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Life Table Studies of *Menochilus sexmaculatus* Fabr. (Coleoptera: Coccinellidae) at Varying Temperature on *Lipaphis erysimi* Kalt

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Abstract: A gauge on the age specific life table of *Menochilus sexmaculatus* at varying temperature (20±1°C, 24±1°C and 28±1 °C) revealed that it took shortest development period (41 days) at 28±1 °C and longest (49 days) at 20±1 °C. There was an undulating pattern of mortality was observed at different age intervals with varying temperature. However, a sharp decline in expectation of life (e_x) towards the end of generation was seen specifically at 28±1 °C as compared to other temperatures. As far as stage specific life table was concerned, the development stages of *M. sexmaculatus* attained minimum apparent, indispensable mortality, mortality survival ratio and maximum survival at 20±1°C as well as 24±1 °C. Similarly, the total generation mortality (K) was recorded minimum (0.2441) at 24±1 °C followed by (0.2597) 20±1 °C and (0.3010) 28±1 °C. The present study exhibited that among three different constant temperatures, 20±1 °C followed by 24±1 °C has been proved as a most suitable for the development of *M. sexmaculatus*.

Key words: Ladybird · Life table · Mustard aphid · Temperature

INTRODUCTION

Mustard aphid, *Lipaphis erysimi* (Kaltenbach) recorded as a notorious pest of rapeseed and mustard throughout the globe. It causes damage directly by sucking cell sap and indirectly as vectors of certain plant viruses [1]. Ladybird beetles occupy a prominent position as predators of this aphid species all over the world. Beside aphids, it also feed on many soft bodied insects such as whiteflies, coccids, thrips, mites, adelgids, psyllids, mealy bugs and scale insects, but when they are missing the coccinellids eat fungal spores, pollen and nectar as alternative foods [2-4].

Life table study provides detailed information on population dynamics, which generate simple and more informative statistics. It also gives a comprehensive description of the survivorship, development, mortality and life expectancy [5, 6]. The life-table data of predators at different temperature gives an important task for pest management. In present investigation, an attempt has been made to construct age and stage specific life table of *Menochilus sexmaculatus* at three different constant temperatures on *L. erysimi*.

MATERIALS AND METHODS

Aphid and Ladybeetle Culture: Indian mustard, *Brassica juncea* L. was grown in a plot sized 10 x 10 m at the experimental field of Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, during winter seasons of year 2005-06. Each plot was replicated thrice and exposed to natural infestation of aphids. The aphid commenced their attack initially on Indian mustard plants in the month of November, 2005. They were collected and identified as *Lipaphis erysimi* Kalt. from the Laboratory of Aphidology, Department of Zoology, University of Kalyani, West Bengal, India. On the other hand, a ladybeetle complex was also found to be associated with aphid colonies. Of which, *M. sexmaculatus* was recorded to be dominating species.

The pairs of *M. sexmaculatus* were collected from the field and brought to the laboratory. Each pair was kept in separate Petri dishes (90 x 10 mm) and placed in the BOD incubator. A blotting paper was spread over the inner surface of Petri dishes for egg laying. Fresh infested cut twigs of Indian mustard plant were provided as food to adult *M. sexmaculatus* daily. The eggs laid by females were counted and transferred in other Petri dishes

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with the help of soft camel hair brush. Further, counted number of zero day old eggs (approximately 1000) obtained from female *M. sexmaculatus* were placed in Petri dishes and allowed to hatch at a constant temperature (20 ± 1°C). However, for construction of life tables of *M. sexmaculatus* at varying temperature, eggs were also placed at 24 ± 1°C and 28 ± 1°C calibrated with 65 ± 5 % RH and 12L:12D photometer maintained in BOD incubator. Hatching percentage was recorded from each aliquot and subsequently adjusted, so that life-table commenced with 100 eggs in a cohort.

One hundred same aged grubs of *M. sexmaculatus* were collected from the hatched eggs. These were individually reared on *L. erysimi* at varying temperature in plastic vials (4.0 x 6.0 cm). Initially, counted number of first and second instar nymphs of *L. erysimi* was provided as food to the early instar larvae of *M. sexmaculatus*. Thereafter, with an advancement in the age of larvae, third and fourth instar nymphs were supplied. The number of supplied aphids was also increased subsequently up to 100 nymphs daily. The exuvae found in vials was removed soon after the grubs entered into next instar. This procedure was followed till pupation. After the emergence of adults (male and female), they were again provided with a minimum of 100 nymphs/day till their death.

Life Table Construction

Age Specific Life-Table: Observations on number of alive and dead out of hundred larvae were recorded daily. The following assumptions were used in the construction of age specific life-table of *M. sexmaculatus*.

- x = Age of the insect in days.
- l_x = Number surviving at the beginning of each interval, out of 100
- d_x = Number dying during the age interval, out of 100
- $100q_x$ = Mortality rate at the age interval x and calculated by using formula
- $100q_x$ = $[d_x / l_x] \times 100$
- e_x = Expectation of life or mean life remaining for individuals of age x Life expectation was calculated using the equation

$$e_x = T_x / l_x$$

To obtain e_x two other parameters L_x and T_x were also computed as below.

- L_x = The number of individuals alive between age x and x + 1 and calculated by the equation.
- L_x = $l_x + 1 (x + 1) / 2$
- T_x = The total number of individual of x age units beyond the age x and obtained by the equation;

$$T_x = l_x + (l_x + 1) + (l_x + 2) \ldots\ldots\ldots\ldots\ldots\ldots + l_w.$$

Where, l_w = The last age interval.

Stage Specific Life-Table: Data on stage specific survival and mortality of eggs, larvae, pupae and adults of *M. sexmaculatus* were recorded from the age specific life-table. Following standard heads were used to complete stage specific life table.

- x = Stage of the insect.
- l_x = Number surviving at the beginning of the stage x.
- d_x = Mortality during the stage indicated in the column x.

The data calculated through above assumptions were used for computing various life parameters as given below:

Apparent Mortality (100 q_x): It gives the information on number dying as percentage of number entering that stage and was calculated by using the formula:

$$\text{Apparent Mortality} = [d_x / l_x] \times 100$$

Survival fraction (Sx): Data obtained on apparent mortality was used for the calculation of the stage specific survival fraction (Sx) of each stage by using the equation:

Sx of particular stage = [l_x of subsequent stage] / [l_x of particular stage].

Mortality Survivor Ratio (MSR): It is the increase in population that would have occurred if the mortality in the stage, in question had not occurred and was calculated as follows:

MSR of particular stage = [Mortality in particular stage] / [l_x of subsequent stage]

Indispensable Mortality (IM): This type of mortality would not be there in case the factor (s) causing it is not allowed to operate. However, the subsequent mortality factors operate. The equation is,

IM = [Number of adults emerged]
x [M.S.R. of particular stage]

***k-values*:** It is the key factor, which is primarily responsible for increase or decrease in number from one generation to another and was computed as the difference between the successive values for "log l_x". However, the total generation mortality was calculated by adding the k-values of different development stages of the insect, which is designated/ indicated as "K" [7, 8].

$$K = k_E + k_{L1} + k_{L2} + k_{L3} + k_{L4} + k_{PP} + k_P$$

Where, k_E, k_{L1}, k_{L2}, k_{L3}, k_{L4}, k_{PP} and k_P are the k-values at egg, first instar, second instar, third instar, fourth instar, pre-pupal and pupal stage of *M. sexmaculatus*.

RESULT AND DISCUSSION

Age Specific Life-Table: The age specific life table of *M. sexmaculatus* at varying temperature revealed that it took shortest development period of 41 days at 28±1°C followed by 47 days 24±1°C and longest 49 days at 20±1°C (Fig. 1). There was no set pattern of the mortality was observed at different age intervals at each temperature regimes. Yet, it showed some high peaks of mortality on 6, 11, 30, 38, 42 and 46 day at 20±1°C. Further, the high mortality was encountered on 1, 6, 9, 21, 31, 37 and 41 day at 24±1 °C and 1, 8, 27 and 34 day at 28±1°C. Interestingly, a sharp decline in life expectancy (e_x) towards the end of generation was seen specifically at 28±1 °C as compared to other temperatures. A negligible increase in e_x was, nonetheless, observed on 7, 8, 12, 13 and 31 day at 20±1°C; 2, 7, 10 and 32 day at 24±1°C and 2, 5, 9 and 28 day at 28±1 °C (Fig. 1). The trend in e_x of observations was found akin as reported on *Creatonotus gangis* [9].

Stage Specific Life-Table

Apparent Mortality: The minimum apparent mortality (9.00), at egg stage, was obtained at 20±1 °C and maximum (10.00 %) at 24±1 °C as well as 28±1 °C. As far as larval instars were concerned, third instar recorded the lowest mortality (4.35 %) at 24±1 °C. However, the highest apparent mortality (14.44 %) was evidenced at first instar at 24±1 °C and 28±1 °C. On the other hand, at pre-pupal stage, the minimum mortality (3.17 %) was encountered at 24±1 °C, comparing maximum (5.36 %) at 28±1 °C. Similarly,at pupal stage, it remained minimum (5.17 %) at 20±1 °C and maximum (6.56 %) at 24±1 °C (Table 1).

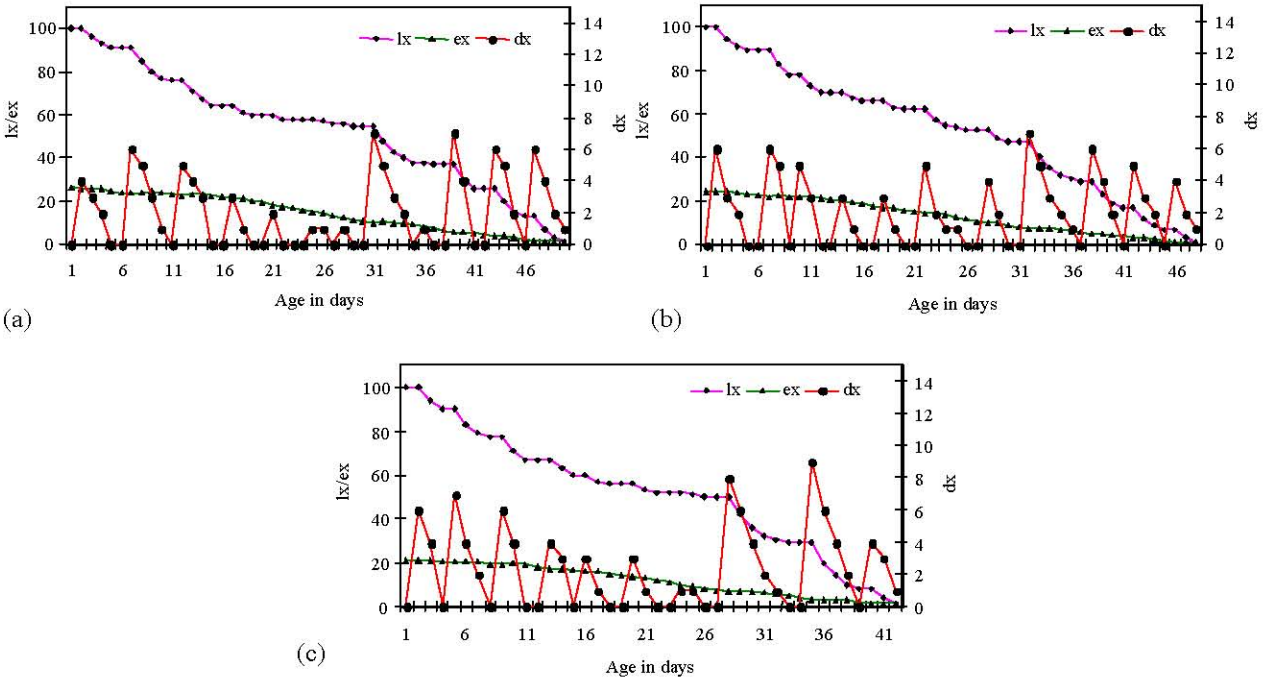

Fig. 1: Age specific survivorship, mortality and life expectancy of *Menochilus sexmaculatus* on *Lipaphis erysimi* at varying temperature (20±1°C, 24±1 °C and 28±1°C)

Table 1: Stage specific survival and mortality of *Menochilus sexmaculatus* on *Lipaphis erysmi* at varying temperature (20±1°C, 24±1°C and 28±1°C)

Stage x	No. surviving at the beginning of the stage l_x	No. dying in each stage d_x	Apparent mortality $100q_x$	Survival fraction Sx	Mortality/ survivor ratio MSR	Indispensable mortality IM	log l_x	k-values
20 ± 1 °C								
Egg	100.00	9.00	9.00	0.91	0.10	5.44	2.00	0.0410
First instar	91.00	11.00	12.09	0.88	0.14	7.56	1.96	0.0560
Second instar	80.00	9.00	11.25	0.89	0.13	6.97	1.90	0.0518
Third instar	71.00	7.00	9.86	0.90	0.11	6.02	1.85	0.0451
Fourth instar	64.00	4.00	6.25	0.94	0.07	3.67	1.81	0.0280
Pre-pupa	60.00	2.00	3.33	0.97	0.03	1.90	1.78	0.0147
Pupa	58.00	3.00	5.17	0.95	0.05	3.00	1.76	0.0231
Adult	55.00	55.00	100.00	--	--	--	1.74	--
								K=0.2596
24 ± 1 °C								
Egg	100.00	10.00	10.00	0.90	0.11	6.33	2.00	0.0458
First instar	90.00	13.00	14.44	0.86	0.17	9.62	1.95	0.0678
Second instar	77.00	8.00	10.39	0.90	0.12	6.61	1.89	0.0476
Third instar	69.00	3.00	4.35	0.96	0.05	2.59	1.84	0.0193
Fourth instar	66.00	3.00	4.55	0.95	0.05	2.71	1.82	0.0202
Pre-pupa	63.00	2.00	3.17	0.97	0.03	1.87	1.80	0.0140
Pupa	61.00	4.00	6.56	0.93	0.07	4.00	1.79	0.0295
Adult	57.00	57.00	100.00	--	--	--	1.76	--
								K=0.2441
28 ± 1 °C								
Egg	100.00	10.00	10.00	0.90	0.11	5.56	2.00	0.0458
First instar	90.00	13.00	14.44	0.86	0.17	8.44	1.95	0.0678
Second instar	77.00	10.00	12.99	0.87	0.15	7.46	1.89	0.0604
Third instar	67.00	7.00	10.45	0.90	0.12	5.83	1.83	0.0479
Fourth instar	60.00	4.00	6.67	0.93	0.07	3.57	1.78	0.0300
Pre-pupa	56.00	3.00	5.36	0.95	0.06	2.83	1.75	0.0239
Pupa	53.00	3.00	5.66	0.94	0.06	3.00	1.72	0.0253
Adult	50.00	50.00	100.00	--	--	--	1.70	--
								K=0.3010

The early larval instars were much delicate than the later instars and hence, showed higher mortality at first instar stage than last instars [10, 11].

Survival Fraction: At egg stage, *M. sexmaculatus* exhibited maximum Sx (0.91), at 20±1 °C and minimum (0.90) at 24±1 °C as well as 28±1 °C. While comparing larval instars, the highest Sx (0.96) was recorded at third instar at 24±1 °C and lowest (0.86) at first instar at 24±1 °C and 28±1 °C (Table 1). At pre-pupal stage, the fraction was found maximum (0.97) at 20±1 °C and 24±1 °C. In contrast, the minimum survival (0.95) of pre-pupa was recorded at 28±1 °C. Similarly, pupal survival was higher (0.95) at 20±1 °C as compared to lower (0.93) at 24±1 °C (Table 1). The trends for the survival faction of this ladybird species are similar as reported in *C. septempunctata* and *C. transversalis* [12].

Mortality Survivor Ratio: While calculating the ratio between mortality and survival of *M. sexmaculatus*, at egg stage, it attained minimum MSR (0.10) at 20±1 °C and maximum (0.11) at 24±1 °C as well as 28±1 °C. Among different larval instars, the third and fourth instar showed lowest MSR (0.05) at 24±1 °C as compared to highest MSR (0.17) at first instar at 24±1 °C and 28±1 °C. When pre-pupal stage was examined, the minimum MSR (0.03) was obtained at 20±1 °C and 24±1 °C in contrast to maximum (0.06) at 28±1 °C. However, at pupal stage, it remained lowest (0.05) at 20±1 °C and highest (0.07) at 24±1 °C (Table 1).

Indispensable Mortality: At egg stage, minimum IM (5.44) was recorded at 20±1 °C and maximum (6.33) at 24±1 °C. As far as larval instars were concerned, the IM remained minimum (2.59) at third instar at 24±1 °C and maximum (9.62) at first instar at 24±1 °C. Whereas, at pre-pupal, lowest IM was recorded as 1.87 at 24±1 °C and highest as 2.83 at 28±1 °C. Similarly, the pupa of *M. sexmaculatus* attained minimum IM (3.00) at 20±1 °C and maximum (4.00) at 24±1 °C (Table 1). The report on indispensable mortality of cabbage butter fly, *Pieris brassicae* is available [13].

***k-values*:** The egg stage of *M. sexmaculatus* obtained minimum (0.0410) k value at 20±1 °C followed by maximum (0.0458) at 24±1 °C as well as 28±1 °C. With respect to larval instars, it remained lowest (0.0193) at third instar at 24±1 °C. In contrast the highest k (0.0768) was recorded at first instar at 24±1 °C and 28±1 °C. Similarly, minimum (0.0140) and maximum (0.0239) 'k', at pre-pupal stage were obtained at 24±1 °C and 28±1 °C, respectively. At pupal stage, the lowest 'k' (0.0231) was recorded at 20±1 °C as compared to highest (0.0295) at 28±1 °C. On the other hand, the total generation mortality was, however, recorded minimum (K=0.2441) at 24±1 °C followed by (0.2596) at 20±1 °C and (K=0.3010) at 28±1 °C (Table 1). Alike trend of mortality was also reported in *Propylea dissecta* [14].

The present study accomplished that among three different temperatures (20±1°C, 24±1°C and 28±1 °C), 20±1°C and 24±1 °C has been proved as a most suitable for superior development and maximum survival. However, the minimum mortality of *M. sexmaculatus* on *L. erysimi* was also recorded at 20±1°C as well as 24±1 °C. Therefore, *M. sexmaculatus* can be mass multiplicated at given temperature for their successful evaluation in biological control program against aphid and other soft bodied insects.

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