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Studies on the impact of temperature changes on the life-table parameters of *Earias vittella* Fabricius (Lepidoptera: Noctuidae) in Ranchi, Jharkhand.

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Abstract- The spotted bollworm, *Earias vitella* (Fabricius, 1794) is one of the major agricultural pests with a wide range of hosts like sorghum, sunflower, cotton, okra, etc. The current study has been done on the okra host to observe the effect of different constant temperatures (15, 18, 20, 28 ± 1°C with 70±5% RH) in laboratory conditions on the growth and reproduction of *Earias vitella* Fabricius using the age-stage, two-sex life table method. The results showed that *Earias vitella* could complete its entire life cycle on the okra hosts, in different constant temperatures with significantly different developmental and reproduction parameters. The result reveals that the durations of egg, larva, pupa, and adult development were significantly prolonged at lower temperatures whereas they became shorter at higher temperatures. The egg stage has the highest mortality in all temperatures. The incubation period at 15°C is longer (14.08±0.07), while the shortest incubation observed at 28°C (2.71± 0.06). The shortest larval period was calculated at 28°C with 12.54± 0.4 whereas it becomes longest at 15°C with 38.39± 0.41. The oviposition recorded more at 28°C (310.21± 1.23) and lowest fecundity was observed at 20°C (97.66± 0.75). No fecundity was observed at 15 and 18°C. The intrinsic rate of increase and finite rate of increase were significantly different at both temperatures (20 and 28°C). The Net reproductive rate and Gross reproductive rate are also significantly different. The mean generation time decreases as the temperature increases. The results indicate that *Earias vitella* can grow and reproduce normally at higher temperatures, but no reproduction is observed at lower temperatures. (15 and 18°C). Nonetheless, the data show that this pest is harmful when the population density is high.

Key words: *Earias vitella*, Life table, Temperature, Okra, Spotted bollworm, Lepidoptera,

INTRODUCTION

Climate change will be more evident in tropical regions of developing countries like India which are already facing staid challenges for food security and economic development.[1] Future changes in temperature are expected to vary spatially and temporally within the geographical region. This variation in temperature will affect many natural systems that are sensitive to temperature including insect establishment, abundance, and development.[2-6] The insect population growth can be disrupted by the low temperature because a certain threshold temperature is required in each life stage of any insect for its complete growth and development. The life table is a powerful and necessary tool for analyzing the effects of environmental factors on insect survival, growth, development, and reproductive capacity. Insects are able to function faster and more efficiently at higher temperatures and they can feed, develop, reproduce, and disperse more rapidly when the climate is warm.[7] It is well known that temperature directly influences the rate of biochemical reactions and

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strongly influences the growth rate and development of insects.[8] As the insects are poikilothermic in nature, many difficulties can occur when collecting data for the life table of any insect population under multiple conditions.

Moths and butterflies belong to the order Lepidoptera. Among them, moths are common pests on plants.[9] The adults of *Earias vitella* are noctuid moths, and the larvae are caterpillars responsible for the damage (borers). It was reported that *Earias* spp. bore in the plant tissue and are difficult to control once they enter the fruits.[10] *Earias vitella* is reported to cause the most serious losses in okra compared to other pests.[11] A life table concisely summarizes certain vital population statistics.[12] Life tables are useful in the study of insect population dynamics, in that they provide a convenient method for recording and accounting for population changes in the life cycle of an insect. The thermal optimum is the temperature at which a species develops, reproduces and survives optimally.[13] Temperatures lower or higher than the optimum temperature lead to a decrease in the development rate. Temperature in?uences the duration of each instar and the number of instars those larvae go through before reaching the adult stage.[14] During the present investigation, okra and artificial diet suggested by Tamhankar *et al.* (1992)[15] and Gupta *et al.* (2005)[16] were screened for life-table and fecundity of *Earias vitella* when larvae are reared under laboratory conditions. The objective of the present study was to collect appropriate information for constructing life tables for spotted bollworms at different temperatures.

MATERIALS & METHODS

Insect culture

Continuous laboratory cultures of *Earias vitella* were established from the larvae of different larval stages collected from the okra field of ICAR Plandu (Namkum, Ranchi), BAU, Ranchi, and different local markets of Ranchi, Jharkhand. The culture was reared in environmentally controlled conditions under four different temperatures 15, 18, 20, and 28 ± 1°C with 70±5% RH. The insects were supplied with okra (*Abelmoschus esculentus*). And the food was changed on a daily basis to develop into pupa and further into adult ones. Larvae pupated in the white papers kept in the jar, were transferred into another glass beaker. When adults emerged, the moth was reared in pair in a large glass beaker and provided will a cotton ball soaked with 5% honey water solution.

Experimental design

The Insect culture was established at the Laboratory of the University Department of Zoology, Ranchi University, and ICAR Research Centre of Eastern Region, Plandu Ranchi (Jharkhand). The laboratory culture of *Earias vitella* Fabricius was maintained at 15, 18, 20, and 28±1°C with (70±5%) relative humidity (RH).

In order to evaluate the development and reproduction of *Earias vitella* at different constant temperatures, five replicates of 30 eggs (150 total) were placed in 500 mL glass jar and petri dishes with an artificial diet suggested by Gupta *et al.* (2005)[16]. At each temperature treatment, the hatching and survival rates were recorded. Hatched larvae were reared in groups of 20 per 500 mL glass jars on an artificial diet until pupation. Excreta was removed and food was replaced on a daily basis. The duration of larval developmental time from hatching to pupation was recorded and the number of surviving larvae was noted daily. Pupal survival was calculated based on the number of emerging adults. Male and female adults that emerged on the same day were paired and placed in the large glass beaker. The fresh healthy twig of okra was also kept in a conical flask containing water that was placed into the glass beaker. Glass beakers were also provided with white paper for oviposition and 5% honey solution for adult feeding, both were replaced daily. The number of eggs laid per female and adult mortality were recorded daily until all adults died.

Life table

The age-stage, two-sex life table approach was used to analyze the raw life-history data for *Earias vitella*.[17,18] The age-stage-specific survival rate (s_{xj}), Female age-stage-specific fecundity (f_{xj}, daily number of eggs produced by a female at age x and stage j), age-specific fecundity of the total population (m_x, daily number of eggs produced by all females at age x), and age-specific survival rate (lx, probability that the newly oviposited egg will survive to age x) were calculated for each cohort from the daily record of the survival and fecundity of all individuals in the cohort.

Data analysis

According to the age-stage two-sex life table theory,[18] the developmental period survival rate, longevity, and female daily oviposition were analyzed by using the computer program, TWOSEX-MS Chart.[19] (Chi 2016b)7. The parameters of s_{xj}, l_x, f_{xj}, m_x, r, λ, T and R0 were calculated using the bootstrap method included in the

computer programme TWOSEX MS Chart.[20] This program enormously reduces the otherwise complications and simplifies the time-consuming processes involved in the calculation of many parameters.

RESULT

Development time

Earias vitella successfully developed to adulthood in all different constant temperatures from 15°C to 28°C on their natural diet as well as on an artificial diet, however, no egg laying and hatching were observed in 15 and 28°C, indicating that 15°C exceeded the lower threshold. The lowest temperature 15°C caused a significant decrease in the egg hatchability when compared with the 28°C. The incubation period of the egg is longer observed at 15°C, 14.08±0.07, whereas at 28°C it was 2.71 ± 0.036. The larval developmental time varied from 38.39± 0.41 at 15°C to 12.54 ± 0.4 at 28°C. According to the results, larval development of *Earias vitella* was completed in five instars at 15, 18, 20, and 28°C. The Pupal period varied from 50.00± 0.14 at 18°C to 11.05 ± 0.09 at 28°C. Mean total time of development significantly decreased with increasing temperature.

Table 1. Mean developmental time (Days SE) of immature stages of *Earias vitella* reared under different constant temperature

Temperature (ºC)	Egg	L1	L2	L3	L4	L5	Pupa
15	14.08±0.07	10.11±0.09	4.89± 0.08	8.03± 0.08	8.36± 0.07	7.00± 0.09	50.00± 0.14
18	7.59±0.04	8.5 ±0.07	4.41±0.07	6.22±0.09	6.24±0.08	4.69±0.09	48.04±0.09
20	4.26± 0.04	3.51± 0.05	4.1± 0.07	5.03± 0.09	4.66± 0.07	3.93± 0.10	42.06± 0.08
28	2.71± 0.06	2.22± 0.06	2.25± 0.07	2.85± 0.08	2.3± 0.08	2.92± 0.11	11.05± 0.09

The length of the Adult pre-oviposition period (APOP), Total pre-oviposition period (TPOP), and fecundity of *Earias vitella* Fabricius under three constant temperatures were presented in Table 2. The length of APOP was longest at 20°C while the shortest was observed at 28°C, with 20°C > 28°C in turn. In addition, the TPOP was longest at 20°C, with 20°C > 28°C in turn, whereas the shortest length of TPOP was recorded at 28°C. Highest fecundity was recorded at 28°C while the lowest fecundity occurred at 20°C. Many researchers reported different findings about the numbers of an egg laid.

Table 3 shows the life table analysis of various parameters for *Earias vitella* Fabricius at different constant temperatures. 'r' is the useful parameter for describing population dynamics, which includes survival, development, and reproduction.

The 'r' and 'λ' increased significantly with increase in temperature from 20°C to 28°C. R0 of *Earias vitella* was higher at 28°C by recording 57.93 ± 9.88 and lowest at 20°C (22.77 ± 3.37). The reduction of 'T' was recorded at 20°C (30.62 ± 0.31) as compared with 28°C (76.86± 0.25). The higher value of GRR was recorded for 28°C (202.03 ± 23.05) while lower at 20°C (58.28 ± 6.07).

The life span of the male moth was recorded as 6, 13, 19, and 22 days while for the female moth, it was 8, 16, 23, and 25 days respectively on 28, 20, 18, and 15 ± 1°C. The life span of adult females of *Earias vitella* was a little bit longer than that of a male adult. The duration of the life cycle is directly correlated with temperature. The minimum duration of the life cycle was 36-37 days at 28°C and the maximum time was observed 128-129 days at 15°C.

Table 2. APOP, TPOP and Fecundity (Days) of *Earias vitella* under different constant temperature

Temperature (ºC)	APOP	TPOP	Fecundity
20	6.17± 0.13	74.23± 0.24	97.66± 0.75
28	2.07± 0.04	28.32±0.00	310.21± 1.23

(APOP-Adult pre-oviposition period, TPOP- Total pre-oviposition period)

Table 3. Life table parameters of *Earias vitella* at a different constant temperature

Temperature (ºC)	r	λ	R0	T	GRR
20	0.04 ± 0.00	1.04 ± 0.00	22.77 ± 3.37	76.86 ± 0.25	58.28 ± 6.07
28	0.13 ± 0.00	1.14 ± 0.00	57.93 ± 9.88	30.62 ± 0.31	202.03 ± 23.05

(r = intrinsic rate of increase, ë= finite rate of increase, R0 = net reproductive rate, T = mean generation time, GRR = Gross Reproductive Rate)

Table 4. Adult lifespan and complete lifecycle (Days) of *Earias vitella* Fabricius.

Temperatures (°C)	Adult life span (Days)		Complete life cycle (Days)	
	Male	Female	Male	Female
15	22	25	128	129
18	19	23	107	111
20	13	16	83	86
28	6	8	36	37

DISCUSSION

The construction of life tables is an important tool for understanding the population dynamics of an insect. It serves as a framework for organizing dates on mortality and natality. It brings about simple summary statistics such as life expectancy and reproduction rate. From the angle of pest management, it is very useful to know when (and why) a pest population suffers high mortality. This is usually the time when it is the most vulnerable. By knowing such vulnerable stages from the life table, we can make time-based applications of insecticides for insect pest management.

The population stage structures of insect pests are susceptible to various environmental factors like temperature, humidity, rainfall, pesticides, food sources, natural enemies, etc. The adult male and females, and larvae are the most common developmental stages that are widely studied to correlate such effectiveness.[21] The author used an array of environmentally controlled conditions of four different rearing temperatures 15, 18, 20, and 28 ± 1°C with 70±5% RH to examine the effects on the life table parameters of *E. vittella.* Results clearly depicted that the temperature significantly influence the entire lifespan of insects. The entire lifespan of males, females, and unknown sex in the experimental cohort gradually decreased as temperatures increased from 15 to 28°C. Various reports depicted that as temperature increases the increase in female fecundity occur in various other insects.[22,23] At 15 and 18°C the fecundity of *E. vitella* was not observed but as temperature increases by 20 and 28°C the fecundity increases (Table 2). Huang and Chi (2012)[24] said that the *r value* was introduced as a useful concept for studying insect populations. According to the life table theory, a population was increasing only when $Ro > 1$ and $r > 0$.[25] In the present study, $Ro > 1$ and $r > 0$ only from 20°C to 28°C, indicating that the *E. vitella* population increased in this temperature range; the *E. vitella* population could not increase, however, when $r < 0$ at 15 and 18°C (Table 3). The bootstrap technique was used to estimate the means and variance of the population parameters. The highest *Ro* value for *E. vitella* (57.93) was found in the 28°C experimental group. Among the other population parameters, the intrinsic rate of increase (r) is a critical demographic element for determining levels of environmental resistance to insects.[26] Contrasting the *Ro* and *r values* invariably yields considerable insight beyond that obtainable from independent analysis of individual life-history parameters.[27] Conversely, the life table values found in the 15°C, and 18°C temperature regimes revealed that these conditions were unfavorable to the pest because their life cycle was completed in about 129 and 111 days, respectively in females, while in males it was 128 and 107 days, respectively. Therefore, the temperature proved to be a vital parameter for the fecundity of *E. vitella* as per the data in the above tables of this article.

CONCLUSION

The effect of changing the temperature of the insect affects the life cycle of the insect. Based on the result of this research, it is concluded that the female fecundity of *E. vitella* is reflected in the special range of temperature.

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