World Journal of Agricultural Sciences 6 (3): 268-273, 2010
ISSN 1817-3047
© IDOSI Publications, 2010

Age and Stage Specific Life Table of *Coocinella septemounctata* (Coleoptera: Coccinellidae) at Varying Temperature

Arshad Ali and Parvez Qamar Rizvi

Department of Plant Protection, Faculty of Agricultural Sciences,
Aligarh Muslim University, Aligarh

Abstract: The data on age and stage specific life-table of *C. septempunctata* at varying temperature revealed that it took maximum period (68 days) to complete generation at 20±1°C followed by (61 days) at 24±1°C and (53 days) at 28±1°C. The survivorship and mortality curve showed an irregular pattern with sharp high peaks and negative low peaks. The expectancy of life exhibited a continuous decline with advancement of age. As far as stage specific life table concerned, the developmental stages of *C. septempunctata* showed highest survivor fraction and lowest apparent mortality, mortality survival ratio, indispensable mortality and k-values at low temperature as compared to high. On the other hand, minimum total generation mortality (K) was recorded (0.1079) at 24±1°C followed by (0.2076) 20±1°C and (0.2676) 28±1°C. The study revealed that among three different constant temperatures, 24±1 °C has been proved as a most suitable for the life cycle of *C. septempunctata*.

Key words: *Coccinella septempunctata* · Ladybeetle · Life table · *Lipaphis erysimi* · Temperature

INTRODUCTION

Ladybirds are well known and diverse group of insect feeding beetles. They are found in many habitats, including fields, gardens, forest, sea coast, mountains and cities [1, 2]. Both adult and larvae can feed on a variety of soft bodied herbivourous pests, including aphids, whiteflies, adelgids, psyllids, mealy bugs and scale insects, but when they are missing the coccinellids eat fungal spores, pollen and nectar as alternative foods [1,3-5]. Among different species of ladybeetles, *C. septempunctata* is a most common throughout the India [3, 6].

In ecological study, life table is a most important analytical tool, which provides detailed information of population dynamics to generate simple but more informative statistics. It also gives a comprehensive description of the survivorship, development and expectation of life [7]. The collection of data on life-table at different temperature gives an important task for pest management in different environmental conditions [6,1]. Therefore, in present investigations, age and stage specific life table of *C. septempunctata* were evaluated on mustard aphid, *Lipaphis erysimi* at varying temperature.

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, *C. septempunctata* was recorded to be dominating species.

The pairs of *C. septempunctata* 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 beetles daily. The eggs laid by females were counted

Corresponding Author: Arshad Ali, Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh

and transferred in other Petri dishes with the help of soft camel hair brush. Further, counted number of zero day old eggs (approximately 1000) obtained from female *C. septempunctata* were placed in Petri dishes and allowed to hatch at a constant temperature (20±1°C). However, for construction of life tables of *C. septempunctata* 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 *C. septempunctata* 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 *C. septempunctata*. Thereafter, with an advancement of age of the 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 *C. septempunctata*.

$$100q_x = [d_x / l_x] \times 100$$

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

$$e_x = T_x / l_x$$

e_x = Expectation of life or mean life remaining for individuals of age x

Life expectation was calculated using the equation

$$L_x = l_x + 1\ (x + 1) / 2$$

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.

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

Where, l_w = The last age interval.

T_x = The total number of individual of x age units beyond the age x and obtained by the equation;

Stage Specific Life-Table: Data on stage specific survival and mortality of eggs, larvae, pupae and adults of *C. septempunctata* 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:

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 "Iog 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" [9, 10].

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

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 *C. septempunctata*.

RESULS AND DISCUSSION

Age Specific Life-Table: The data on age specific life-table at varying temperature revealed that the *C. septempunctata* required maximum 68 days to complete the entire generation at 20±1°C followed by 61 days at 24±1°C and 53 days at 28±1°C (Fig. 1-3). The longest development period of *C. septempunctata* was recorded at low temperature and shortest at high temperature [4, 11]. The survivorship and mortality curve showed an irregular pattern with sharp high peaks on 2, 6, 49 and 61 day at 20±1°C; 34, 41, 47 and 54 day at 24±1°C and 6, 30, 36 and 45 day at 28±1 °C. However, the negative low peaks (nil mortality) were recorded on 20, 24, 32, 40 and 63 day at 20±1°C; 23 and 44 day at 24±1°C and 23 day at 28±1°C. On the other hand, the life expectancy (e_x), exhibited a steady decline at early stage of development of *C. septempunctata* at all temperatures. The negligible increase in e_x was, however, recorded on 3, 7, 8, 12, 13, 57, 58 and 62 day at 20±1°C; 6, 35, 48 and 49 day at 24±1°C and 7, 8, 9, 14, 37 and 47 day at 28±1°C, it plummeted sharply at 28±1°C than 20±1°C (Fig. 1-3). The trend of observations was found akin as reported by Chenchaiah on *Creatonotus gangis* [12].

Stage Specific Life-Table

Apparent Mortality: At egg stage, the apparent mortality was observed maximum (10.00 %) at 28±1°C and minimum (6.00 %) at 24±1 °C. When a comparison was made between larval instars, the highest mortality (12.66 %) was observed at 28±1 °C at second instar, whereas, minimum death (1.23 %) was recorded at fourth instar at 24±1 °C. Similarly, the apparent mortality at pre-pupal and pupal stages remained maximum (3.39 and 5.26 %, respectively) at 28±1 °C and minimum (1.25 and 1.27 %, respectively) at 24±1 °C (Tables 1-3). In present investigations, the early larval instars were much delicate than the later instars and hence, showed higher mortality at first instar stage [3, 13, 14]. However, in another experiment, the survival and mortality of *Hippodamia convergens* at four temperature ranges showed decreased mortality of coccinellid species with increase in the temperature [15].

Survival Fraction: Survival fraction (Sx) was found maximum (0.94), at egg stage, at 24±1°C and minimum (0.90) at 28±1°C. Among larval instars, the Sx remained highest (0.99) at fourth instar at 24±1°C and lowest (0.87) at second instar stage at 28±1°C. At pre-pupal and pupal stage, the maximum Sx (0.99) was obtained at 24±1°C in contrast to minimum (0.97 and 0.95, respectively) at 28±1°C (Tables 1-3). Similarly, in another experiment much higher survival of *C. septempunctata* and *C. transversalis* was recorded at 20°C than other temperatures [8, 16].

Mortality Survivor Ratio: Mortality survival ratio (MSR), at egg stage, was found maximum (0.11) at 28±1°C and minimum (0.06) at 24±1°C. Among larval instars, the maximum MSR (0.14) was observed at first as well as second instar at 28±1°C. On the other hand, the minimum (0.01) ratio was obtained at fourth instar at 24±1°C. Furthermore, when pre-pupal and pupal stages were examined, the respective highest MSR figures were evaluated as 0.04 and 0.06 at 28±1°C and lowest (0.01) at 24±1°C (Tables 1-3). The observations on the mortality performance of above coccinellid species showed corroboration with other findings [17, 18].

Indispensable Mortality: Indispensable mortality (IM), at egg stage was recorded maximum (6.13) at 20±1°C and minimum (4.98) at 24±1°C. While comparing IM between larval instars, it remained maximum (7.83) at second instar at 28±1°C, whereas, the lowest value (0.98) was encountered at fourth instar at 24±1°C. Likewise, the IM for pre-pupae and pupae were recorded maximum (1.94 and 3.00) at 20±1°C and 28±1°C, respectively. Whereas, the minimum IM (0.99 and 1.00) of corresponding stages were recorded at 24±1°C (Table 1-3).

k-values: At egg stage, the k-value was found maximum (0.0458) at 28±1°C and minimum (0.0269) at 24±1°C. While comparing larval instars, it revealed highest 'k' (0.0558) at second instar at 28±1°C and lowest (0.0054) at fourth instar at 24±1°C. At pre-pupal and pupal stage,

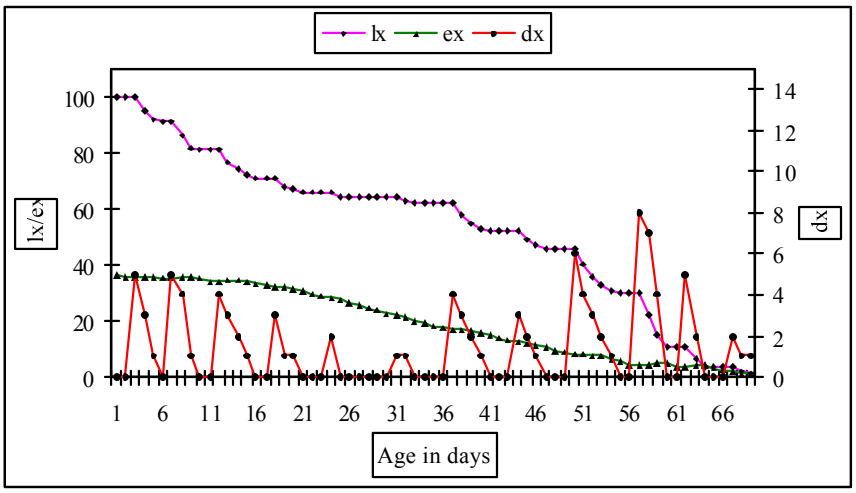

Fig. 1: Age Specific Survivorship (Ix), Death (dx) and Life Expectancy (ex) of *Coccinella septempunctata* on *Lipaphis erysimi* at 20±1ºC

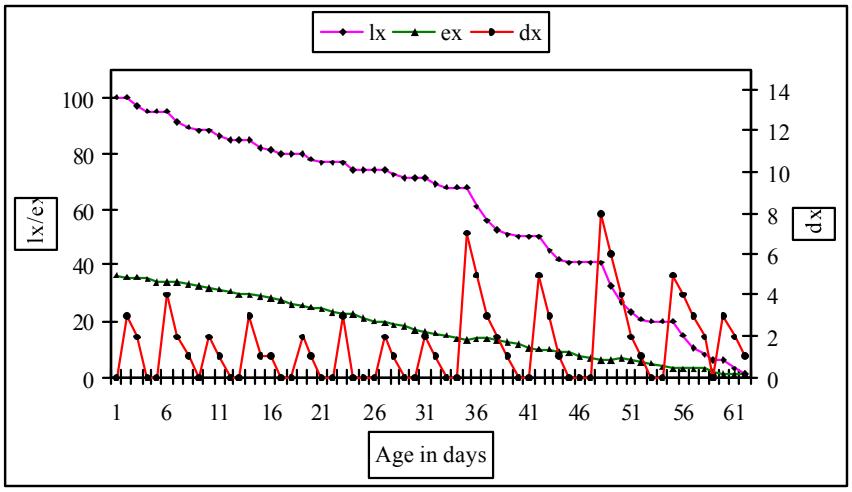

Fig. 2: Age Specific Survivorship (Ix), Death (dx) and Life Expectancy (ex) of *Coccinella septempunctata* on *Lipaphis erysimi* at 24±1ºC

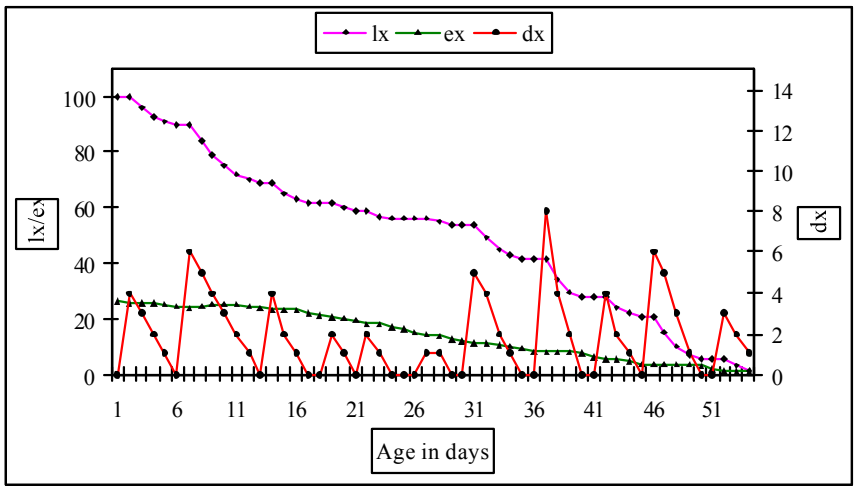

Fig. 3: Age Specific Survivorship (Ix), Death (dx) and Life Expectancy (ex) of *Coccinella septempunctata* on *Lipaphis erysimi* at 28±1ºC

Table 1: Stage specific life table of *Coccinella septempunctata* on *Lipaphis erysimi* at 20±1ºC

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
Egg	100.00	9.00	9.00	0.91	0.10	6.13	2.00	0.0410
First instar	91.00	10.00	10.99	0.89	0.12	7.65	1.96	0.0506
Second instar	81.00	7.00	8.64	0.91	0.09	5.86	1.91	0.0393
Third instar	74.00	6.00	8.11	0.92	0.09	5.47	1.87	0.0367
Fourth instar	68.00	2.00	2.94	0.97	0.03	1.88	1.83	0.0130
Pre-pupa	66.00	2.00	3.03	0.97	0.03	1.94	1.82	0.0134
Pupa	64.00	2.00	3.13	0.97	0.03	2.00	1.81	0.0138
Adult	62.00	62.00	100.00	--	--	--	1.79	--
								---------- K=0.2076

Table 2: Stage specific life table of *Coccinella septempunctata* on *Lipaphis erysimi* at 24±1ºC

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
Egg	100.00	6.00	6.00	0.94	0.06	4.98	2.00	0.0269
First instar	94.00	7.00	7.45	0.93	0.08	6.28	1.97	0.0336
Second instar	87.00	3.00	3.45	0.97	0.04	2.79	1.94	0.0152
Third instar	84.00	3.00	3.57	0.96	0.04	2.89	1.92	0.0158
Fourth instar	81.00	1.00	1.23	0.99	0.01	0.98	1.91	0.0054
Pre-pupa	80.00	1.00	1.25	0.99	0.01	0.99	1.90	0.0055
Pupa	79.00	1.00	1.27	0.99	0.01	1.00	1.90	0.0055
Adult	78.00	78.00	100.00	--	--	--	1.89	--
								---------- K=0.1079

Table 3: Stage specific life table of *Coccinella septempunctata* on *Lipaphis erysimi* at 28±1ºC

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
Egg	100.00	10.00	10.00	0.90	0.11	6.00	2.00	0.0458
First instar	90.00	11.00	12.22	0.88	0.14	7.52	1.95	0.0566
Second instar	79.00	10.00	12.66	0.87	0.14	7.83	1.90	0.0588
Third instar	69.00	7.00	10.14	0.90	0.11	6.10	1.84	0.0465
Fourth instar	62.00	3.00	4.84	0.95	0.05	2.75	1.79	0.0215
Pre-pupa	59.00	2.00	3.39	0.97	0.04	1.89	1.77	0.0150
Pupa	57.00	3.00	5.26	0.95	0.06	3.00	1.76	0.0235
Adult	54.00	54.00	100.00	--	--	--	1.73	--
								---------- K=0.2676

k-value remained the maximum (0.0150 and 0.0235, respectively) at 28±1°C and minimum (0.0055) at 24±1°C for corresponding stages. The total generation mortality 'K' was recorded maximum (0.2676) at 28±1°C and minimum (0.1079) at 24±1°C (Tables 1-3). Similar trend of mortality was recorded on *Propylea dissecta* [19].

Despite the facts it could be concluded that among different temperatures (20±1, 24±1 and 28±1°C), 24±1°C has been proved as a most suitable for superior development, maximum survival and minimum mortality on *L. erysimi*. Therefore, *C. septempunctata* can be mass multiplicated at given temperature for their successful evaluation in biological control program against different soft bodied insects.

ACKNOWLEDMENTS

Authors are highly grateful to Professor Samiran Chakraborty, Department of Zoology, University of Kalyani, West Bengal, for identifying aphid species and also thankful to the Chairman, Department of Plant Protection, Faculty of Agricultural Sciences, for providing necessary facilities during this research.

REFERENCES

1. Ali, A. and P.Q. Rizvi, 2009. Life table studies of *Menochilus sexmaculatus* Fabr. (Coleoptera: Coccinellidae) at varying temperature on *Lipaphis erysimi* Kalt. World Applied Science Journal, 7: 897-901.
2. Hodek, I. and A. Honek, 1996, Ecology of Coccinellidae, Boston: Kiuwer Academic, pp: 464.
3. Ali, A. and P.Q. Rizvi, 2007a, Development and predatory performance of *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) on different aphid species, Journal of Biological Sciences, 7: 1478-1483.
4. Ali, A. and P.Q. Rizvi, 2008a, Influence of aphid species on the development and predation of *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinellidae), Journal of Eco-friendly Agriculture, 3: 134-137.
5. Ali, A., P.Q. Rizvi and M. Pathak, 2009. Reproductive performance of *Coccinella transversalis* Fabricius (Coleoptera: Coccinellidae) on different aphid species, Biosystematica, 3: 37-41.
6. Ali, A. and Rizvi, P.Q., 2008b, Effect of varying temperature on the survival and fecundity of *Coccinella septempunctata* (Coleoptera: Coccinellidae) fed on *Lipaphis erysimi*, Journal of Entomology, 5: 133-137.
7. Ali, A. and P.Q. Rizvi, 2007b, Age specific survival and fecundity table of *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) on different aphid species, Annals of Plant Protection Sciences, 15: 329-334.
8. Ali, A. and P.Q. Rizvi, 2008c, Effect of varying temperature on the development and predation of *Coccinella transversalis* F. (Coleoptera: Coccinellidae) on *Lipaphis erysimi* (Kaltenbach), Trends in Bioscience, 1: 18-21.
9. Southwood, T.R.E., 1978, Ecological methods with particular reference to study of insect population, The English Language Book Society and Chapman and Hall, London, pp: 524.
10. Varley, G.C. and G.R. Gradwell, 1960, Key factors in population studies, Journal of Animal Ecology, 29: 399-401.
11. Naqvi, N.A., 2003. Insect pest management strategies in *Brassica compestris* variety brown sarson with special reference to bio-ecological studies on potential predators of *Lipaphis erysimi* (Kaltenbach), *Ph.D. Thesis, Department of Plant Protection, Faculty of Agricultural Sciences, A.M.U., Aligarh.*
12. Chenchaiah, K.C., P. Mandal and A.K. Bhattacharya, 2007, Life tables and stable-age distribution of *Creatonotus gangis* (Lepidoptera: Arctiidae) on artificial diet, Journal of Eco-Friendly Agriculture, 2: 26-32.
13. Dreyer, B.S., P. Neuenschwander, B. Bouyjou, J. Baumgartner and S. Dorn, 1997, The influence of temperature on the life table of *Hyperaspis notata*, Entomologia Experimentalis et Applicata, 84: 85-92.
14. Padmalatha, C., A.J.A.R. Singh and C. Jeyapauld, 2003. Predatory potential of syrphid predators on banana aphid, *Pentalonia nigronervosa* Coq, Journal of Applied Zoology, 14: 140-143.
15. Rodriguez-Saona, C. and J.C. Miller, 1999, Temperature-dependant effects on development, mortality and growth of *Hippodamia convergens* (Coleoptera: Coccinellidae), Environmental Entomology, 28: 518-522.
16. Katsarou, I., J.T. Margaritopoulos, J.A. Tsitsipis, D.C. Perdikis and K.D. Zarpas, 2005. Effect of temperature on development, growth and feeding of *Coccinella septempunctata* and *Hippodamia convergens* reared on the tobacco aphid, *Myzus persicae nicotianae*, Bio. Control., 50: 565-588.
17. Butler, G.D., 1982, Development time of *C. septempunctata* in relation to constant temperatures (Coleoptera: Coccinellidae), Entomophaga, 27: 349-353.
18. Rai, M.K., Ramamurthy and P.K. Singh, 2002, Biological attributes and morphmetrics of *Coccinella septempunctata* (L.) (Coleoptera: Coccinellidae), Annals of Plant Protection Science, 10: 194-197.
19. Omkar and Pervez, A., 2004. Temperature-dependant development and immature survival of an aphidophagous ladybeetle, *Propylea dissecta* (Mulsant), Journal of Applied Entomology, 128: 510-514.