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Studies on the Life table and Life budget analysis of a coccinellid Coleoptera: *Coccinella transversalis* fab. for five successive generations

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Abstract-

The Life table and Life budget studies of *C. transversalis* for five generations were done for the percentage mortality and the maximum survival of its different life stages throughout the year. The mortality value of eggs was minimum (9.00%) in second generation and maximum (17.60%) in fifth generation. The apparent mortalities (100qx) in larval and pupal stages were minimum in second generation and maximum in the fifth generation. The minimum apparent mortality of first, second, third, fourth larval stage and pupal stage in second generation were 16.70, 10.03, 8.50, 3.53 and 2.99 percent, respectively. The maximum apparent mortality of first, second, third, fourth larval stage and pupal stage were 22.82, 17.61, 12.60, 12.23 and 9.45 percent, respectively, during fifth generation.

The life budget studies of *C. transversalis* for five generations shown the maximum emergence and survival of ladybeetles were found in second generation, whereas the maximum mortality of ladybeetle occurred in fifth generation. The k- values for eggs were lowest (0.0410) in second generation and highest (0.0841) in fifth generation. The minimum k- values for first, second, third, fourth instar larvae and pupae were 0.0794, 0.0459, 0.0386, 0.0156 and 0.0132, respectively, during second generation and 0.1125, 0.0841, 0.0585, 0.0566 and 0.0431, respectively, in fifth generation. The Kappa (K) value was found minimum in second generation (0.2336) followed by third (0.2807), first (0.3224), fourth (0.3645) and fifth (0.4389) generations.

The lowest real mortality (100rx) in first, second, third, fourth larval instar and pupal stage were 15.20, 7.60, 5.80, 2.20 and 1.80 percent, respectively, in second generation. Highest real mortality during these stages was 18.80, 11.20, 6.60, 5.60 and 3.80 percent in fifth generation. The maximum survival rates of larvae and pupae were in second generation and minimum in fifth generation. The survival rate of first, second, third, fourth larval instar and pupae was 0.83, 0.90, 0.91, 0.96 and 0.97, respectively during second generation and 0.77, 0.82, 0.87, 0.88 and 0.91 during fifth generation.

Key Words: Life history, Lady beetle, predation rate, *Coccinella transversalis*, population ecology, life table.

Introduction-

According to Hawkeswood (1987), Karpacheva (1991), Boopathi et al. (2017), coccinellid predators are among the most significant helpful insects. They eat pest sucking insects like aphids, scales, thrips, mealybugs, and mites as well as other soft-bodied insects (Nunez-Perez et al. 1992). There are numerous habitats where the coccinellid beetles are seen (Hodek and Honek 1996; Boopathi et al. 2017).

Due to sexual dimorphism, higher reproductive potential, ease of availability, straightforward laboratory care, and shorter life cycles, it is a superior model for examining the aspects of life history (Omkar and Pervez 2000; Omkar and Mishra 2005). The life table is a crucial tool for population ecology and pest management as well as for mass-cultivating and harvesting insects for biocontrol, pheromone extraction, and toxicology research (Chi and Getz 1988). Understanding population ecology and *Coccinella transversalis* mass production requires analysis of fertility, development, and survival and its effects on the population growth rate and life table.

To account for both sexes and stage differentiation, the life table data for *Coccinella transversalis* in this study are used for the age-stage life tables to examine the outcomes (Chi and Liu 1985; Chi 1988). Life table and predation rate assessments are the elements for determining predation rate, fecundity, stage differentiation, and growth rate. Only a life table can provide a thorough summary of the species' fecundity, growth, and survival. A life table review is necessary for a proper assessment of the threat of predation.

Materials And Methods-

The life table studies on *C. transversalis* were made for five generations under laboratory conditions (temperature 22±2^{0}C to 35±2^{0}C and R.H. 45±5% to 65±5%). For the construction of life tables, five hundred eggs of the ladybeetles were taken randomly from the laboratory-reared stock and were kept in petri-dish. The newly hatched first instar larvae were introduced into the small glass tubes (height 7.5cm x diameter 5.0cm) and were provided with the aphid species available in that season for the feeding. The aphids were changed daily. The second larval instars, which survived were again transferred into other glass tube and the mortality in the first instar stage was recorded along with the mortality factors (parasitism and abiotic factors). The survival and mortality factors were also investigated in the similar manner for remaining larval stages, *i.e.* second, third and fourth instar and pupal stage of ladybeetle.

The different life stages of first generation were maintained on aphid preys, *viz. R. maidis,* and *A. craccivora*. The second generation was reared on *A. craccivora* and *A. gossypii*, which started from September 1998 to October 1998. The third generation, was reared on aphids, *viz. L. erysimi* and *U. compositae* that started from November 1998 to December 1998. The fourth generation begun from January 1999 to February 1995 was fed on aphids, *L. erysimi, A. gossypii* and *M. persicae* and the fifth generation started from March, 1999 to April, 1999 was reared on aphids, *viz. M. persicae, L. erysimi* and *A. nerii*.

The survival and mortality at different life stages, *viz.* eggs, larvae and pupae were recorded and computed. The whole experiment of life tables was designed as suggested by Morris and Miller (1954), which included the following columns:

x = The age interval *i.e.* eggs, larvae, pupae and adults.

lx = The number of surviving at beginning stage.

dx = The number dying within age interval x

dxf = Mortality factors responsible for dx.

100qx = Apparent mortality, dx as % of lx.

100rx = Real mortality, dx as a % of the original cohort size.

k = A dimension less measure of the mortality within age interval of x.

Sx = Survival rate of a stage.

K (Kappa) = The total of k- values.

The sex ratio was calculated by following formula:

$$\text{Sex ratio} = \frac{\text{Number of emerged females}}{\text{Number of total emergence}} \times 100$$

The Generation survival values were calculated by the formula given by Hercourt, (1969):

$$\text{Generation survival} = \frac{\text{Number of female beetles}}{\text{Number of initial eggs}}$$

OBSERVATION TABLES-

LIFE TABLES FOR DIFFERENT GENERATIONS:

Table 1: Life table of *C. transversalis* for first generation

Age interval X	No. entering interval x Lx	Factors responsible for dx DxF	No. dying in age x dx	dx as % of lx 100qx	Real mortality 100rx	Survival rate Sx
Eggs	500	Infertility, *T. coccinellae*, temperature and R.H.	66	13.20	13.20	0.87
Eggs hatched	434		0.00	0.00	0.00	1.00
First instar	434	*T. coccinellae, B. bassiana*, temp. and R.H.	87	20.05	17.40	0.80
Second instar	347	*T. coccinellae, B. bassiana*, temp. and R.H.	49	14.12	9.80	0.86
Third instar	298	*T. coccinellae, B. bassiana*, temp. and R.H.	38	12.75	7.60	0.87
Fourth instar	260	*T. coccinellae, B. bassiana*, temp. and R.H.	14	5.38	2.80	0.95
Pupae	246	*T. coccinellae*, temp. and R.H.	8	3.25	1.60	0.97
Emergence	238					
Male	105					
Female	133					

Table 2: Life table of *C. transversalis* for second generation.

Age interval X	No. entering interval x Lx	Factors responsible for dx DxF	No. dying in age x dx	Dx as % of lx 100qx	Real mortality 100rx	Survival rate Sx
Eggs	500	Infertility, *T. coccinellae*, temperature and R.H.	45	9.00	9.00	0.91
Eggs hatched	455		0.00	0.00	0.00	1.00
First instar	455	*T. coccinellae, B. bassiana* temp. and R.H.	76	16.70	15.20	0.83
Second instar	379	*T. coccinellae, B. bassiana*, temp. and R.H.	38	10.03	7.60	0.90
Third instar	341	*T. coccinellae, B. bassiana*, temp. and R.H.	29	8.50	5.80	0.91
Fourth instar	312	*T. coccinellae, B. bassiana*, temp. and R.H.	11	3.53	2.20	0.96
Pupae	301	*T. coccinellae*, temp. and R.H.	9	2.99	1.80	0.97
Emergence	292					
Male	124					
Female	168					

Table 3: Life table of *C. transversalis* for third generation

Age interval X	No. entering interval x Lx	Factors responsible for dx DxF	No. dying in age x dx	dx as % of lx 100qx	Real mortality 100rx	Survival rate Sx
Eggs	500	Infertility, *T. coccinellae*, temperature and R.H.	58	11.60	11.60	0.88
Eggs hatched	442		0.00	0.00	0.00	1.00
First instar	442	*T. coccinellae, B. bassiana* temp. and R.H.	82	18.55	16.40	0.81
Second instar	360	*T. coccinellae, B. bassiana*, temp. and R.H.	40	11.11	8.00	0.89
Third instar	320	*T. coccinellae, B. bassiana*, temp. and R.H.	32	10.00	6.40	0.90
Fourth instar	288	*T. coccinellae, B. bassiana*, temp. and R.H.	15	5.21	3.00	0.95
Pupae	273	*T. coccinellae*, temp. and R.H.	11	4.03	2.20	0.96
Emergence	262					
Male	117					
Female	145					

Table 4: Life table of *C. transversalis* for fourth generation

Age interval X	No. entering interval x Lx	Factors responsible for dx DxF	No. dying in age x Dx	dx as % of lx 100qx	Real mortality 100rx	Survival rate Sx
Eggs	500	Infertility, *T. coccinellae*, temperature and R.H.	75	15.00	15.00	0.85
Eggs hatched	425		0.00	0.00	0.00	1.00
First Instar	425	*T. coccinellae, B. bassiana* temp. and R.H.	89	20.94	17.80	0.79
Second instar	336	*T. coccinellae, B. bassiana*, temp. and R.H.	52	15.48	10.40	0.85
Third Instar	284	*T. coccinellae, B. bassiana*, temp. and R.H.	34	11.97	6.80	0.88
Fourth instar	250	*T. coccinellae, B. bassiana*, temp. and R.H.	19	7.60	3.80	0.92
Pupae	231	*T. coccinellae*, temp. and R.H.	15	6.49	3.00	0.94
Emergence	216					
Male	97					
Female	119					

Table 5: Life table of *C. transversalis* for fifth generation

Age interval X	No. entering interval x Lx	Factors responsible for dx DxF	No. dying in age x Dx	Dx as % of lx 100qx	Real mortality 100rx	Survival rate Sx
Eggs	500	Infertility, *T. coccinellae*, temperature and R.H.	88	17.60	17.60	0.82
Eggs hatched	412		0.00	0.00	0.00	1.00
First instar	412	*T. coccinellae*, *B. bassiana* temp. and R.H.	94	22.82	18.80	0.77
Second instar	318	*T. coccinellae*, *B. bassiana*, temp. and R.H.	56	17.61	11.20	0.82
Third instar	262	*T. coccinellae*, *B. bassiana*, temp. and R.H.	33	12.60	6.60	0.87
Fourth instar	229	*T. coccinellae*, *B. bassiana*, temp. and R.H.	28	12.23	5.60	0.88
Pupae	201	*T. coccinellae*, temp. and R.H.	19	9.45	3.80	0.91
Emergence	182					
Male	80					
Female	102					

TABLES FOR LIFE BUDGET

Table 1: Life budget of *C. transversalis* for first generation.

Life stages	Numbers	Log Number	k- value
Eggs	500	2.6990	0.0615
First instar	434	2.6375	0.0972
Second instar	347	2.5403	0.0661
Third instar	298	2.4742	0.0592
Fourth instar	260	2.4150	0.0240
Pupae	246	2.3909	0.0144
Emergence	238	2.3766	

Kappa = 0.3224

Table 2: Life budget of *C. transversalis* for second generation.

Life stages	**Numbers**	**Log Number**	**k- value**
Eggs	500	2.6990	0.0410
First instar	455	2.6580	0.0794
Second instar	379	2.5786	0.0459
Third instar	341	2.5328	0.0386
Fourth instar	312	2.4942	0.0156
Pupae	301	2.4786	0.0132
Emergence	292	2.4654	

Kappa = 0.2336

Table 3: Life budget of *C. transversalis* for third generation

Life stages	**Numbers**	**Log Number**	**k- value**
Eggs	500	2.6990	0.0535
First instar	442	2.6454	0.0891
Second instar	360	2.5563	0.0512
Third instar	320	2.5051	0.0458
Fourth instar	288	2.4594	0.0232
Pupae	273	2.4362	0.0179
Emergence	262	2.4183	

Kappa = 0.2807

Table 4: Life budget of *C. transversalis* for fourth generation

Life stages	Numbers	Log Number	k- value
Eggs	500	2.6990	0.0706
First instar	425	2.6284	0.1020
Second instar	336	2.5263	0.0730
Third instar	284	2.4533	0.0554
Fourth instar	250	2.3979	0.0343
Pupae	231	2.3636	0.0292
Emergence	216	2.3345	

Kappa = 0.3645

Table 5: Life budget of *C. transversalis* for fifth generation

Life stages	Numbers	Log Number	k- value
Eggs	500	2.6990	0.0841
First instar	412	2.6149	0.1125
Second instar	318	2.5024	0.0841
Third instar	262	2.4183	0.0585
Fourth instar	229	2.3598	0.0566
Pupae	201	2.3032	0.0431
Emergence	182	2.2601	

Kappa = 0.4389

Table 6: A comparison of the 100qx for the mortality factors operating within five generations in *C. transversalis*

Age interval	Generation I	Generation II	Generation III	Generation IV	Generation V
Eggs	13.20%	9.00%	11.60%	15.00%	17.60%
First instar	20.05%	16.70%	18.55%	20.94%	22.82%
Second instar	14.12%	10.03%	11.11%	15.48%	17.61%
Third instar	12.75%	8.50%	10.00%	11.97%	12.60%
Fourth instar	5.38%	3.53%	5.21%	7.60%	12.23%
Pupae	3.25%	2.99%	4.03%	6.49%	9.45%
% overall mortality in first instar	46.28%	49.35%	48.52%	45.88%	44.55%
% overall mortality in second instar	26.06%	24.68%	23.67%	26.80%	26.54%
% overall mortality in third instar	20.21%	18.83%	18.93%	17.53%	15.64%
% overall mortality in fourth instar	7.45%	7.14%	8.88%	9.79%	13.27%
% overall mortality prior to adult stsge	52.40%	41.60%	47.60%	56.80%	63.60%
Sex ratio	.56	.58	.55	.55	.56
Generation survival	0.27	0.34	0.29	0.24	0.20

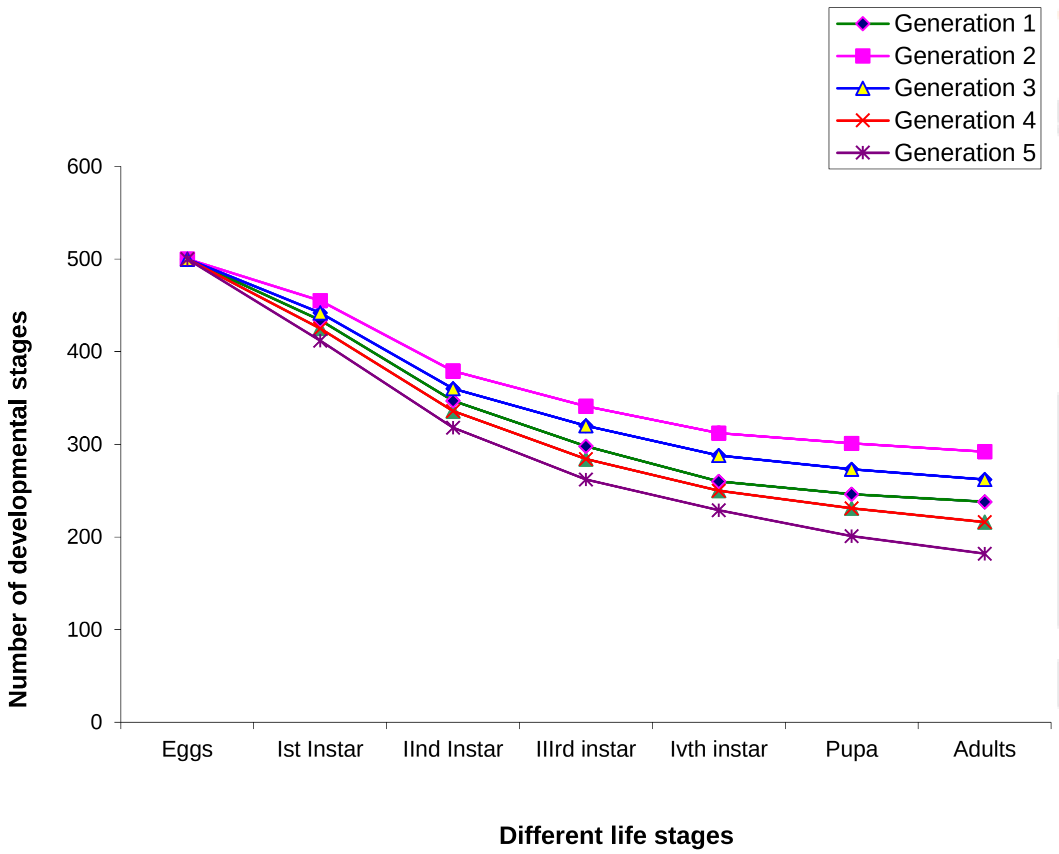

Figure 1: Number of developmental stages of *C. transversalis* in different generations

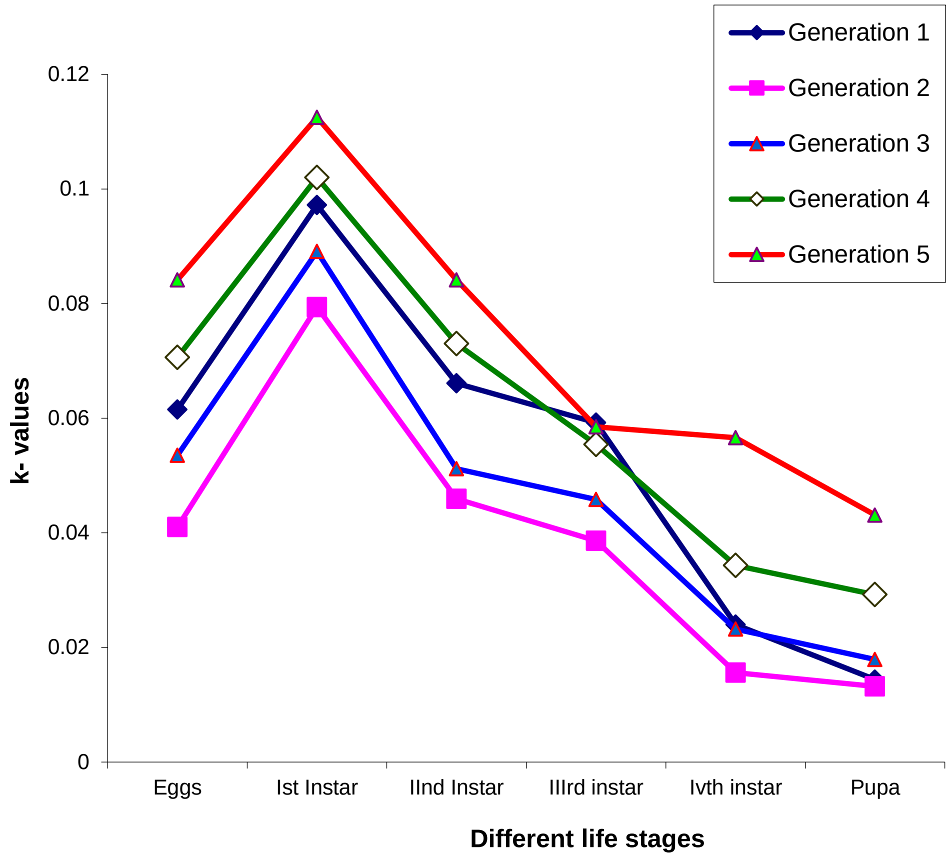

Figure 2: k-values of mortality of *C. transversalis* in different generations

Results-

The data presented in Tables- 1 to 5 and Figure-1 revealed the percentage mortality in different life stages of *C. transversalis* during five generations throughout the year. The mortality values of eggs in first, second, third, fourth and fifth generations were 13.20%, 9.00% 11.60%, 15.00% and 17.60%, respectively. Survival rate (Sx) was 0.87, 0.91, 0.88, 0.85 and 0.82 during five generations. Maximum mortality of eggs occurred in the fifth generation (17.60%). Maximum survival rate (0.91) was found in the second generation and minimum (0.82) in the fifth generation.

The apparent larval mortalities (100qx) in the first larval stage were 20.05, 16.70, 18.55, 20.94 and 22.82 percent in first, second, third, fourth and fifth generations, respectively. The real mortalities (100rx) were 17.40, 15.20, 16.40, 17.80 and 18.80 percent during five generations. The survival rates of first instar larvae were 0.80, 0.83, 0.81, 0.79 and .077 during first to fifth generations.

The apparent mortality values in the second larval instar were 14.12, 10.03, 11.11, 15.48 and 17.61 percent during first, second, third, fourth and fifth generations, respectively. The real mortalities were 9.80, 7.60, 8.00, 10.40 and 11.20 percent during five generations. The survival rates were 0.86, 0.90, 0.89, 0.85 and 0.82 during five generations.

The apparent mortalities in third instar larvae were 12.75, 8.50, 10.00, 11.97 and 12.60 percent during first, second, third, fourth and fifth generations, respectively. The real mortalities were 7.60, 5.80, 6.40, 6.80

and 6.60 percent during five generations. The survival rates of third instar larvae were 0.87, 0.91, 0.90, 0.88 and 0.87 during five generations.

The apparent mortalities in the fourth larval instar were 5.38, 3.53, 5.21, 7.60 and 12.23 percent during first, second, third, fourth and fifth generations, respectively. The real mortalities of fourth instar larvae were 2.80, 2.20, 3.00, 3.80 and 5.60 percent during first, second, third, fourth and fifth generations, respectively. The survival rates were 0.95, 0.96, 0.95, 0.92 and 0.88 during first, second, third, fourth and fifth generations, respectively.

The apparent pupal mortality in first, second, third, fourth and fifth generations were 3.25, 2.99, 4.03, 6.49 and 9.45 percent, respectively. The real mortality values were 1.60, 1.80, 2.20, 3.00 and 3.80 percent during first, second, third, fourth and fifth generations, respectively. The survival rates of pupae were 0.97, 0.97, 0.96, 0.94 and 0.91 during five generations. Thus, the pupal mortality was maximum in fifth generation and minimum in second generation.

The apparent mortality values of first instar larvae were highest during all the generations than those of second, third and fourth instar larvae. The maximum mortality during first instar larval stage occurred in fifth generation and minimum in second generation. This may be inferred that the real mortality values of different stages were always less than the apparent mortality values of all stages. Although the real mortality values were highest in first instar stage of all the generations but highest mortality among all the larval stages occurred in fifth generation.

The data given in Tables-2 to 6 and Figure-2 displayed the life budget of *C. transversalis* and revealed the mortality values (k- values) of all the stages during five generations. The k- values for the eggs were 0.0615, 0.0410, 0.0535, 0.0706 and 0.0841 during five generations. The k- values for first instar larvae were 0.0972, 0.0794, 0.0891, 0.1020 and 0.1125, for second instar larvae were 0.0661, 0.0459, 0.0512, 0.0730 and 0.0841 during first, second, third, fourth and fifth generations, respectively.

The k- values for third larval instar were 0.0592, 0.0386, 0.0458, 0.0554 and 0.0585 and 0.0240, 0.0156, 0.0232, 0.0343 and 0.0566 for fourth instar larvae during first, second, third, fourth and fifth generations, respectively. The k- values for the pupae were 0.0144, 0.0132, 0.0179, 0.0292 and 0.0431 during first, second, third, fourth and fifth generations, respectively.

The results were also strengthened by the calculation of total mortality (Kappa value), which were 0.3224, 0.2336, 0.2807, 0.3645, and 0.4389 during first, second, third, fourth and fifth generations, respectively. Thus, total mortality value was maximum in fifth generation and minimum in second generation. The mortality value (k) was maximum for first instar in all generations.

The data presented in Table-32 displays the comparison of different mortality factors in the different stages of *C. transversalis* in the five generations. The overall percent mortality of first larval instar was 46.28, 49.35, 48.52, 45.88 and 44.55 from first to fifth generations, respectively. The overall mortality percent of second instar larvae was 26.06%, 24.68%, 23.67%, 26.80% and 26.54% from first to fifth generations, respectively. The overall percent larval mortality in third larval instar was 20.21, 18.83, 18.93, 17.53 and 15.64

during first, second, third, fourth and fifth generations, respectively. The overall mortality in fourth larval instar was 7.45, 7.14, 8.88, 9.79 and 13.27 percent during the five generations.

The percent values of overall mortality of *C. transversalis* prior to adult stage were 52.40, 41.60, 47.60, 56.80 and 63.60 percent during first, second, third, fourth and fifth generations, respectively. Hence, mortality prior to adult stage was maximum in the fifth generation and minimum in second generation.

The sex ratios (proportions of female in total survived emergence) varied very little between generations as the values were 0.56, 0.58, 0.55, 0.55 and 0.56 during first, second, third, fourth and fifth generations, respectively. The values of generation survival were 0.27, 0.34. 0.29, 0.24 and 0.20 during first, second, third, fourth and fifth generations, respectively. The generation survival was maximum (0.34) in the second generation. Thus, it could be inferred from the mortality factors that the second generation was the best generation followed by third, first, fourth and fifth generations.

The results revealed that second generation was the best generation of *C. transversalis*, when they were reared in the laboratory for five generations, which was followed by third, first, fourth and fifth generations. The operating mortality factors might have reduced their population survival. The decreased emergence in these generations may be due to many mortality factors operating, *viz.* infertility, parasitism, abiotic factors, and change of food quality and lack of preferred aphids, *A. gossypii* and *A. craccivora*. This may be ascribed to the availability of preferred preys as *A. gossypii*, *A. craccivora* and *L. erysimi*. The change in season and suitable temperature may also be the possible reason for high survival and success of second generation, as temperature started decreasing from first generation to other successive generations.

It is also clear from the results that the maximum mortality was found in the larval stage than egg and pupal stages. The larval stages of all five generations suffered greatly, as the mortality factors operating were maximum at this stage. The heavy mortality in the first larval instar during all the five generations revealed that first larval instar was most sensitive to the natural abiotic factors, *viz.* temperature and relative humidity and the biotic factors, such as parasitization by *T. coccinellae* and fungus, *Beauveria bassiana* and non-availability of suitable prey species.

The pupal mortality was minimum in second generation and maximum in fifth generation. The causes of pupal mortality were unfavourable abiotic factors, such as, temperature and relative humidity and certain biotic factors, such as the parasitoid, *T. coccinellae*. The decreased percentage of larval and pupal mortality in second generation followed by third, first, fourth and fifth generations may be attributed to the availability of suitable prey species that increased the tolerance to unfavourable conditions, thus they become less susceptible to abiotic and biotic factors.

The high generation survival in second generation revealed that the mortality factors operating in this generation were the minimum and this may be ascribed to the availability of preferred preys, favourable temperature, humidity and low level of parasitism. The low generation survival in fifth generation indicated that the operating mortality factors were the maximum in that generation. Thus, the life table studies on *C.*

transversalis suggests that this ladybeetle can be successfully reared in the laboratory and further utilized in the biological control of aphid pests of the economically important crops.

The overall percent mortality prior to adult stage was lowest (41.60%) in second generation and highest (63.60%) in fifth generation. The generation survival was highest in second generation (0.34) followed by third (0.29), first (0.27), fourth (0.24) and fifth (0.20) generations. The major mortality factors operating in the larval stages were the non-availability of suitable prey species; unfavourable abiotic factors, such as, temperature and relative humidity and certain biotic factors, *i.e.* attack of parasitoid, *T. coccinellae* and fungus, *B. bassiana*. The causes of pupal mortality were unfavourable abiotic factors, such as, temperature and relative humidity and certain biotic factors, as parasitoid, *T. coccinellae.* Thus, it may be inferred that second generation was the best generation followed by third, first, fourth and fifth generations.

Discussion-

Owing to the fact wherein each individual's rate of development ranges, the Ladybird Beetle's survival rate, life expectancy, and reproductive value were discovered to have overlapped stages (Liu et al. 1997); this general occurrence is crucial to consider while assessing the life table. The findings also showed how important it is to accurately describe and interpret the survival rate, life expectancy, reproductive value, and fecundity when assessing life tables for both sexes and including stage difference. To estimate the potential rate of population growth, one must be familiar with the biological characteristics of coccinellids. These characteristics also allow us to calculate the likelihood that these predators would compete with one another and to calculate the success of an invading species (Lanzoni et al., 2004; Raak-van den Berg et al., 2018).

Hamalainen (1976) reared nine generations of *C. septempunctata* and ten generations of *A. bipunctata* and found that majority of females laid eggs in each generation. The average number of eggs per female and proportion of eggs that hatched and development time and mortality in larvae and pupae varied in different generations in both the beetles. The significant degeneration factor was increasing mortality in larvae and pupae and decreasing hatching rate of eggs in successive generation of *A. bipunctata*. Osawa (1992) studied life table of *H. axyridis* in relation of seasonal change in the aphid species and found that 31.16% of egg mortality was due to cannibalism. Mortality of fourth instar larvae was 93.33% that was drastically higher than other life stages. The oviposition synchronized with the change in the aphid species. Drayer *et al.* (1997) studied the influence of temperature on the life table of ladybeetle, *H. notata*. Two cohorts of strains, one feeding on *P. manihoti* and other feeding on *Phenococcus herreni* were studied at different temperatures between 15^0C and 34^0C. The slight difference in the survivorship and development time was noticed at the same temperature between the two strains.

Katsoyannos *et al.* (1997) studied four complete and fifth partial generation of *C. septempunctata* for two years and found that only adults of first generation reproduced well in both the years. Second, third, and fourth generations reproduced partly in the following year. Fifth generation adults did not reproduce. (Obrycki *et al,* 1997) studied the partial life table of C. *maculata* and *C. septempunctata* and found that highest mortality occurred in first larval instars and the low survival rate caused by the other predatory arthropods and abiotic factors.

Few other workers investigated the life tables of various coccinellids, such as, *O. v-nigrum* (Chazeau *et al.*, 1991), *Coelophora mulsanti*, (Sallee and Chazeau, 1985), *C. sexmaculata* (Hussein and Hassanjaya, 1994). Thus, review of literature revealed that most of the work pertaining to life table studies was made on other coccinellids and investigations for the same are yet not made on *C. transversalis.*

The mortality factors in the egg stage were the infertility of eggs, attack of parasitoid, *T. coccinellae* and abiotic factors as unfavourable temperature and humidity. At very low and very high temperatures, the eggs failed to hatch. The infertility of eggs may be ascribed to the parthenogenetically laid eggs, as parthenogenetic eggs did not hatch (Kapur, 1942 and Bagal and Trehan, 1945). The inbreeding also effects the viability of the eggs (Morjan *et al.* (1999). The soft body of the larvae also makes them vulnerable to abiotic and biotic factors (Puttarudriah and Basavanna, 1953 and Schaefer and Semyanov, 1992).

Kapur (1942) studied the parasites of *A. variegata*, *B. suturalis* and *S. quadrillum*. *Hylopterus flamineous* was the parasite of last two instars of *A. variegata* and *B. suturalis*, but *Parachrysocharis* sp. parasitized the pupal stage of *A. variegata*. *S. quadrillum* was parasitized by *Homalotylus terminalis*, *H. terminalis californicus* and *Homalotylus* sp. and P*achyneuron* sp. Puttarudriah and Basavanna (1953) investigated the parasites of *C. septempunctata* and *C. transversalis* and noticed that *Tetrastichus* sp., a eulophids parasite, attacked the larvae of both the ladybeetles. Lipa *et al.* (1975) found that *C. septempunctata* was heavily parasitized by *P. coccinellae* and fungus, *Beaveria bassiana*. The field mortality was recorded 20%. Hodek (1977) observed parasites from *C. septempunctata* and reported *Perilitus coccinellae* from the active stages and pupal stages of the ladybeetle. Kharsun and Vinokurov (1977) studied certain nematode species parasitizing the individuals of Coccinellidae and procured a list of nematodes with their brief descriptions.

Obrycki and Tauber (1978) reported *P. coccinellae* as a parasite of coccinellid, *C. maculata*. Ceryngier *et al.* (1992) found that *P. coccinellae* affected the activity of testicular follicles of male *C. septempunctata* and decreased the intensity of female beetle. Schaefer and Semyanov (1992) generated a list of parasites attacking *C. septempunctata* and reported that sixteen species of parasitoids (14 hymenopterans from 6 families, 2 dipterans from 2 families and 2 ectoparasitic mites) parasitized it. James and Lighthart (1994) found that the two strains of fungus *B. bassiana* caused 75-95% mortality in *H. convergens*. Okuda *et al.* (1995) found that the parasite, *P. coccinellae (=Dinocampus coccinellae)* effected the larval, pupal and adult stages by terminating the development. Triltshit (1996) found the parasites, P. *coccinellae* (33 and 12.5%), *Phalacrotophora fasciata* (4.9 and 20.20%), *Oomyzus scaposus* and *Tetrastichus* (0.9 and 1.4 %) to be present on *C. septempunctata*. Zhang *et al.* (1996) found that the larvae of *Allothrombium triticium* are ectoparasite on the pupae and adults of *C. septempunctata*. Majerus (1997) found that *C. septempunctata*, *C. undecimpunctata*, and *H. quadripunctata* were heavily parasitized by *D. coccinellae* and the percent of parasitization were 22.1, 19.4, 17.4%, respectively.

Geoghegan *et al*. (1997 and 1998) reported that the parasitoid*D. coccinellae* effected the larval, pupal and adult stages of *C. septempunctata*. Haseeb and Murad (1998) noticed that the pathogenic fungus, *B. bassiana* attacked certain coccinellids. James *et al*. (1998) found that *H. convergens* attacked by *B. bassiana*. Omkar and Bind (2000) reported a pteromalid parasite, *Pachyneuron* sp. and an eulophid parasite, *Tetrastichus* sp parasites in *C. sexmaculata*. The first larval instar was mainly parasitized by *Pachyneuron* sp. and rests of the larval instars were parasitized by *Tetrastichus* sp. They also suggested that mortality was the maximum in the first larval instar, which was more prone to the parasitism

A few other workers investigated the parasites of few coccinellids, such as, *T. coccinellae* on *C. undecimpunctata* (Karaman *et al*., 1996) and *P. coccinellae* on *C. septempunctata* (Cartwright *et al*. (1982), O. *scaposus*, *Phalacrotophora sp*., and *H. flaminius* on *C. septempunctata* (Won, *et al*., 1996, Gregory *et al*., 1998), *B. bassiana* on all embryonic stages of the lady beetles (Thalji, 1997), *P. philaxyridis* on *A. bipunctata* (Disney, 1997), *B. bassiana* and *Paecilomyces fumosoroseus* on *Serangium parcesetosum* (Poprawski *et al*., 1998), *P. coccinellae* on *C. maculata* (Wright and Liang, 1982).

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References-

- Agarwala, B.K. and Bardhanroy, P. (1997). Oviposition behaviour and reproduction efficiency in ladybeetles (Coccinellidae: Coleoptera): A case study of Menochilus sexmaculatus (Fabr.) J. Aphidol. 11(1): 49-59
- Agarwala, B.K. and Dixon A. F. G. (1993). Why do ladybirds lay eggs in cluster? Func. Ecol. 7: 541-548
- Agarwala, B.K., Bhattacharya, S. and Bardhanroy, P. (1997): Cluster laying of eggs does not increase the risk of cannibalism by first instar larvae in ladybird beetles. Proc. Ind. Natn. Sci. Acad., 63(1): 1-10
- Ali, A., & Rizvi, P. Q. (2010). Age and stage specific life table of Coccinella septempunctata (Coleoptera: Coccinellidae) at varying temperature. World Journal of Agricultural Sciences, 6(3), 268-273.
- Bagal, S.R. and Trehan, K.N. (1945). Life-history and bionomics of two predaceous and one mycophagous species of Coccinellidae. J. Bombay Nat. Hist. Soc. 45: 566 - 575.
- Bind, R.B. (1998). Bioecology and behaviour of a ladybird beetle, Cheilomenes (=Menochilus) sexmaculata (Fabricius) (Coleoptera: Coccinellidae). Ph.D. Thesis. University of Lucknow, Lucknow.
- Boldyrev, M. I., Wilde, W. H. A. and Smith, B. C. (1969). Predaceous coccinellid oviposition responses to Juniperus wood. Can. Entomol. 101: 1199-1206.
- Boopathi, T., Singh, S. B., Dutta, S. K., Dayal, V., Singh, A. R., Chowdhury, S., ... & Lalhruaipuii, K. (2020). Biology, predatory potential, life table, and field evaluation of Propylea dissecta (Coleoptera: Coccinellidae), Against Lipaphis erysimi (Hemiptera: Aphididae) on broccoli. Journal of Economic Entomology, 113(1), 88-97.
- Chaudhary, D., David, B.A. and Singh, D.R. (1983). Studies on the host preference of Chilomenus sexmaculata (Fabr.) (Coleoptera: Coccinellidae). Comp. Physiol. Ecol., 8(4): 289-290

- Cole, P. G., Cutler, A. R., Kobelt, A. J., & Horne, P. A. (2010). Acute and long-term effects of selective insecticides on Micromus tasmaniae Walker (Neuroptera: Hemerobiidae), Coccinella transversalis F.(Coleoptera: Coccinellidae) and Nabis kinbergii Reuter (Hemiptera: Miridae). Australian Journal of Entomology, 49(2), 160-165.
- Dixon, A. F. G. (1959). An experimental study of the searching behaviour of the predatory coccinellid beetle Adalia decempunctata (L.). J. Anim. Ecol. 28: 259-281
- Dixon, A. F. G. and Guo, Y. (1993). Egg and cluster size in ladybird beetles (Coleoptera Coccinellidae): The direct and indirect effects of aphid abundance. European J. Entomol. 90: 457-463
- Doumbia, M. (1998). Study of the oviposition behaviour of Adalia bipunctata (L.) (Coleoptera: Coccinellidae). Gembloux. 125p
- Evans, E. W. and Dixon, A. F. G. (1986). Cues for oviposition by ladybird beetles (Coccinellidae): response to aphids. J. Anim. Ecol. 55: 1027-1034
- Ferran, A., Iperti, G., Lapchin, L., Lyon, J.P. and Rabasse, J.M. (1989). Quantification of predatory effeciency of C. septempunctata (Col., Coccinellidae) in wheat crops: 1. Comparison between biomasss consumption and aphid production. Organisation Internationale de Lutte Biologique. Section Regionale quest Palearctique. Working group "integrated control in cereal crops" Antebes. 63-72
- Gautam, R. D. (1990a). Effect of substrata and age of Menochilus sexmaculatus (Fabr.) (Coleoptera : Coccinellidae) on its oviposition. J. Biol. Control 4(1): 8-10.
- Gautam, R. D. (1990b). Influence of substrata and age of Coccinella septempunctata on its oviposition. Indian J. Agric. Sci. 60(4): 393-396.
- Harmon, J. P., Losey, J. E. and Ives, A. R. (1998). The role of vision and colour in the close proximity foraging behaviour of four coccinellid species. Oecologia 115: 287-292.
- Hemptinne, J.L. (1991). Structure and function of exocrine glands of the genitalia of female of the two spot ladybird, Adalia bipunctata (Linnaeus, 1758) (Coleoptera: Coccinellidae). Belg. J. Zool., 121: 27-37.
- Hemptinne, J.L., Dixon, A.F.G. and Coffin, J. (1992). Attack strategy of ladybird beetles (Coccinellidae): factors shaping their numerical response. Oecologia 90: 238-245
- Hemptinne, J.L., Dixon, A.F.G., Doucet, J.L. and Petersen, J.E. (1993). Optimal foraging by hoverflies (Diptera: Syrphidae) and ladybirds (Coleoptera: Coccinellidae): mechanisms. Eur. J. Ent. 90(4): 451-455.
- Honek, A. (1978). Trophic regulation of postdiapause ovariole maturation in Coccinella septempunctata (Col: Coccinellidae). Entomophaga. 23: 213-216.
- Honek, A. (1980). Population density of aphid at the time of settling and ovariole maturation in Coccinella septempunctata (Coleoptera: Coccinellidae). Entomophaga 23: 213-216
- Iperti, G. (1966). The choice of oviposition sites in aphidophagous Coccinellidae. In: Hodek I. (ed.): Ecology of Aphidophagous Insects. Academia, Prague & Dr. W. Junk, The Hague. Pp. 137-138Iperti, G. and Prudent, P. (1984). Effect of the substrate properties on the choice of oviposition sites by Adalia bipunctata In: Hodek I. (ed.): Ecology of Aphidophaga. Academia, Prague and Dr. W. Junk, Dordrecht. Pp. 143-149.
- Iperti, G. and Quilici, S. (1984). Some factors influencing the selection of oviposition sites by Propylea quatuordecimpunctata. In: Hodek I. (ed.): Ecology of Aphidophaga. Academia, Prague & Dr. W. Junk, Dordrecht., Pp. 137-142.
- Ives, P. M. (1981). Feeding and egg production of two species of coccinellids in the laboratory. Can. Entomol. 113 (11): 999-1005.

- Kapur, A.P. (1942). Bionomics of some Coccinellidae, predaceous on aphids and coccids in North India. Indian J. Entomol. 4(1): 49-66
- Kindlmann, P and Dixon, F.G. (1993). Optimal foraging in ladybird beetles (Coleoptera: Coccinellidae) and its consequences for their use in biological control. Eur. J. Entomol. 90(4): 443-450
- Lusis Ya Ya(1973). The choice of oviposition sites in female of three species of Adalia (Coleoptera: Coccinellidae) by breeding in laboratory. Zool. Muz. Rakasti 11: 55-63.
- Mills, N.J. (1981). Essential and alternative foods for some British Coccinellidae (Coleoptera). Entomol. Gaz. 32, 197-202.
- Mills, N.J. (1982). Satiation and the functional response: A test of a new method. Ecol. Entomol. 7(3): 305-316.
- Nohara, K. and Iwata, M. (1988). Studies on the ovipositing behaviour of Chilocorus kuwanae Silvestri (Coleoptera: Coccinellidae). Proc. Fac. Agric. Kyushu Tokoi Univ., 7: 17-24
- Patnaik, N.C. and Sahu, D.C. (1980). Influence of aphid host ant certain artificial diets on ovipositional response and longevity of ladybeetle, Menochilus sexmaculatus (Fabr.) (Coleoptera: Coccinellidae). Science and Culture, 46:103-105.
- Rawat, U. S. and Sangal, S. K. (1993). Influence of quality of food and host density on the ovipositional behaviour and longevity of predatory beetle, Chilocorus bijugas Mulsant. J. Insect Sci. 6(1): 109-11
- Rhamalinghan, M. (1986). Seasonal variation in ovariole number /ovary in C. septempunctata L. (Coleoptera: Coccinellidae). Proc. Indian Natn. Sci. Acad., 52: 619-623.
- Rhamalinghan, M. (1987). Seasonal variation in ovarioler output in Coccinella septempunctata L. (Coleoptera: Coccinellidae). In: Palanichamy S. (ed.): Proc. 5th Indian Symposium Invert. Reprod., P.G. and Res. Dept. Zool., A.P.A. College of Arts and Culture, Palani, India. Pp. 149-157.
- Sakurtani, Y. and Nakamura, Y. (1997). Oviposition strategies of Coccinella septempunctata (Coleoptera: Coccinellidae). Entomophaga 42(1/2): 33-40.
- Sengonca, C. and Liu, B. (1994). Responses of the different instar predator, Coccinella septempunctata L. (Coleoptera: Coccinellidae), to the kairomones produced by the prey and non prey insects as well as the predator itself. Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz, 101: 173-177
- Shands, W.A., Simpson, G.W. and Brunson, M.H. (1970). Insect predators for controlling aphids on potatoes: I. In small plots with two kinds of barriers, in small fields or in charge cages. J. Econ. Entomol. 62(2): 514- 518
- Singh, R. and Malhotra, R.K. (1979). Bionomics of Coccinella septempunctata Linn. Indian J. Entomol. 41(3): 244-249.
- Srivastava, S. (2000). Certain aspects of bioecology and ethology of a ladybeetle Coccinella septempunctata Linnaeus (Coccinellidae: Coleoptera). Ph. D. thesis Department of Zoology, University of Lucknow, Lucknow
- Stewart, L. A., Hemptinne, J. L. and Dixon, A.F.G. (1991b). Reproductive tactics of ladybird beetles: relationships between egg size, ovariole number and developmental time. Functional Ecology, 5: 380-385.
- Stewart, L.A., Dixon, A.F.G., Ruzicka Z., and Iperti, G. (1991a). Clutch and egg size in ladybird beetles. Entomophaga 36: 329-333.
- Takahashi K. (1987). Differences in oviposition initiation and sites of ladybeetles Coccinella septempunctata brucki Mulsant and Harmonia axyridis (Pallas) (Coleoptera: Coccinellidae) in the fields. J. Ecol. Entomol. 90(5): 1102-1105

- Udayagiri, S., Meson, C. F., Pesek, J. D. Jr. (1997). Coleomegilla maculata, Coccinella septempunctata (Coleoptera: Coccinellidae), Chrysoperla carnea (Neuroptera: Chrysopidae), and Macrocentrus grandii (Hymenoptera: Braconidae) trapped on coloured sticky traps in corn habitats. Environ. Entomol. 26(4): 983-988
- Volkl, W. (1995). Behavioural and marphological adaptations of the coccinellid Platynaspis luteorubrafor exploiting ant-attended resources (Coleoptera: Coccinellidae). Journal of Insect Behaviour, 8: 653-670