Age and Stage Specific Life-Table of *Coccinella transversalis* with Regards to Various Temperatures

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ABSTRACT

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The age specific life-table of *Coccinella transversalis* at various temperatures reveals that it took maximum period of 60 days to complete a generation at 20 ± 1°C followed by 56 days at 24 ± 1°C and 50 days at 28 ± 1°C. The survivorship showed a stair step pattern, whereas mortality curve exhibited an irregular pattern with sharp high peaks and negative low peaks. However, the life expectancy exhibited a continuous decline with advancement of age. The developmental stages (egg, larva, pre-pupa and pupa) of *C. transversalis* showed highest survivor fraction and lowest apparent mortality, mortality/ survival ratio, indispensable mortality, and k-values at lowest temperature as compared to high. On the other hand, minimum total generation mortality (K) was recorded of 0.1612 at 24 ±1°C followed by 0.2076 at 20 ± 1°C, and 0.2596 at 28 ± 1°C. The study revealed that among three different constant temperatures, 24 ± 1°C has been proved as a most suitable for the development of *C. transversalis*.

Keywords: *Coccinella transversalis*, life-table, stage specific, temperature

Presently, biological control is a priority for insect management through integrated approaches and also to avoid insecticidal applications in different crop ecosystems (1). Development of biological control requires evaluation of the biological control agents (predators, parasitoids etc.). In integrated aphid management, ladybeetles are the key predators of the aphids throughout India (1). The coccinellid beetles are cosmopolitan and found in many habitats, including fields, gardens, forests, sea coasts, mountains and cities (10). Both larvae and adult of coccinellids can feed on aphids but when they are missing, they can eat a variety of soft bodied insects, including whiteflies, psyllids, mealy-bugs and scale insects (1, 3, 6). The feeding propensity of coccinellids is different with species and also change with aphid species as well as environmental conditions (6). It is known that mortality of ladybeetles increases at relatively cool and extreme hot temperatures (12).

In ecological study, life-table is a most important analytical tool which provides detailed information on population dynamics and generates simple but informative statistics. It also gives a comprehensive description of the survivorship, development, feeding and expectation of life (2). The collection of

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life-table data at different temperatures gives an important task for pest management in different environmental conditions (4). Therefore, in present investigations, age and stage specific life-table of *Coccinella transversalis* were evaluated on mustard aphid, *Lipaphis erysimi*, at various temperatures.

MATERIALS AND METHODS

Aphid and ladybeetle culture. Indian mustard, *Brassica juncea*, 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 season of year 2005-06. Each plot was replicated three times and exposed to natural infestation of aphids. The aphids started their attack on Indian mustard plants in the month of November, 2005. They were collected and identified as *L. erysimi* 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, where *C. transversalis* was recorded to be identically represented.

The pairs of *C. transversalis* 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 biological oxygen demand (BOD) incubator. A blotting paper was spread over the inner surface of Petri dishes for egg laying. Fresh aphid infested cut twigs of Indian mustard plant were provided as food to beetles daily. The eggs laid by females were counted 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. transversalis* were placed in Petri dishes and allowed to hatch at a constant temperature (20 ± 1°C). However, for construction of life-tables of *C. transversalis* at varying temperatures, 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. transversalis* were collected from the hatched eggs. These were individually reared on *L. erysimi* at varying temperatures 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 grubs of *C. transversalis*. Thereafter, with an advancement of age of the grubs, 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. Similar procedure was followed for the study of second generation.

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. transversalis*, as per suggestions of Southwood (18):

- Mortality rate at the age interval x and calculated by using formula: $100q_x = [d_x / l_x] \times 100$, where x = Age of the insect in days, l_x = Number surviving at the beginning of each interval, out of 100,

and d_x = Number dying during the age interval, out of 100,

- Life expectation was calculated using the equation: $e_x = T_x / l_x$, where ex = Expectation of life or mean life remaining for individuals of age x and T_x = The total number of individual of age units beyond the age x,

- Total number of individual of x age units beyond the age x: $T_x = l_x + (l_x+1) + (l_x+2)..... + l_w$, where l_w = The last age interval,

- Number of individuals alive between age x and x + 1: $L_x = l_x + 1\ (x + 1)/2$.

Stage specific life-table. The data on stage specific survival and mortality of eggs, larvae, pupae and adults of *C. transversalis* 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, and 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 [MSR 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" (18, 19):

$K = k_E + k_{L1} + k_{L2} + k_{L3} + k_{L4} + k_{PP} + k_P$, 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. transversalis*.

RESULTS

Age specific life-table. The age specific life-table of *C. transversalis* showed that it took maximum development period of 60 days at 20 ± 1°C in contrast to minimum 50 days at 28 ± 1°C. The survivorship and mortality curve showed a stair step pattern. It was depicted from the curve that high peaks of mortality were seen on 6, 11, 33, 39, 45, 54 and 58 day at 20 ± 1°C; 33, 40, 44, and 48 day at 24 ± 1°C and 1, 4, 7, 28, 34, 39 and 44 day at 28 ± 1°C. Conversely, the low peaks of nil mortality were observed on 15, 23 and 30 day at 20 ± 1°C; 16 and 24 day at 24 ± 1°C and 20 and 25 day at 28 ± 1°C. As far as life expectancy was concerned, a gradual drop in e_x from day one till death, was witnessed at all temperatures.

Nonetheless, a negligible increase in e_x was recorded on 2, 7, 8, 12, 13, 34, 40 and 46 day at 20 ± 1°C. Similarly, the e_x increased marginally on 2 and 7 day at 24 ± 1°C and 2, 5, 8, 29, 30 and 40 day at 28 ± 1°C (Fig. 1 a, b, c).

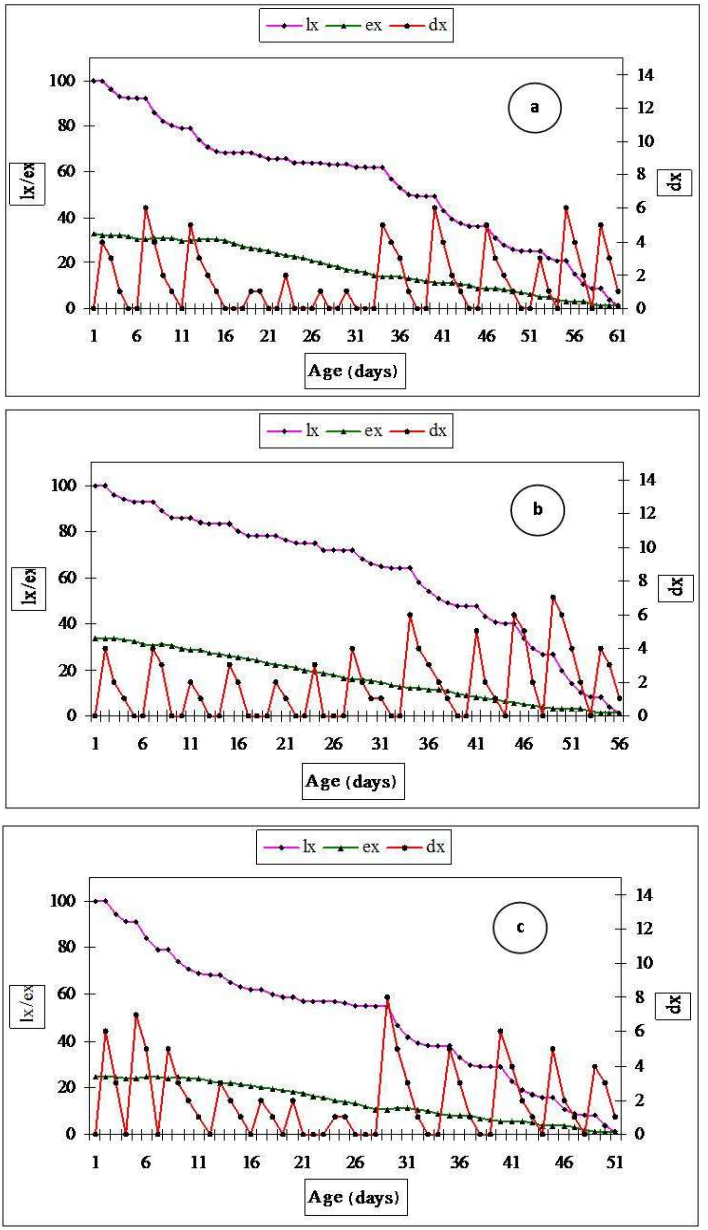

Fig. 1. Age specific survivorship (l_x), death (d_x) and life expectancy (e_x) of *C. transversalis* on *L. erysimi* at 20 ± 1°C (a), 24 ± 1°C (b), and 28 ± 1°C (c).

Stage specific life-table.

Apparent mortality. At egg stage, apparent mortality was observed minimum (8%) at 20 ± 1°C as well as 24 ± 1°C and maximum (9%) at 28 ± 1°C. While comparing larval instars, the lowest mortality (1.35%) was recorded at fourth instar stage at 24 ± 1°C, whereas first instar showed highest mortality (13.19%) at 28 ± 1°C (Table 1). On the other hand, pre-pupal and pupal mortality was found minimum (1.37 and 3.13%) at 24 ± 1°C and 20 ± 1°C, respectively. Similarly, the corresponding values of maximum mortality (3.39 and 3.51%, respectively) were recorded at 28 ± 1°C (Table 1).

Survival fraction. At egg stage, the survival fraction was noted maximum 0.92 at 20 ± 1°C as well as at 24 ± 1°C and minimum 0.91 at 28 ± 1°C. Among larval instars, fourth instar larvae exhibited the highest Sx (0.99) at 24 ± 1°C, whereas the lowest fraction (0.87) was recorded at first as well as second instar at 28 ± 1°C. Similarly, at pre-pupal stage, the Sx was found maximum (0.99) at 24 ± 1°C and minimum (0.97) at 20 ± 1°C as well as 28 ± 1°C. In contrast, pupal stage attained high fraction (0.97) at 20 ± 1°C and low (0.96) at 28 ± 1°C (Table 1).

Mortality survivor ratio. C. transversalis registered lowest value of MSR (0.09) at 20 ± 1°C as well as 24 ± 1°C and highest (0.11) at 28 ± 1°C. While considering larval instars, the minimum MRS (0.01) was obtained at fourth instar at 24 ± 1°C as compared to maximum (0.15) at first instar at 28 ± 1°C. However, the pre-pupal stage attained minimum MSR (0.01) at 24 ± 1°C and maximum (0.04) at 28 ± 1°C. On the other hand, at pupal stage minimum MSR was recorded (0.03) at 20 ± 1°C and maximum (0.04) at 28 ± 1°C as well as 24 ± 1°C (Table 1).

Indispensable mortality. The lowest (5.39) and highest (6.00) indispensable mortality (IM), at egg stage, was examined at 20 ± 1°C and 24 ± 1°C, respectively. While comparing larval instars, such mortality was recorded minimum (0.95) at fourth instar at 24 ± 1°C and maximum (8.35) at first instar at 28 ± 1°C (Table 1). Nevertheless, a considerable variation was observed at pre-pupal as well as pupal stage. The corresponding lowest value (0.96) for pre-pupal stage was found at 24 ± 1°C, while for pupal period minimum IM (2.00) was observed at 20 ± 1°C as well as 28 ± 1°C. On the other hand, the highest IM (1.94), at pre-pupal stage, was recorded at 20 ± 1°C, whereas at pupal stage the mortality was obtained maximum (3.00) at 24 ± 1°C (Table 1).

k-values. At egg stage of *C. transversalis*, k-value was found minimum (0.0362) at 20 ± 1°C as well as 24 ± 1°C and maximum (0.0410) at 28 ± 1°C. Among larval instars, it remained lowest (0.0059) at fourth instar at 24±1°C as compared to highest (0.0614) at first instar at 28 ± 1°C. On the other hand, the pre-pupal and pupal stages showed minimum 'k' (0.0134 and 0.0060) at 20 ± 1°C and 24 ± 1°C, respectively, whereas the maximum 'k' at pre-pupal (0.0150) and pupal (0.0185) stage was obtained at 28 ± 1°C and 24 ± 1°C, respectively. Similarly, the total generation mortality (K) was observed lowest (0.1612) at 24 ± 1°C and highest (0.2596) at 28 ± 1°C (Table 1).

DISCUSSION

The observation on age specific life-table revealed that development period of *C. transversalis* varied significantly with varying temperature. The shortest

Table 1. Stage specific life-table of *C. transversalis* on *L. erysimi* at varying temperature

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	Indis-pensable mortality IM	$logl_x$	k-values
20 ± 1ºC								
Egg	100.00	8.00	8.00	0.92	0.09	5.39	2.00	0.0362
First instar	92.00	10.00	10.87	0.89	0.12	7.56	1.96	0.0500
Second instar	82.00	8.00	9.76	0.90	0.11	6.70	1.91	0.0446
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
24 ± 1ºC								
Egg	100.00	8.00	8.00	0.92	0.09	6.00	2.00	0.0362
First instar	92.00	9.00	9.78	0.90	0.11	7.48	1.96	0.0447
Second instar	83.00	6.00	7.23	0.93	0.08	5.38	1.92	0.0326
Third instar	77.00	3.00	3.90	0.96	0.04	2.80	1.89	0.0173
Fourth instar	74.00	1.00	1.35	0.99	0.01	0.95	1.87	0.0059
Pre-pupa	73.00	1.00	1.37	0.99	0.01	0.96	1.86	0.0060
Pupa	72.00	3.00	4.17	0.96	0.04	3.00	1.86	0.0185
Adult	69.00	69.00	100.00	--	--	--	1.84	--
								K=0.1612
28 ± 1ºC								
Egg	100	9	9.00	0.91	0.10	5.44	2.00	0.0410
First instar	91	12	13.19	0.87	0.15	8.35	1.96	0.0614
Second instar	79	10	12.66	0.87	0.14	7.97	1.90	0.0588
Third instar	69	6	8.70	0.91	0.10	5.24	1.84	0.0395
Fourth instar	63	4	6.35	0.94	0.07	3.73	1.80	0.0285
Pre-pupa	59	2	3.39	0.97	0.04	1.93	1.77	0.0150
Pupa	57	2	3.51	0.96	0.04	2.00	1.76	0.0155
Adult	55	55	100.00	--	--	--	1.74	--
								K=0.2596

development period was recorded at high temperature (28 ± 1°C) and longest at low temperature (20 ± 1°C). Similar findings on *C. septempunctata* are available (4, 13). In present findings, a curve was plotted on the survivorship vis-à-vis mortality of the *C. transversalis*, it exhibited an irregular pattern of sharp high peaks (maximum mortality) and low peaks (negligible mortality) at different age intervals. The high peaks of mortality were observed more at 28 ± 1°C, while low peaks were obtained at 20 ± 1°C (4, 13). The life expectancy (e_x) showed an intermittent decline at an early stage of development and thereafter, it declined steadily till the culmination of generation at all the temperatures. The trend of observations was found akin as recorded on *Creatonotus gangis* (8).

In present findings, the pre-imaginal stages (egg, larvae, pre-pupae and pupae) of *C. transversalis* showed minimum percent mortality at 24 ± 1°C than other temperatures (20 ± 1 and 28 ± 1°C). However, in another experiment, the mortality of *Hippodamia convergens* decreased with increase in the temperature while working at four temperatures ranges (17). On the other hand, the early larval instars were much delicate than the later instars and hence, showed higher mortality at first as well as second instar stages (1, 9, 15).

The data on survival fraction of *C. transversalis* showed a reverse pattern as of apparent mortality. The survival varied significantly with stage to stage also change with the temperature. The eggs and pupae of *C. transversalis* survived more at 20 ± 1°C, whereas larvae and pre-pupae showed maximum survival at 24 ± 1°C. In previous study, much higher survival of *C. septempunctata* and *C. transversalis* was recorded at 20°C than other temperatures (1, 5, 13).

In the present study, all the development stages (egg, larval instars, pre-pupa and pupa) of *C. transversalis* recorded minimum mortality survival ratio (MSR) at 24 ± 1°C than other temperatures (20 ± 1 and 28 ± 1°C). Similar observations on the mortality performance of above coccinellid species has been reported (7, 13, 16).

The IM of *C. transversalis* followed similar pattern as observed for apparent mortality and mortality/survival ratio. All the developmental stages (egg, larval instar, pre-pupa and pupa) registered minimum IM at 24 ± 1°C than other temperature regimes (20 ± 1°C and 28 ± 1°C). The findings on IM at varying temperatures recorded on *C. septempunctata* showed corroboration with present study (13).

The k-value is the key factor that is primarily responsible for increase or decrease in number from one generation to another. In the present findings, the k-value exhibited similar pattern to that of apparent mortality as well as indispensable mortality. The pre-imaginal stages (egg, larval instar, pre-pupa and pupa) of *C. transversalis* attained minimum 'k' at 20 ± 1°C as well as 24 ± 1°C. Similarly, the total generation mortality (K) was observed lowest (0.1612) at 24 ± 1°C as compared to highest at 28 ± 1°C. Similar trend of mortality was reported in *Propylea dissecta* (13, 14).

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 of *C. transversalis* on *L. erysimi*. Therefore, *C. transversalis* can be mass multiplicated at given temperature for their successful

evaluation in biological control program against different soft bodied insects.

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RESUME

Ali A. et Rizvi P.Q. 2009. Age et stade spécifiques dans le tableau de vie de *Coccinella transversalis* en considérant diverses températures. Tunisian Journal of Plant Protection 4: 211-219.

L'âge spécifique dans le tableau de vie de *Coccinella transversalis* à diverses températures révèle qu'il faut une période maximale de 60 jours pour terminer une génération 20 ± 1°C suivie de 56 jours à 24 ± 1°C et 50 jours à 28 ± 1°C. La survie a montré une courbe en escalier tandis que la courbe de mortalité montre une tendance irrégulière avec de hauts pics pointus et des pics bas négatifs. Toutefois, l'espérance de vie a montré une diminution continue avec l'avancement de l'âge. Les stades de développement (œuf, larve, pré-pupe et pupe) de *C. transversalis* ont montré la plus élevée fraction de survie et les plus basses mortalité apparente, rapport mortalité/survie, mortalité indispensable et valeurs k aux plus basses températures par comparaison à celles qui sont élevées. D'autre part, la mortalité totale minimale des générations (K) était de 0,1612 à 24 ±1°C suivie par 0,2076 à 20 ± 1°C et 0.2596 à 28 ± 1°C. L'étude a révélé que parmi trois différentes températures constantes, 24 ± 1°C a été prouvée être la plus convenable au développement de *C. transversalis*.

Keywords: *Coccinella transversalis*, stade spécifique, tableau de vie, température

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ملخص

علي، أرشاد وبرويز قمر رزوي. 2009. العمر والمراحل الخاصة في جدول الحياة للدعسوقة *Coccinella transversalis* فيما يخص درجات حرارة مختلفة.

Tunisian Journal of Plant Protection 4: 211-219.

بيّنت هذه الدراسة أن العمر الخاص بجدول الحياة للدعسوقة *Coccinella transversalis* عند درجات حرارة مختلفة، يحتاج إلى فترة قصوى قدرها 60 يوماً لاستكمال جيل واحد عند درجة 20±1°س متبوعة بـ 56 يوماً عند 24±1°س و50 يوماً عند 28±1°س. في المقابل، أظهر منحنى البقاء على قيد الحياة أنه متدرج بينما أظهر منحنى الموت نمطاً غير منتظم مع ذروات عالية حادة وذروات دنيا سلبية. أظهرت الحياة المتوقعة انخفاضاً مستمراً مع تقدّم العمر. كما بيّنت مراحل التطّور (بيضة، يرقة، ما قبل الحورية، حورية) لحشرة *C. transversalis* أعلى جزء بقاء على قيد الحياة وأصغر موت ظاهري ونسبة موت/بقاء على قيد الحياة ووفيات ضرورية وقيم k، عند درجات الحرارة المنخفضة بالمقارنة مع الدرجات المرتفعة. من ناحية أخرى، كان الحد الأدنى الإجمالي للأجيال (K) 0.1612 عند درجة حرارة 24±1°س متبوعا بـ 0.2076 عند 20±1°س و 0.2596 عند 28±1°س. بينت هذه الدراسة أنه من بين ثلاث درجات حرارة مختلفة ومستقرة، كانت الدرجة 24±1°س هي الأكثر ملائمة لتطور حشرة *C. transversalis*.

كلمات مفتاحية : جدول الحياة، درجة الحرارة، مراحل خاصة، *Coccinella transversalis*

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