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Effect of Varying Temperature on the Survival and Fecundity of *Coccinella septempunctata* (Coleoptera: Coccinellidae) Fed on *Lipaphis erysimi* (Hemiptera: Aphididae)

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Abstract: The observations on the survival and fecundity of *Coccinella septempunctata* at varying temperatures viz., 18±1, 24±1°C and 28±1°C coupled with 65±5% RH and 12 h L: 12 h D photoperiod under laboratory condition was made for two successive generations. The highest potential fecundity and net reproductive rate of *C. septempunctata* were obtained at 24±1°C (165.67 eggs/female and 41.09 females/female/generation, respectively) and the lowest at 28±1°C (146.63 eggs/female and 29.70 females/female/generation, respectively). Finite, intrinsic and annual rate of increase were however, found maximum at 28±1°C (1.0876, 0.0840 females/female/day and 2.04×10^{13}/annum, respectively) and minimum at 18±1°C (1.0794, 0.0764 females/female/day and 1.281×10^{12}/annum, respectively). The mean length of generation and doubling time was found minimum at 28±1°C (40.77, 8.26 days, respectively) and maximum at 18±1°C (48.27 and 9.08 days, respectively).

Key words: Varying temperatures, survival, fecundity, *Coccinella septempunctata*, *Lipaphis erysimi*

INTRODUCTION

Mustard aphid, *Lpaphis erysimi* (Kaltenbach) is a serious pest of mustard in India and other tropical regions in the world. Its population increases in the cold and cloudy weather. The use of natural enemies of aphids is a good pest management tactic to minimize its population below the level of invasive pests (Pervez and Omkar, 2005). In India, *Coccinella septempunctata* is considered as a beneficial insect; potentially predate on *L. erysimi* (Ali and Rizvi, 2007).

Many factors are known to influence the rate of growth and development of aphid and its predators. Among them, temperature has a profound influence, as it governs the certain biological attributes of *Coccinella septempunctata* (Omkar and Srivastava, 2003). There has been no systematic evaluation of the influence of temperature on the survival and fertility of ladybirds. Such information could be useful for mass rearing of the natural enemies in a biological control program. Therefore, present investigation was aimed to find out survival and fecundity of *Coccinella septempunctata* on *Lipaphis erysimi* at varying temperatures.

MATERIALS AND METHODS

To maintain the culture of mustard aphid, Indian mustard (*Brassica juncea* L. var. varuna) was sown on October 25, 2005 in the experimental field of the Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh. The natural infestation of mustard aphid, *Lipaphis erysimi* commenced in the first week of December and its population density increased from

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the day of infestation. For natural control of this aphid, various ladybird species were also attributed with the aphid colonies in the field. Of all the coccinellids, *C. septempunctata* was found dominantly feeding on *Lipaphis erysimi*.

To determine the response of *C. septempunctata* on mustard aphid at varying temperature, three constant temperatures viz., 18±1, 24±1 and 28±1°C coupled with 65±5% RH and 12 h L: 12 h D photoperiod were maintained in BOD incubator. The grubs and pupae of *C. septempunctata* were collected from infested field and were kept in BOD incubator for adult emergence at respective temperatures. Freshly emerged adult beetles were reared in pairs in petri dishes (90 mm diameter and 10 mm height), provided with blotting paper spread over its inner surface for egg laying. The eggs laid by each female were collected with soft camel hair brush and transferred to other petri dishes for hatching. After hatching, a total of one hundred newly hatched (zero day old) grubs were reared individually in plastic vials (measuring 4.0 cm in diameter and 6.0 cm in height) at respective temperatures. For newly born grubs, 50 early instar nymphs were provided as food. The number of aphids subsequently increased reaching maximum 100 nymphs daily till grubs entered into pupal stage. After the emergence of adult (male and female), they were again provided with a minimum of 100 aphid nymphs daily till their death and sexing of adult was done as per suggestion of Sathe and Bhosle (2001). Fifteen pairs of different age groups of *C. septempunctata* were collected randomly from respective temperatures and reared as individual pair in petri dishes to obtain fecundity. The longevity and mortality of female during the course of investigation were also recorded daily. The observations were made for two successive generations of *C. septempunctata* on respective temperature.

The age specific survival and fertility table were constructed as per suggestion made by Birch (1948) and Southwood (1978). As it was not possible to identify the sexes prior to the adult stage, the survivorship rate was assumed to be the same for both the sexes with a ratio of 1:1.

The table consisted of following columns:

x = Pivotal age of the class in days.

l_x = Number of females alive at the beginning of the age interval × (as fraction of initial population of one).

m_x = Average number of eggs laid per female in each age interval assuming 50:50 sex ratio and computed as:

$$m_x = N_x/2$$

where:

N_x = Total natality per female off springs in each age.

Following parameters were also calculated for survivorship and fertility table:

Net Reproductive or Replacement Rate (R_0)

$$R_0 = l_x m_x$$

Mean length of Generation (T)

$$T = \Sigma\,[I_x.m_x x] / \Sigma\,[l_x.m_x]$$

Intrinsic Rate of Increase (r)

$$\text{(I) } r = [\text{Log}_e\, R_0] / T \text{ (for rough estimation)}$$
$$\text{(ii) } e^{-rx}.l_x.m_x = 1 \text{ (for accurate estimation of r)}$$

where, R_o represents net reproductive rate and T represents mean length of the generation.

Finite Rate of Increase (λ)

$$\lambda = e^r. \text{ Taking log on both sides we get } \log_e \lambda = \log_e e^r$$

where:

$$\lambda = \text{Antilog } e^r$$

Potential Fecundity (P_f)

$$P_f = \Sigma m_x$$

Doubling Time (DT)

$$DT = \text{Log}_e 2/r$$

7. Annual Rate of Increase (ARI)

$$ARI = 365 = e^{365r} = 2^{365/DT} = R_o^{\ 365/T}$$

RESULTS AND DISCUSSION

The pooled observation for two successive generations revealed that the last (terminating) pivotal age of *C. septempunctata* varied from 33.5 to 58.5 days at different temperatures. The female took maximum time to complete its fecundity in 19 days at 18±1 and 24±1°C and minimum in 15 days at 28±1°C. The immature stages required maximum period of development at 18±1°C as compared to 24±1 and 28±1°C. Similarly, female also registered their highest developmental period at 18±1°C followed by 24±1 and 28±1°C (Table 1). Similar was the opinion made by Omkar and Pervez (2004), they reported that at different temperature regimes (20, 25, 27 and 30°C) 27°C was found to be the most suitable temperature for development of *Propylea dissecta*.

There was an undulating pattern of egg laying of *C. septempunctata* over the period of time with respect to different temperatures. However, major contribution of egg laying was observed over a definite period (75.40% at 24±1°C between 43.5 to 51.5 days followed by 71.45% 28±1°C between 38.5 to 44.5 days and 60.57% 18±1°C between 43.5 to 51.5 days). The life parameters viz., potential fecundity and net reproductive rate of female was recorded maximum at 24±1°C (165.67 eggs/female and 41.09 females/female/generation, respectively) and the minimum at 28±1°C (146.63 eggs/female and 29.70 females/female/generation, respectively). The present investigation is complete agreement with the study made by Naqvi (2003), who also investigated maximum offsprings at 24±1°C. However, Omkar and Srivastava (2003) reported maximum fecundity of *C. septempunctata* at 30°C in contrast to 20°C.

The mean length of generation and doubling time of female was recorded maximum at 18±1°C (48.27 days and 9.06 days) and the minimum at 28±1°C (40.77 days and 8.26 days). This study has been well supported by the findings of other workers such as Singh and Singh (1994) and Abbas (2004), who reported shortest developmental time at 25±1°C.

The finite rate of increase and intrinsic rate increase were found maximum at 28±1°C (1.0876 and 0.0840, females/female/day, respectively) and the minimum at 18±1°C (1.0794 and 0.0764, females/female/day, respectively). A similar trend with respect to annual rate of increase was obtained; it was highest at 28±1°C (2.04×10^{13}) and the lowest at 18±1°C (1.281×10^{12}). Naqvi (2003) and Abbas

Table 1: Survival and fertility table of *C. septempunctata* on *L. erysimi* at varying temperatures for two successive generations (Pooled analysis)

Pivotal age (days) (x	Age specific female survivorship (l_x)	Natility rate (m_x)	Net reproductive rate ($l_x.m_x$)	($l_x.m_x.x$)	Value of $e^{-rx}.l_x.m_x$	Contribution of each age group towards 'r' (%)
18±1°C					r = 0.07638	
0.5 to 39.5 immature stages and pre-oviposition period						
40.5	0.35	0.70	0.25	9.92	0.0111	1.1111
41.5	0.35	2.55	0.89	37.04	0.0375	3.7498
42.5	0.35	4.10	1.44	60.99	0.0559	5.5858
43.5	0.31	6.75	2.09	91.02	0.0755	7.5462
44.5	0.31	8.25	2.56	113.81	0.0854	8.5449
45.5	0.29	11.40	3.31	150.42	0.1023	10.2335
46.5	0.29	15.30	4.44	206.32	0.1272	12.7244
47.5	0.27	17.50	4.73	224.44	0.1255	12.5539
48.5	0.26	14.25	3.71	179.69	0.0912	9.1200
49.5	0.26	13.65	3.55	175.68	0.0809	8.0936
50.5	0.26	11.20	2.91	147.06	0.0615	6.1526
51.5	0.22	10.40	2.29	117.83	0.0448	4.4787
52.5	0.19	9.85	1.87	98.25	0.0339	3.3940
53.5	0.17	8.60	1.46	78.22	0.0246	2.4564
54.5	0.16	7.66	1.23	66.80	0.0191	1.9078
55.5	0.15	5.33	0.80	44.37	0.0115	1.1530
56.5	0.14	3.20	0.45	25.31	0.0060	0.5986
57.5	0.13	2.66	0.35	19.88	0.0043	0.4280
58.5	0.11	1.33	0.15	8.56	0.0017	0.1678
Sum		154.68	38.44	1855.61	1.000	100.000
24±1°C					r = 0.08035	
0.5 to 36.5 immature stages and pre-oviposition period						
37.5	0.31	0.42	0.13	4.88	0.0064	0.6399
38.5	0.31	1.31	0.41	15.63	0.0184	1.8417
39.5	0.31	2.92	0.91	35.76	0.0379	3.7882
40.5	0.29	4.60	1.33	54.03	0.0515	5.1517
41.5	0.29	6.15	1.78	74.02	0.0636	6.3558
42.5	0.29	7.10	2.06	87.51	0.0677	6.7711
43.5	0.29	10.57	3.07	133.34	0.0930	9.3021
44.5	0.26	12.23	3.18	141.50	0.0890	8.9046
45.5	0.25	14.50	3.63	164.94	0.0937	9.3676
46.5	0.25	18.28	4.57	212.51	0.1090	10.8979
47.5	0.25	19.68	4.92	233.70	0.1083	10.8268
48.5	0.25	14.34	3.59	173.87	0.0728	7.2799
49.5	0.23	13.57	3.12	154.49	0.0585	5.8486
50.5	0.23	11.18	2.57	129.86	0.0445	4.4465
51.5	0.21	10.57	2.22	114.31	0.0354	3.5420
52.5	0.21	8.42	1.77	92.83	0.0260	2.6037
53.5	0.19	6.89	1.31	70.04	0.0178	1.7789
54.5	0.19	2.10	0.40	21.75	0.0050	0.5003
55.5	0.16	0.84	0.13	7.46	0.0016	0.1555
Sum		165.67	41.09	1922.42	1.000	100.000
28±1°C					r = 0.08396	
0.5 to 32.5 immature stages and pre-oviposition period						
33.5	0.28	0.60	0.17	5.63	0.0101	1.0086
34.5	0.28	2.50	0.70	24.15	0.0386	3.8642
35.5	0.27	4.33	1.17	41.50	0.0593	5.9340
36.5	0.26	6.66	1.73	63.20	0.0808	8.0813
37.5	0.25	7.33	1.83	68.72	0.0786	7.8634
38.5	0.23	10.55	2.43	93.42	0.0957	9.5738
39.5	0.23	15.66	3.60	142.27	0.1307	13.0665
40.5	0.21	18.50	3.89	157.34	0.1296	12.9588
41.5	0.21	19.20	4.03	167.33	0.1237	12.3660
42.5	0.19	16.50	3.14	133.24	0.0884	8.8406
43.5	0.19	13.50	2.57	111.58	0.0665	6.6507
44.5	0.16	10.85	1.74	77.25	0.0414	4.1387
45.5	0.15	9.60	1.44	65.52	0.0316	3.1565
46.5	0.13	6.35	0.83	38.39	0.0166	1.6638
47.5	0.10	4.50	0.45	21.38	0.0083	0.8339
Sum		146.63	29.70	1210.91	1.000	100.000

Table 2: Life parameters of *C. septempunctata* on *Lipaphis erysimi* at varying temperatures for two successive generations (Pooled analysis)

Life parameters	18±1°C	24±1°C	28±1°C
Potential fecundity	154.68	165.67	146.63
Net reproductive rate	38.44	41.09	29.70
Mean length of generation	48.27	46.79	40.77
Doubling time	09.08	08.63	08.26
Finite rate of increase	01.0794	01.0837	01.0876
Intrinsic rate of increase approx	00.0756	00.0794	00.0832
Intrinsic rate of increase accurate	00.0764	00.0803	00.0840
Annual rate of increase	01.281×10^{12}	05.45×10^{12}	02.04×10^{13}

(2004) also held similar opinion. Nevertheless, the study made by Baitha and Sinha (2005) revealed that the different rate (finite, intrinsic and annual) of increase are responsible for the numerical changes in population, the high rate of increase follow the speedy development whereas low rate responsible for slow development of insect.

From the findings it could be consummate that among 18±1, 24±1 and 28±1°C temperatures, 28±1°C was the most preferred for survival and 24±1°C for high fecundity of the *C. septempunctata*. Therefore, present investigations are essential knowledge or preliminary step for the mass rearing of *C. septempunctata* in the biological control program of *L. erysimi*.

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