significantly lower (406.69 female eggs per female) at 35°C. The net reproductive rate (R_0) also followed the same trend as GRR. R_0 was significantly higher (503.2 female eggs per female) at 25°C followed by 20 and 30°C, respectively. R_0 was significantly lower (244.02 female eggs per female) at 35°C. The approximate generation time (Tc) was longest at 20°C, with shorter durations at 25°C and 30°C, and the shortest at 35°C. In contrast, the intrinsic rate of natural increase (rm) was significantly higher at 35°C, indicating rapid population growth under warmer conditions. The true generation time (T) was longest at 20°C and decreased with increasing temperature. The weekly multiplication rate (WM) was highest at 35°C, suggesting potential for rapid population expansion, while the finite rate of natural increase (λ) was significantly greater at 20°C. The doubling time (DT) was also longer at 20°C, decreasing with higher temperatures.Bharathi et al. (2008) observed similar findings on different tobacco cultivars. Similarly, Farahani et al. (2011) noted that the mean duration of pupae for *S. eridania* was greater than for *S. exigua* on different soybean cultivars. Contrasting results were obtained by Patil et al. (2014, 2015) on tobacco, highlighting variability in reproductive potential and generation periods across studies. Supriya et al. (2018) reported that *S. litura's* life parameters were negatively affected by Bt-II hybrids, indicating the impact of host plant resistance on pest population dynamics.

In this study, the age-specific survival and fecundity parameters of *S. litura* on capsicum were analyzed at four different temperatures (20°C, 25°C, 30°C and 35°C). The results demonstrated significant variations in survival and reproductive output across temperatures. Survival rates declined more rapidly at higher temperatures, with the coolest condition (20°C) prolonging the lifespan of the moths. Fecundity patterns showed that peak egg laying occurred earlier and in higher numbers as temperature increased, but the duration of egg-laying was shorter, indicating a more condensed reproductive phase in warmer conditions. The intrinsic rate of increase (r_m) and finite rate of increase (λ) were higher at elevated temperatures, leading to faster population growth. However, the net reproductive rate (R_0) and gross reproductive rate (GRR) peaked at 25°C, suggesting this temperature provides optimal conditions for the reproductive success of *S. litura*. The lowest GRR and (R0) were observed at 35°C, indicating that higher temperatures may adversely affect the reproductive potential of the species. The approximate generation time (Tc) and true generation time (T) decreased with increasing temperature, reflecting accelerated development and reproductive cycles at higher temperatures, which enable faster population turnover. Both the innate capacity for increase (r_c) and the intrinsic rate of natural increase (r_m) showed a positive correlation with temperature, indicating that higher temperatures substantially boost the reproductive efficiency and population growth rate of *S. litura*.

The finite rate of natural increase (λ) was highest at 20°C and lowest at 35°C, while the doubling time (DT) decreased with rising temperature, suggesting rapid population growth under warmer conditions despite reduced individual fecundity. The weekly multiplication rate (WM) also increased with temperature, underscoring the potential for rapid population expansion of *S. litura* in warmer climates. The results align with previous studies but also highlight the importance of temperature in influencing fertility parameters and developmental periods. Feeding on different plant parts can also cause variations in fertility parameters. The intrinsic rate of natural increase (r_m) is a critical value for determining the

Table 1. Fertility parameters of *Spodoptera litura* on capsicum at different temperatures

Parameter	Unit	20°C	25°C	30°C	35°C
Gross reproductive rate (GRR)	Female eggs/female	594.130	718.860	492.110	406.690
Net reproductive rate (R_0)	Female progeny/female	338.650	503.200	310.030	244.020
Approximate generation time (T_c)	Days	58.160	44.380	32.320	20.030
The innate capacity for increase (r_c)	Females/female/day	0.038	0.061	0.077	0.119
Intrinsic rate of natural increase (r_m)	Females/female/day	0.101	0.141	0.178	0.276
True generation time (T)	Days	25.090	19.170	13.970	8.640
Weekly multiplication rate (WM)	Folds	2.020	2.680	3.480	6.920
Finite rate of natural increase (λ)	Females/day	2.290	1.960	1.720	1.290
Doubling time (DT)	Days	2.980	2.140	1.690	1.090

temperature at which population growth is most favorable. The highest (r_m) was observed at 35°C, indicating this temperature is optimal for the reproduction of *S. litura*, leading to rapid population proliferation. However, the optimal reproductive output and growth rates were observed at 25°C, suggesting this temperature provides the best overall conditions for the reproductive success of *S. litura* on capsicum.

These findings can be used to predict *S. litura* population dynamics at different temperatures under field conditions. While many models, such as the Lotka-Volterra and Nicholson-Bailey models, use (r_m) as a key parameter, the accuracy of these models can be limited by temperature fluctuations in the field. The present study, conducted at various constant temperatures, provides a more comprehensive understanding of *S. litura* population dynamics, offering a rational and predictive basis for pest control under varying environmental conditions.

REFERENCES

Bharathi JL, Sreedar U, Kishore B, Prasad JV and Raju KS 2008. Differential response of types of tobacco to *Spodoptera litura* (Fabricius). *Indian Journal of Entomology* **70**: 123-130.

Birch LC 1948. The intrinsic rate of natural increase in an insect population. *Journal of Animal Ecology* **17**: 15-26.

Brar TS and Sharma S 2017. Influence of temperature and carbon dioxide levels on growth and development of *Spodoptera litura* Fabricius on cauliflower. *Journal of Agrometeorology* **19**(4): 306-311.

Brar TS and Sharma S 2017. Influence of temperature and carbon dioxide levels on growth and development of *Spodoptera litura* Fabricius on cauliflower. *Journal of Agrometeorology* **19**(4): 306-311.

Chi H and Su HY 2006. Age-stage, two-sex life tables of *Aphidius gifuensis* (Ashmead) (Hymenoptera: Braconidae) and its host *Myzus persicae* (Sulzer) (Homoptera: Aphididae) with mathematical proof of the relationship between female fecundity and the net reproductive rate. *Environmental Entomology* **35**: 10-21.

Duraimurugan P 2018. Effect of weather parameters on the seasonal dynamics of tobacco caterpillar, *Spodoptera litura* (Lepidoptera: Noctuidae) in castor in Telangana State. *Journal of Agrometeorology* **20**(2): 139-143.

Farahani S, Naseri B and Talebi A 2011. Comparative life table parameters of the beet armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae) on five host plants. *Journal of Entomological Research Society* **13**: 91-101.

Howe RW 1953. The rapid determination of intrinsic rate of increase of an insect population. *Annals of Applied Biology* **40**: 134-155.

Islam Y, Güncan A, Zhou X, Naeem A and Shah FM 2022. Effect of temperature on the life cycle of *Harmonia axyridis* (Pallas), and its predation rate on the *Spodoptera litura* (Fabricius) eggs. *Scientific Reports* **12**(1): 15303.

Karmakar P and Pal S 2017. Influence of temperature on food consumption and utilization parameters of the common cutworm, *Spodoptera litura* (Fab) (Lepidoptera: Noctuidae). *Journal of Entomology and Zoology Studies* **5**: 92-95.

Maia ADHN, Luiz AJB and Campanhola C 2000. Statistical Inference on Associated Fertility Life Table Parameters Using Jackknife Technique: Computational Aspects. *Journal of Economic Entomology* **93**(2): 511-518.

Meyer JS, Ingersoll CG, McDonald LL and Boyce MS 1986. Estimating uncertainty in population growth rates: Jackknife vs. Bootstrap techniques. *Ecological Society of America* **67**(5): 1156-1166.

Patil RA, Ghetiya LV, Jat BL and Shitap MS 2015. Life table evaluation of *Spodoptera litura* (Fabricius) on bidi tobacco, *Nicotiana tabacum. The Ecosan* **9**: 25-30.

Patil RA, Mehta DM and Jat BL 2014. Studies on Life Fecundity Tables of *Spodoptera Litura* Fabricius on Tobacco *Nicotiana tabacum* Linnaeus. *Entomol Ornithol Herpetol* **3**:118.

Rao MS and Prasad TV 2020. Temperature-based phenology model for predicting establishment and survival of *Spodoptera litura* (Fab.) on groundnut during climate change scenario in India. *Journal of Agrometeorology* **22**(1): 24-32.

Sharma KR, Raju SVS, Singh SK and Chandra U 2024. Impact of crop phenology and environmental factors on rice leaf folder infestation in middle gangetic plains of India. *Indian Journal of Ecology* **51**(4): 837-841.

Sharma S, Kooner R, Sandhu SS and Arora R 2018. Impact of elevated temperature and carbon dioxide on insect performance indices of *Spodoptera litura* Fabricius. *Journal of Entomological Research* **42**(3): 315-324.

Supriya GB, Singh TVK, Sunitha V, Vinod SK and Narendra reddy 2018. Life table study of tobacco caterpillar *Spodoptera litura* (F.) (Noctuidae: Lepidoptera) on different Bt cotton hybrids during 120-150 DAS (days after sowing). *International Journal of Current Microbiology and Applied Science* **7**: 2367-2386.

Watson TF 1964. Influence of host plant conditions on population increase of *Tetranychus telarius* (Linn.) (Acarina: Tetranychidae). *Hilgardia* **35**: 273-322.

Wu CJ, Fan SY, Jiang YH and Zhang AB 2004. Inducing gathering effect of taro on *Spodoptera litura* Fabricius. *Chinese Journal of Ecology* **23**: 172-174.

Yi SJ, Hopkins RJ, Chen XY, Chen ZM, Wang X, Huang GH 2020. Effects of temperature on the development and fecundity of *Microplitis similis* (Hymenoptera: Braconidae), a parasitoid of *Spodoptera litura* (Lepidoptera: Noctuidae). *Physiological Entomology* **45**(2-3): 95-102.

Zakria M, Zaib MS, Abbas K, Sarmad M, Zaka SM and Noor-ul-Ane M 2022. Influence of temperature on the development and reproduction of *Spodoptera litura* (Fabricius) on castor bean: Implications for its use as a trap crop. *Arthropod-Plant Interactions* **16**(5): 505-515.

Zhong T, Gong L, Pan Y, Li J, Lu A, Liu L and Wang L 2024. Performance of *Spodoptera litura* (Lepidoptera: Noctuidae) in responses to different amplitudes of alternating temperatures across permissive warm temperature regimes. *Journal of Economic Entomology* **117**(3): 1041-1046.

Zhu GH, Peng YC, Zheng MY, Zhang XQ, Sun JB, Huang Y and Dong SL 2017. CRISPR/Cas9 mediated *BLOS2* knockout resulting in disappearance of yellow strips and white spots on the larval integument in *Spodoptera litura. Journal of Insect Physiology* **103**: 29-35.

Received 10 September, 2024; Accepted 22 October, 2024