Asian Journal of Agriculture & Life Sciences Vol. 1(4), October 2016: 1-7

Website: www.crsdindia.com/ajals.html e-ISSN: 2455-6149

ORIGINAL ARTICLE

Age specific survival, death and life expectancy of *Chilocorus circumdatus* Fabr (Coleoptera: Coccinellidae) on mustard aphid *Lipaphis erysimi* Kalt at varying temperature

Arshad Ali

Department of Zoology, Gandhi Faiz-e-Aam (P.G.) College- 2420071, UP, India

Email: drarshadali@yahoo.com

Received: 21st Jan. 2016, Revised: 5th March 2016, Accepted: 19th March 2016

ABSTRACT

Age specific survival, death and life expectancy of Chilocorus circumdatus at varying temperature showed that it took a maximum of 38 days to complete generation at 16±1°C and minimum of 31 days at 28±1°C on Lipaphis erysimi, respectively. The survivorship and mortality showed an irregular pattern with high and low peaks. The high peaks reflecting maximum mortality and low peaks showed negligible mortality. As far as life expectancy was concerned, it declined gradually till completion of generation at all the temperature regimes. Although, the minimum peaks of high mortality was observed at 24±1°C as compared to other temperatures. C. circumdatus developed faster at 28±1°C, but number of high peaks of mortality increased accordingly at this temperature. Therefore, 24±1°C considered as most suitable temperature for development of C. cirumdatus under laboratory conditions.

Key Words: *Aphids, development, feeding, ladybird beetle, temperature*

INTRODUCTION

Ladybirds are most familiar group of brightly colored beetles, which are symbols of Good in many myths. Some authors believe that the term "lady" in ladybird refers to the Virgin Mary. They believe that during the middle age, in Europe, the agricultural crops were plagued by pests, and then farmers began praying to Lady Mary. Thereafter, when they returned to their field, ladybeetles appeared in the fields and miraculously saving their crops by eating the pests, therefore farmers to call them beetles of our lady. Among different ladybird beetle species *Chilocorus circumdatus* is a small sized beetle with orange elytra and black margin. *C. circumdatus* is considered as insectivorous by feeding on variety of insect like aphid, thrips, scale insect, whiteflies and other soft bodied insects. *C. circumdatus* was introduced from China to India, Sri Lanka, Indonesia (Miyatake, 1970), Hawaii (Leeper ,1976) and other countries including California, Australia and South Africa (Rao et al. 1971, Rosen and De Bach 1978, Houston 1991 and Seago et al. 2011).

The study of life tables can provide accurate data of mortality, survival and expectancy of life. The collection of life-table data is an important factor for pest management strategies through the release of natural enemies (Devi et al., 1997) and play important role in biological control system (Chi and Yang 2003 and Ali and Rizvi 2010). Therefore, to identify the numerical changes in age distribution, age specific life table of *Chilocorus circumdatus* was constructed in the present study.

MATERIAL AND METHOD

To accomplish present objective, Indian mustard, *Brassica juncea* were grown in a plot sized 10 x 10 meter and each replicated thrice. There is no pest management practices flowed to grow the Indian mustard in the field, and crop were exposed to aphid infection. The aphids collected during the course of study were identified as *Lipaphis erysimi* Kaltenbach from the Laboratory of Aphidology, Department of Zoology, University of Kalyani, West Bengal, India. Among the complex of different ladybird beetle *Chilocorus circumdatus* were also found to feed on mustard aphid.

Adult females of *C. circumdatus* were collected and brought to the laboratory for rearing them singly in Petri dishes (90 x 10 mm). A blotting paper was spread over inner surface of Petri dishes for egg laying. Fresh infested cut twigs of mustard plant along with aphids 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 100 zero day old eggs obtained from *C.*

circumdatus were placed in Petri dishes and allowed to hatch at varying temperature (16±1, 20±1, 24±1 and 28±1°C) in the BOD incubators in the laboratory. The survival and mortality of grubs were recorded daily, and this procedure was followed till pupation.

After the emergence of adults (male and female), they were again provided aphids and placed in BOD incubators at respective temperatures till their death. The record of longevity and mortality of each larval instar, pre-pupa, pupa and adult during the course of investigation were also recorded on respective temperature regimes. The data collected during rearing of *C. circumdatus* was employed for construction of age specific life-table.

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. circumdatus* at varying temperature.

x = Age of the *C. circumdatus* in days.

l_x = Number surviving *C. circumdatus* at the beginning of each interval, out of 100

d_x = Number dying *C. circumdatus* 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;

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

Where, l_w = The last age interval.

RESULTS AND DISCUSSION

Chilocorus circumdatus took maximum period of 38 days to complete its life cycle on *L. erysimi* at 16±1°C and minimum of 31 days at 28±1°C, respectively (Table 1-4). However, at other temperature developmental duration of *C. circumdatus* was recorded as 35 days at 20±1°C and 32 days at 24±1°C, respectively (Table 2-3). The mortality and survival showed an irregular pattern with high and low peaks. The peaks reflecting maximum mortality of *C. circumdatus* and recorded as 10, 5, 4, 4, 3, 6, 5 and 13 individual on 2, 8, 14, 18, 22, 25, 30 and 35th day at 16±1°C (Table 1). However, at 20±1°C; 24±1°C; and 28±1°C highest mortality of *C. circumdatus* was observed as 9, 6, 4, 4, 3, 8 and 9 individual; 8, 5, 4, 4, 3, 8 and 11 individual; and 11, 6, 7, 5, 4, 7 and 4 individual on 2, 8, 14, 18, 22, 26 and 33rd day; 2, 8, 14, 18, 22, 25 and 30th day; and 2, 8, 13, 18, 22, 25 and 30th day, respectively (Table 2-4). In contrast, low peak of negligible mortality was observed on 1, 6, 12, 17, 21, 24, 29, and 34th day at 16±1°C; 1, 4, 12, 17, 21, 24 and 32nd day at 20±1°C; 1, 6, 12, 17, 21, 24 and 29th day at 24±1°C; and 1, 7, 12, 17, 21, 24 and 29th day at 28±1°C; respectively (Table 1-4). The observations on life expectancy of *C. circumdatus* revealed that it declined gradually till the culmination of generation at every temperature (16±1, 20±1, 24±1 and 28±1°C). The intermittent pauses in the life expectancy of *C. circumdatus* were, however, recorded on 3 and 4th day at 16±1°C; 3 and 9th day at 20±1°C; 3rd day at 24±1°C; and 3, 4 and 14th day at 28±1°C on *L. erysimi*, respectively (Table 1-4).

The observations on comparative data on age specific life-table of *C. circumdatus* showed that development was slower at lowest temperature (16±1°C) and become fastest at highest temperature (28±1°C). Similar result with respect to temperature were also reported by Srivastava and Omkar (2003), Katsarou et al. (2005), Ali and Rizvi (2008a) on *Coccinella septempunctata*, Omkar and Pervez (2004) on *Propylea dissecta*, Ali and Rizvi (2008b & 2009a) on *Coccinella transversalis*, Jagadish and Jayaramaiah (2004), Ali and Rizvi (2009b & 2010) on *Menochilous sexmaculatus*, Hemchandra et al. (2010) on *Micraspis discolor*, Mandour et al. (2011) and Skouras

and Stathas (2015) on *Hippodamia variegate*, Papanikolaou et al. (2014) on *Propylea quatuordecimpunctata*, Solano et al. (2016) *Cycloneda sanguine*.

Table 1: Age specific survival (l_x), death (d_x) and life expectancy (e_x) of *Chilocorus circumdatus* on *Lipaphis erysimi* at 16±1°C

x	l_x	d_x	$100q_x$	L_x	T_x	e_x
1	100.00	0.00	0.00	100.00	2050.00	20.50
2	100.00	10.00	10.00	95.00	1950.00	20.53
3	90.00	6.00	6.67	87.00	1855.00	21.32
4	84.00	3.00	3.57	82.50	1768.00	21.43
5	81.00	1.00	1.23	80.50	1685.50	20.94
6	80.00	0.00	0.00	80.00	1605.00	20.06
7	80.00	0.00	0.00	80.00	1525.00	19.06
8	80.00	5.00	6.25	77.50	1445.00	18.65
9	75.00	3.00	4.00	73.50	1367.50	18.61
10	72.00	2.00	2.78	71.00	1294.00	18.23
11	70.00	1.00	1.43	69.50	1223.00	17.60
12	69.00	0.00	0.00	69.00	1153.50	16.72
13	69.00	0.00	0.00	69.00	1084.50	15.72
14	69.00	4.00	5.80	67.00	1015.50	15.16
15	65.00	2.00	3.08	64.00	948.50	14.82
16	63.00	1.00	1.59	62.50	884.50	14.15
17	62.00	0.00	0.00	62.00	822.00	13.26
18	62.00	4.00	6.45	60.00	760.00	12.67
19	58.00	2.00	3.45	57.00	700.00	12.28
20	56.00	1.00	1.79	55.50	643.00	11.59
21	55.00	0.00	0.00	55.00	587.50	10.68
22	55.00	3.00	5.45	53.50	532.50	9.95
23	52.00	2.00	3.85	51.00	479.00	9.39
24	50.00	0.00	0.00	50.00	428.00	8.56
25	50.00	6.00	12.00	47.00	378.00	8.04
26	44.00	4.00	9.09	42.00	331.00	7.88
27	40.00	3.00	7.50	38.50	289.00	7.51
28	37.00	1.00	2.70	36.50	250.50	6.86
29	36.00	0.00	0.00	36.00	214.00	5.94
30	36.00	5.00	13.89	33.50	178.00	5.31
31	31.00	3.00	9.68	29.50	144.50	4.90
32	28.00	2.00	7.14	27.00	115.00	4.26
33	26.00	1.00	3.85	26.00	88.00	3.38
34	26.00	0.00	0.00	26.00	62.00	2.38
35	26.00	13.00	50.00	19.50	36.00	1.85
36	13.00	6.00	46.15	10.00	16.50	1.65
37	7.00	4.00	57.14	5.00	6.50	1.30
38	3.00	3.00	100.00	1.50	1.50	1.00

Table 2: Age specific survival (l_x), death (d_x) and life expectancy (e_x) of *Chilocorus circumdatus* on *Lipaphis erysimi* at 20±1°C

x	l_x	d_x	$100q_x$	L_x	T_x	e_x
1	100.00	0.00	0.00	100.00	1943.00	19.43
2	100.00	9.00	9.00	95.50	1843.00	19.30
3	91.00	5.00	5.49	88.50	1747.50	19.75
4	86.00	3.00	3.49	84.50	1659.00	19.63
5	83.00	1.00	1.20	82.50	1574.50	19.08
6	82.00	0.00	0.00	82.00	1492.00	18.20
7	82.00	0.00	0.00	82.00	1410.00	17.20
8	82.00	6.00	7.32	79.00	1328.00	16.81
9	76.00	4.00	5.26	74.00	1249.00	16.88
10	72.00	2.00	2.78	71.00	1175.00	16.55
11	70.00	1.00	1.43	69.50	1104.00	15.88
12	69.00	0.00	0.00	69.00	1034.50	14.99
13	69.00	0.00	0.00	69.00	965.50	13.99
14	69.00	4.00	5.80	67.00	896.50	13.38
15	65.00	2.00	3.08	64.00	829.50	12.96
16	63.00	1.00	1.59	62.50	765.50	12.25
17	62.00	0.00	0.00	62.00	703.00	11.34
18	62.00	4.00	6.45	60.00	641.00	10.68
19	58.00	2.00	3.45	57.00	581.00	10.19
20	56.00	1.00	1.79	55.50	524.00	9.44
21	55.00	0.00	0.00	55.00	468.50	8.52
22	55.00	3.00	5.45	53.50	413.50	7.73
23	52.00	2.00	3.85	51.00	360.00	7.06
24	50.00	0.00	0.00	50.00	309.00	6.18
25	50.00	6.00	12.00	47.00	259.00	5.51
26	44.00	8.00	18.18	40.00	212.00	5.30
27	36.00	6.00	16.67	33.00	172.00	5.21
28	30.00	4.00	13.33	28.00	139.00	4.96
29	26.00	3.00	11.54	24.50	111.00	4.53
30	23.00	2.00	8.70	22.00	86.50	3.93
31	21.00	1.00	4.76	20.50	64.50	3.15
32	20.00	0.00	0.00	20.00	44.00	2.20
33	20.00	9.00	45.00	15.50	24.00	1.55
34	11.00	8.00	72.73	7.00	8.50	1.21
35	3.00	3.00	100.00	1.50	1.50	1.00

The result clearly indicated that the curve drawn between age and survivorship of *C. circumdatus* vis-à-vis temperature, it showed a stair step like pattern at every temperature regimes. Which showed complete corroboration with the findings of Rodriguez-Saona and Miller (1999), Omkar and Pervez (2002) and Ali and Rizvi (2009a & b) and Ali (2015).

The mortality trend of *C. circumdatus* showed an irregular pattern with more number of high peaks of maximum mortality at 28±1°C at the latter stage of development coincided with pupal as well as adult mortality. Although low peaks of minimum mortality was recorded at 24±1°C as compared to

other temperature regimes (16±1, 20±1 and 28±1°C). Such variation in the mortality with respect to variable temperature on different coccinellid species (*Adalia bipunctata*, *Chilocorus circumdatus Coccinella septempunctata*, *Coccinella trasversalis*, *Cycloneda sanguine, Harmonia axyridi*, *Hippodamia variegate*, *Menochilous sexmaculatus*, *Micraspis discolour* and *Propylea quatuordecimpunctata*) were also reported by Srivastava and Omkar (2003), Jagadish and Jayaramaiah (2004), Omkar and Pervez (2004), Ali and Rizvi (2008a & b), Ali et al. (2014), Benelli et al. (2015), Ahmadov and Hasanova (2016) and Solano et al. (2016), giving strengthen to present findings.

Table 3: Age specific survival (l_x), death (d_x) and life expectancy (e_x) of *Chilocorus circumdatus* on *Lipaphis erysimi* at 24±1°C

x	l_x	d_x	$100q_x$	L_x	T_x	e_x
1	100.00	0.00	0.00	100.00	1871.00	18.71
2	100.00	8.00	8.00	96.00	1771.00	18.45
3	92.00	5.00	5.43	89.50	1675.00	18.72
4	87.00	3.00	3.45	85.50	1585.50	18.54
5	84.00	2.00	2.38	83.00	1500.00	18.07
6	82.00	0.00	0.00	82.00	1417.00	17.28
7	82.00	0.00	0.00	82.00	1335.00	16.28
8	82.00	5.00	6.10	79.50	1253.00	15.76
9	77.00	4.00	5.19	75.00	1173.50	15.65
10	73.00	3.00	4.11	72.00	1098.50	15.26
11	71.00	2.00	2.82	70.00	1026.50	14.66
12	69.00	0.00	0.00	69.00	956.50	13.86
13	69.00	0.00	0.00	69.00	887.50	12.86
14	69.00	4.00	5.80	67.00	818.50	12.22
15	65.00	3.00	4.62	63.50	751.50	11.83
16	62.00	2.00	3.23	61.00	688.00	11.28
17	60.00	0.00	0.00	60.00	627.00	10.45
18	60.00	4.00	6.67	58.00	567.00	9.78
19	56.00	2.00	3.57	55.00	509.00	9.25
20	54.00	1.00	1.85	53.50	454.00	8.49
21	53.00	0.00	0.00	53.00	400.50	7.56
22	53.00	3.00	5.66	51.50	347.50	6.75
23	50.00	1.00	2.00	49.50	296.00	5.98
24	49.00	0.00	0.00	49.00	246.50	5.03
25	49.00	8.00	16.33	45.00	197.50	4.39
26	41.00	7.00	17.07	37.50	152.50	4.07
27	34.00	5.00	14.71	31.50	115.00	3.65
28	29.00	4.00	13.79	27.00	83.50	3.09
29	25.00	0.00	0.00	25.00	56.50	2.26
30	25.00	11.00	44.00	19.50	31.50	1.62
31	14.00	8.00	57.14	9.50	12.00	1.26
32	5.00	5.00	100.00	2.50	2.50	1.00

Table 4: Age specific survival (l_x), death (d_x) and life expectancy (e_x) of *Chilocorus circumdatus* on *Lipaphis erysimi* at 28±1°C

x	l_x	d_x	$100q_x$	L_x	T_x	e_x
1	100.00	0.00	0.00	100.00	1358.00	13.58
2	100.00	11.00	11.00	94.50	1258.00	13.31
3	89.00	8.00	8.99	85.00	1163.50	13.69
4	81.00	6.00	7.41	78.00	1078.50	13.83
5	75.00	4.00	5.33	73.00	1000.50	13.71
6	71.00	2.00	2.82	70.00	927.50	13.25
7	69.00	0.00	0.00	69.00	857.50	12.43
8	69.00	6.00	8.70	66.00	788.50	11.95
9	63.00	5.00	7.94	60.50	722.50	11.94
10	58.00	3.00	5.17	56.50	662.00	11.72
11	55.00	1.00	1.82	54.50	605.50	11.11
12	54.00	0.00	0.00	54.00	551.00	10.20
13	54.00	7.00	12.96	50.50	497.00	9.84
14	47.00	4.00	8.51	45.00	446.50	9.92
15	43.00	3.00	6.98	41.50	401.50	9.67
16	40.00	1.00	2.50	39.50	360.00	9.11
17	39.00	0.00	0.00	39.00	320.50	8.22
18	39.00	5.00	12.82	36.50	281.50	7.71
19	34.00	2.00	5.88	33.00	245.00	7.42
20	32.00	1.00	3.13	31.50	212.00	6.73
21	31.00	0.00	0.00	31.00	180.50	5.82
22	31.00	4.00	12.90	29.00	149.50	5.16
23	27.00	2.00	7.41	26.00	120.50	4.63
24	25.00	0.00	0.00	25.00	94.50	3.78
25	25.00	7.00	28.00	21.50	69.50	3.23
26	18.00	5.00	27.78	15.50	48.00	3.10
27	13.00	4.00	30.77	11.00	32.50	2.95
28	9.00	2.00	22.22	8.00	21.50	2.69
29	7.00	0.00	0.00	7.00	13.50	1.93
30	7.00	4.00	57.14	5.00	6.50	1.30
31	3.00	3.00	100.00	1.50	1.50	1.00

CONCLUSION

The overall findings on age specific survival, death and life expectancy of *Chilocorus circumdatus* at varying temperature revealed that it took shortest period to complete generation at 28±1°C, but 24±1°C found to be more suitable temperature with lowest mortality than other temperature regimes. However, mustard aphid *Lipaphis erysimi* was found to be suitable for development in the laboratory.

ACKNOWLEDGEMENTS

Author is highly thankful to University Grants Commission, New Delhi for providing financial assistance as Dr. D.S. Kothari Post Doctoral Fellowship (DSK-PDF) during present research.

REFERENCES

1. Ahmadov B.A., Hasanova S. Sh. (2016): The role of coccinellids (Coccinellidae) in suppression of the number of *Aphis craccivora* Koch, 1854, and *Aphis gossypii* Glover, 1877. J. Entomol. Zool. Stud., 4(3): 234-237.
2. Ali A. (2015): Age specific survival, death and life expectancy of *Menochilus sexmaculatus* Fabr (Coleoptera: Coccinellidae) on different aphid species under natural environment. Annal Nat. Sci., 1(1): 39-48.
3. Ali A. and Rizvi P.Q. (2008b): Effect of varying temperature on the development and predation of *Coccinella transversalis* F. (Coleoptera: Coccinellidae) on *Lipaphis erysimi* (Kaltenbach). Trend. Biosci., 1(1-2): 18-21.
4. Ali A. and Rizvi P.Q. (2009a): Age and stage specific life-table of *Coccinella transversalis* with regards to various temperatures. Tunisian J. Pl. Protec., 4(2): 211-219.
5. Ali A. and Rizvi P.Q. (2009b): Life table studies of *Menochilus sexmaculatus* Fabr. (Coleoptera: Coccinellidae) at varying temperature on *Lipaphis erysimi* Kalt. World Appl. Sci. J., 7(7): 897-901.
6. Ali A. and Rizvi P.Q. (2010): Age and stage specific life table of *Coccinella septempunctata* (Coleoptera: Coccinellidae) at varying temperature. World J. Agric. Sci., 6(3): 268-273.
7. Ali A. and Rizvi P.Q., (2008a): Effect of varying temperature on the survival and fecundity of *Coccinella septempunctata* (Coleoptera: Coccinellidae) fed on *Lipaphis erysimi*. J. Entomol., 5(2): 133-137.
8. Ali A., Rana K.S. and Rizvi P.Q. (2014): Development and predation of *Chilocorus circumdatus* (Coleoptera: Coccinellidae) at variable temperature. World J. Appl. Sci. Res., 4(1): 36-38.
9. Benelli M., Leather S.R., Francati S., Marchetti E. and Dindo M.L. (2015): Effect of two temperatures on biological traits and susceptibility to a pyrethroid insecticide in an exotic and native coccinellid species. Bulletin Insectol., 68(1): 23-29.
10. Chi H. and Yang T.C. (2003): Two-sex life table and predation rate of *Propylaea japonica* Thunberg (Coleoptera: Coccinellidae) fed on *Myzus persicae* (Sulzer) (Homoptera: Aphididae). Environ. Entomol., 32: 327-333.
11. Devi P.B., Singh T.K. and Devi S. (1997): Population density, predatory potential and development of two syrphid predators of *Myzus persicae* (Sulzer) on cabbage. J. Aphidol., 11: 123-127.
12. Hemchandra O., Sarmah B., Zamal T., Premila A. and Kalita J. (2010): affect of temperature on age-specific fecundity of the ladybird beetle *Micraspis discolor* (Fabricius). The Bioscan, 2: 523-528.
13. Houston K. J. (1991): *Chilocorus czrcumdatus* Gyllenhal newly established in Australia and additional records for *Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae). J. Aust. Ent. Soc., 30: 341-342.
14. Jagadish K.S. and Jayaramaiah M. (2004): Life cycle of the predaceous ladybird beetle, *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinellidae) as influenced by temperature and relative humidity regimes. Environ. Ecol., 22: 759-762.
15. Katsarou I., Margaritopoulos J.T., Tsitsipis J.A., Perdikis D.C. and Zarpas K.D. (2005): Effect of temperature on development, growth and feeding of *Coccinella septempunctata* and *Hippodamia convergens* reared on the tobacco aphid, *Myzus persicae nicotianae*. BioControl, 50: 565-588.
16. Leeper J. R. (1976): A review of the Hawaiian Coccinellidae. Proc. Hawaii. Ent. Soc., 22: 279-306.
17. Mandour N.S., Sarhan A.A., El-Basha N.A., Abdel-Motaal D.S. (2011). Effect of different temperature regimes on the biology, reproduction and predation of *Hippodamia variegata* (Goeze) (Coleoptera: Coccinellidae). *Egyptian Journal of Biological Pest Control* 21(1): 305–312.
18. Miyatake M. (1970): The East-Asian coccinellid beetles preserved in the California Academy of Sciences, tribe Chilocorini. Mem. Ehime Daigaku Coll. Agric., Agriculture, 14: 303-340.
19. Omkar and Pervez A. (2002): Influence of temperature on the age-specific fecundity of a ladybeetle, *Micraspis discolor* (Fabricius). Insect Sci. Applic., 22: 61-65.
20. Omkar and Pervez A. (2004): Temperature-dependant development and immature survival of an aphidophagous ladybeetle, *Propylea dissecta* (Mulsant). J. Appl. Entomol., 128: 510-514.
21. Papanikolaou N.E., Milonas P.G., Kontodimas D.C., Demiris N., Matsinos Y.G. (2014): Life table analysis of *Propylea quatuordecimpunctata* (Coleoptera: Coccinellidae) at constant temperatures. Annal. Entomol. Soci. America, 107(1): 158–162.
22. Rao V. P., Ghani M. A., Sankaran T. and Mathur K.C. (1971): A review of the biological control of insects and other pests in South-East Asia and the Pacific Region. Tech. Commun. Commonw. Inst. Biol. Control, 6: 1-149.
23. Rodriguez-Saona C. and Miller J.C. (1999): Temperature-dependant effects on development, mortality and growth of *Hippodamia convergens* (Coleoptera: Coccinellidae). Environ. Entomol., 28: 518-522.
24. Rosen D. and De Bach P. (1978): Diaspididae. In Clausen, C. P. (Ed.). Introduced parasites and predators of arthropod pests and weeds: a world review. Agric. Handb. U.S. Dep. Agric. 480: 78-128.
25. Seago A.E., Giorgi J.A., Li J. and Slipiński A. (2011): Phylogeny, classification and evolution of ladybird beetles (Coleoptera: Coccinellidae) based on simultaneous analysis of molecular and morphological data. Mol. Phylogenet. Evol., 60(1): 137-151.
26. Skouras P.G. and Stathas G.J. (2015): Development, growth and body weight of *Hippodamia variegata* fed *Aphis fabae* in the laboratory. Bullet. Insectol., 68 (2): 193-198.
27. Solano Y., Delgado N., Morales J., Vásquez C. (2016): Biological studies and life table of *Cycloneda sanguinea* (L.) (Coleoptera: Coccinellidae) on *Aphis craccivora* Koch (Hemiptera: Aphididae). Entomotropica, 31(34): 267-275.
28. Srivastava S. and Omkar (2003): Influence of temperature on certain biological attributes of a ladybeetle *Coccinella septempunctata* Linnaeus. Entomol. Sinica, 10(3): 185-193.