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# Life table studies of green lacewing, *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae), on the cabbage aphid, *Brevicoryne brassicae* L.

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**ABSTRACT:** Life tables are important tools to assess the reproductive performance of predators on their target preys. Studies were conducted at the Department of Entomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India during 2019-20 to construct life fertility tables of of green lacewing predator, *Chrysoperla zastrowii sillemi* (Esben-Petersen) on cabbage aphid, *Brevicoryne brassicae* L. Through stage specific life tables, it was revealed that the net reproductive rate ($R_o$), approximate generation time ($T_c$) and innate capacity of natural increase ($r_c$) of C. zastrowi sillemi were 80.83 female eggs per female, 42.29 days and 0.103, respectively. The true intrinsic rate of increase ($r_m$) on *B. brassicae* was found to be 0.1098.

**Keywords:** *Brevicoryne brassicae*, Cabbage aphid, *Chrysoperla zastrowi sillemi*, life table, net reproductive rate, predator

## INTRODUCTION

A life table represents an age-specific summary of mortality rates operating on a cohort of individuals and was first applied to the study of animal populations by Deevey (1947). Life table gives the number of individuals surviving at a particular stage or age in the life cycle, along with their reproductive output at that stage. A perusal of these tables facilitates estimation of survival rates of different stages and comparisons of the degree of mortality contributed by agents acting at differing points in the life cycle (Bellows *et al.,* 1992a). Life tables help in generating information on the survivorship, development and reproduction of a population of species which are critical to both basic and applied ecology and also for mass rearing of a particular species (Chi and Yang, 2003). Constructing life fertility tables is of high relevance while evaluating predators against a particular prey species. We report here the life fertility table of an aphidophagous predator, *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae), *on the cabbage aphid, Brevicoryne brassivcae L.*

The aphid, *B. brassicae* is one of the major pests of cabbage. Nymphs and adults colonise on leaves and leaf whorls and feed by sucking the plant sap. Aphid infestation results in wilting and yellowing of leaves and stunting of the plants (Jamaya and Ronald, 1998). Besides causing direct damage by sucking sap, they also excrete honeydew which results in growth of black sootymold on leaves affecting the photosynthetic ability of the plants. Cabbage aphid infestation causes significant yield losses and reduction in marketing value in all the cabbage growing areas (Bhalla, 1990; Bashir *et al*; 2013).

In order to manage cabbage aphid, generally farmers resort to spray synthetic insecticides indiscriminately which leads to undesirable effects such as pest resurgence, insecticide resistance build up in pests and residue problems besides causing environmental pollution. Hence, it is essential to explore safer alternatives to chemical control, of which biological control is an ideal and viable option to manage sucking pests like aphids. There are many biological control agents reported against cabbage aphid among which, the green lacewing, *C. zastrowi sillemi* has a greater potential (Singh and Jalali, 1994). It is a generalist predator and occurs naturally in a wide range of agroecosystems and is also commercially reared. The adults of *C. zastrowi sillemi* are not insectivorous and they feed on pollen and honeydew, while the larvae are polyphagous and predatory in nature. It is reported to feed on a large number of prey species across five insect orders. However, maximum number of prey species is from the order Hemiptera and predominantly aphids (Principi and Canard 1984; Venkatesan *et al*; 2008). The polyphagous nature coupled with its amenability for mass rearing and compatibility with selected chemical insecticides, microbial agents make this predator an effective biocontrol agent and hence it has received much attention from researchers as well as farmers. Sound knowledge of the biology and ecology of predators including fecundity, development, survivorship and longevity are essential in order to make them effective and viable components of integrated pest management (IPM) programmes. With this background present studies were conducted to prepare life fertility tables of *C. zastrowii sillemi* on the cabbage aphid in order to understand the key mortality factors.

## MATEERIALS AND METHODS

The predator, *C. zastrowi sillemi* was reared in the laboratory on the cabbage aphid under fixed temperature ($28\pm2^0$C) and RH (65-70%). Life table studies were conducted as per the method given by Southwood (1978). One hundred eggs of *C. zastrowi sillemi* were used with 20 eggs constituting one replication and five replications were maintained. The freshly collected eggs were allowed for hatching. Soon after hatching, the larvae were transferred to separate vials and maintained individually. Observations were recorded daily on the number of eggs hatched, larval development, number of larvae pupated, pupal development, number of adults emerged, their longevity and fecundity. The mortality in different stages was recorded. The adults were kept in oviposition cage with a black cloth placed on top of oviposition cage for egg laying and provided with diet of 50% honey solution, protienx mixture and water. By considering the sex ratio as 1:1, the number of female births (mx) was calculated according to the Southwood (1978), by dividing the number of eggs laid per female by two.

The data on daily survival and fecundity for each pivotal age were recorded until the death of last adult. Data analysis was carried out following the single sex method and the life tables were constructed using the following parameters.

X = Pivotal age (days).

$l_x$ = The proportion of the individuals alive at age X.

$m_x$ = The number of female eggs produced per female at age interval X.

Other parameters calculated as per Southwood (1978) are as given below.

**Net reproductive rate:** The net reproductive rate was calculated by the sum of products of $l_x m_x$. The rate of multiplication of the population in each generation is measured in terms of females produced per generation and recorded as the net reproductive rate. Therefore, the number of times the population multiplied per generation was calculated using the formula $R_o = \Sigma\, l_x m_x$

**Approximate generation time:** It is the average period from birth to weighted mean reproductive age of the adult. It was calculated with the formula: $T_c = \Sigma x l_x m_x / R_o$

**Innate capacity of increase in numbers:** The capacity of the population to increase in number i.e. the reproductive rate is innate capacity of increase. The number of average female offsprings produced at each age interval and number of individuals survived was recorded. The innate capacity of increase was calculated from the formula: $r_c = \log_e R_o / T_c$

**Intrinsic rate of natural increase:** The true intrinsic rate of increase ($r_m$) is the actual increase in the population when there is constant environmental conditions in which food and space are unlimited (Andrewartha and Birch, 1954). It was calculated on the basis of two arbitrary values of $r_c$ in the expression $\Sigma\,(e^{7-rmx}.l_x m_x) = 1096.6$ by graphic method.

**True generation time:** The average period from the birth of parent to birth of offspring is the true generation time, it is calculated by the formula $T = \text{Log}_e R_o / r_m$

**Finite rate of natural increase:** The number of times the population increases per unit time is finite rate of natural increase, it is determined as $\lambda = \text{Antilog}_e\, r_m$

**Weekly multiplication rate:** The number of times the population multiplies in a week is weekly multiplication rate, it is determined by formula $WM = e^{7rm}$

**Doubling time:** The time taken for the population to double its size is doubling time (DT) and it is determined by $DT = \log_e 2/r_m$

## RESULTS AND DISCUSSION

Life fertility table of *C. zastrowi sillemi* on *B. brassicae* was constructed and different parameters were estimated (Table 1). It is evident from this table that the adult emergence occurred from the 23rd day of pivotal age. Since that age there was 68 per cent adult survival which had continued up to 46th day of pivotal age. The survival rate had marginally declined to 67 per cent by 47th day and remained same on 48th day. On the 49th and 50th day, the survival was found to be 66 per cent which had come down to 63 and 59 per cent by 51st and 52nd day, respectively. Since then the fall in adult survival rate was steep and it reached down to 52 per cent on 53rd day, 43 per cent on 54th day and 34 per cent on 55th day of pivotal age. The survival rate of female adults had further declined to 23 and 14 per cent, respectively on 56th and 57th day. On 58th day, the survival rate reached 6 per cent

**Table 1. Life table and age specific fecundity of *Chrysoperla zastrowi sillemi* on *B. brassicae***

| Pivotal age in days (x) | Age specific survival (lx) | Female progeny per female (mx) | lxmx | xlxmx | rm=0.10 | rm=0.11 |
|---|---|---|---|---|---|---|
| 0-4 | 1 | | | Egg | | |
| 5-8 | 0.89 | | | 1st instar | | |
| 9-12 | 0.78 | | | 2nd instar | | |
| 13-16 | 0.74 | | | 3rd instar | | |
| 17-22 | 0.69 | | | pupal | | |
| 23-30 | 0.68 | | | pre oviposition | | |
| 31 | 0.68 | 0.90 | 0.61 | 18.97 | 30.23 | 22.18 |
| 32 | 0.68 | 1.30 | 0.88 | 28.29 | 39.52 | 28.69 |
| 33 | 0.68 | 1.90 | 1.29 | 42.64 | 52.26 | 37.57 |
| 34 | 0.68 | 3.30 | 2.24 | 76.30 | 82.13 | 58.46 |
| 35 | 0.68 | 3.60 | 2.45 | 85.68 | 81.07 | 57.13 |
| 36 | 0.68 | 4.10 | 2.79 | 100.37 | 83.54 | 58.28 |
| 37 | 0.68 | 4.80 | 3.26 | 120.77 | 88.50 | 61.13 |
| 38 | 0.68 | 4.40 | 2.99 | 113.70 | 73.40 | 50.20 |
| 39 | 0.68 | 6.20 | 4.22 | 164.42 | 93.59 | 63.36 |
| 40 | 0.68 | 7.40 | 5.03 | 201.28 | 101.07 | 67.75 |
| 41 | 0.68 | 8.20 | 5.58 | 228.62 | 101.34 | 67.25 |
| 42 | 0.68 | 9.80 | 6.66 | 279.89 | 109.59 | 72.00 |
| 43 | 0.68 | 10.70 | 7.28 | 312.87 | 108.26 | 70.43 |
| 44 | 0.68 | 10.10 | 6.87 | 302.19 | 92.47 | 59.55 |
| 45 | 0.68 | 9.60 | 6.53 | 293.76 | 79.53 | 50.71 |
| 46 | 0.68 | 7.20 | 4.90 | 225.22 | 53.97 | 34.07 |
| 47 | 0.67 | 7.40 | 4.96 | 233.03 | 49.45 | 30.91 |
| 48 | 0.67 | 6.80 | 4.56 | 218.69 | 41.12 | 25.44 |
| 49 | 0.66 | 4.80 | 3.17 | 155.23 | 25.87 | 15.85 |
| 50 | 0.66 | 3.00 | 1.98 | 99.00 | 14.63 | 8.87 |
| 51 | 0.63 | 2.20 | 1.39 | 70.69 | 9.27 | 5.56 |
| 52 | 0.59 | 1.30 | 0.77 | 39.88 | 4.64 | 2.76 |
| 53 | 0.52 | 0.40 | 0.21 | 11.02 | 1.14 | 0.67 |
| 54 | 0.43 | 0.30 | 0.13 | 6.97 | 0.64 | 0.37 |
| 55 | 0.34 | 0.30 | 0.10 | 5.61 | 0.46 | 0.26 |
| 56 | 0.23 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 57 | 0.14 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 58 | 0.06 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 59 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total** | | **120** | **80.834** | **3435.064** | **1417.66** | **949.46** |

which eventually became zero by 59th day.

A female on an average laid 0.9 female eggs on 31st day of pivotal age and on 32nd, 33rd, 34th, 35th and 36th day the female progeny produced was 1.3, 1.9, 3.3, 3.6 and 4.1 female eggs/ female. The female progeny produced on 37th, 38th, 39th and 40th day of pivotal age was 4.8, 4.4, 6.2 and 7.4 female eggs/ female. On 41st and 42nd day the female progeny produced was 8.2 and 9.8 female eggs/ female. The maximum number of female eggs/ female (10.7) was recorded on 43rd day of pivotal age. Thereafter, there was a decrease in the egg laying which was recorded till 55th day of pivotal age. A minimum of 0.3 female eggs per female were recorded on 55th day of pivotal age. The egg laying had completely ceased by the 56th day of the pivotal age. Fertility parameters of *C. zastrowi sillemi* were calculated from the data obtained in the present investigations (Table 3). The gross reproductive rate (GRR) and net reproductive rate ($R_0$) were estimated to be 120 and 80.83 female eggs per female, respectively, while the approximate generation time ($T_c$) was of 42.29 days. The innate capacity of natural increase ($r_c$) was found to be 0.103, whereas the true intrinsic rate of increase ($r_m$) that was estimated from the graphical presentation was 0.1098 (Fig. 3). The true generation time was 40 days and the finite rate of increase (λ) was 1.116 times with doubling time (DT) as 6.31 days. Weekly multiplication rate was found to be 2.16 times.

Life tables are essential to generate information on the survivorship, development and reproduction of a population of species. Life table studies of *C. zastrowi sillemi* were conducted by different workers using different preys. Subhan *et al.* (2009) also conducted similar studies on life fecundity table of *C. carnea* on sterilized eggs, unsterilized eggs and neonate larvae of *C. cephalonica* and recorded the survival of immature stages ($l_x$) to the extent of 0.68, 0.75 and 0.54 per individual within a pivotal age of 17, 27 and 37 days, respectively. The net reproductive rate ($R_o$) was 277.13, 296.09 and 148.41 females per female per generation, the mean length of generation time (T) was 45.25, 44.36 and 44.37 days, and the innate capacity for increase in numbers was 0.1243, 0.1283 and 0.1127 females per female per day. The present findings are on similar lines with the slight deviations which could be attributed to the differences in rearing conditions and host used.

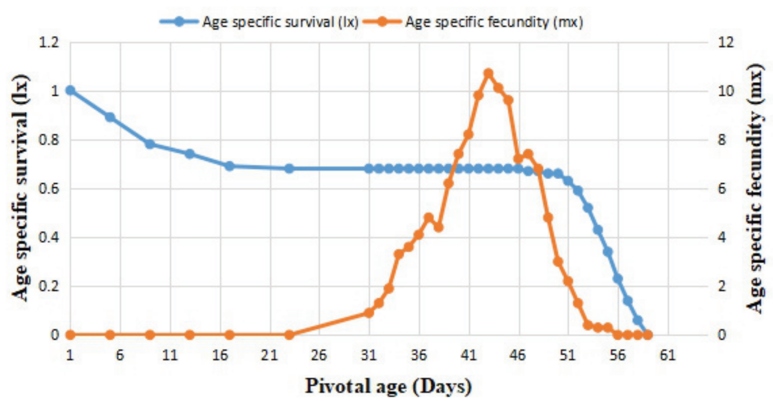


**Fig. 2. Age specific survival ($l_x$) and age specific fecundity ($m_x$) of *Chrysoperla zastrowi sillemi* on *Brevicoryne brassicae***

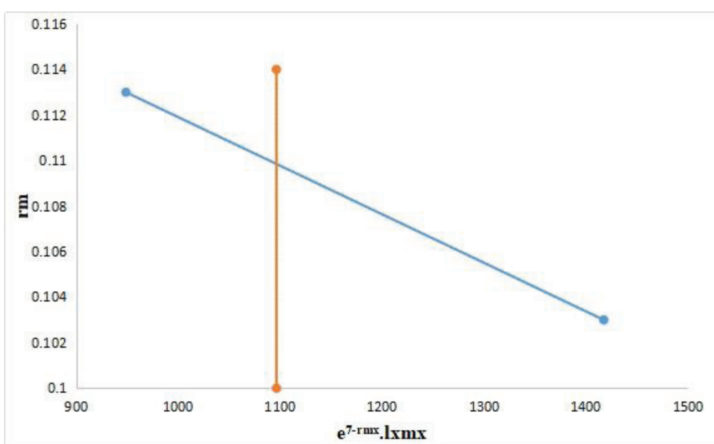


**Fig. 3. Determination of true intrinsic rate of increase ($r_m$) of *C. zastrowi sillemi* on *B. brassicae***

**Table 2. Fertility parameters of *C. zastrowi sillemi* on *B. brassicae***

| Parameter | Unit | Value |
|---|---|---|
| Gross reproductive rate (GRR) | Female eggs/ female | 120.0 |
| Net reproductive rate ($R_o$) | Number of eggs | 80.83 |
| Approximate generation time ($T_c$) | Female eggs/ female | 42.49 |
| The innate capacity of increase ($r_c$) | Days | 0.103 |
| Intrinsic rate of natural increase ($r_m$) | Females / female / day | 0.1098 |
| True generation time (T) | Females / female /Day | 40.00 |
| Finite rate of increase (λ) | folds | 1.116 |
| Weekly multiplication rate (WM) | Folds | 2.16 |
| Doubling time (DT) | Days | 6.31 |

The survival of immature stages ($l_x$), the net reproductive rate ($R_o$), the mean generation time (T) and innate capacity for increase of *C. carnea* at the pivotal age of 40, 20 and 13 days, was 0.87, 0.97 and 0.67; 19.56, 68.27 and 9.63 females per female per generation; 59.95, 35.61 and 23.84 days and 0.0496, 0.1186 and 0.0950 females per female per day, respectively at different temperature levels (Timke *et al*., 2016).

In a similar study, Sultan *et al.,* (2017) also reported $l_x$, $R_o$, T and $M_x$ as 0.91, 106.45, 50 days and 263 for *C. carnea* preying on *Sitotroga cerealella*. The doubling time was reported to be 8.03 days and the death rate (Dx) was 0.196. The rm was found to be 0.1082 which is in line with the present study. According to Khan *et al*. (2017), the highest mortality rate of *C. carnea* was observed in pupal stage (8.22 %) followed by 2nd instar larva (8.14 %) and egg stage (8.0 %). Survival fraction (Sx) was maximum (0.97) at 3rd instar stage followed by pre-pupal stage (0.95). The gross reproductive rate (GRR) was 176.5 and net reproductive rate (Ro) was 44.39 females per female per generation. Mean generation time (T) was 19.96 days, the intrinsic rate of natural increase (rm) was 0.19 females per female per day, the finite rate of increase (λ) was 1.21 females per female per day and the population doubling time (DT) was 3.63 days. Mhaske *et al.,* (2018) studied the fertility parameters of *C. zastrowi sillemi* feeding on mealy bugs and aphids and reported that the survival of immature stages (lx) was to the extent of 0.70, 0.59 and 0.52 per individual within a pivotal age of 22, 24 and 24 days, the net reproductive rate (Ro) was 136.31, 63.26 and 31.088 females per female per generation, the mean length of generation time (T) was reported as 33.20, 35.75 and 35.07 days, innate capacity for increase was of 0.1480, 0.1160 and 0.0980 female per female per day. Finite rate of increase in numbers (λ) was to an extent of 1.16, 1.12 and 1.102 females per female which corroborates with the present findings.

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**REFERENCES**

Bellows Jr.,T. S., Van Driesche,R. G. and Elkinton, J. S. 1992. Life-Table Construction and Analysis in the Evaluation of Natural Enemies. *Annual Review of Entomology*, **37**: 587-612.

Chi, C. and Yang, T. 2003. Two-sex life table and predation rate of *Propyleajaponica* Thunberg (Coleoptera: Coccinellidae) fed on *Myzuspersicae* (Sulzer) (Homoptera: Aphididae). *Environmental Entomology,* **32**: 327–333.

Deevey Jr., E. S. 1947. Life tables for natural populations of animals. *The Quarterly Review of Biology,* **22**: 283-314.

Jamaya, L.M. and Ronald, F.L. 1998. *Brevicoryne brassicae* Linn. Department of Entomology. Honolulu University, Hawaii.

Bhalla, O.P. 1990. Integrated pest management strategy in vegetable crops. Summer Institute of Production Technology of off-season vegetable and seed crops.

June 15 to July 4, 1990. Department of Vegetable crops. Dr. Y. S. Paramat University of Horticulture and Forestry, Nauni, Solan, (HP). Pp234-245.

Bashir, F., Azim, N.M., Akhter, N and Muzaffar, G. 2013. Effect of texture/morphology of host plants on the biology of *Brevicoryne brassicae* L.(Homoptera: Aphididae). *International Journal of Current Research,* **5**: 178-180.

Singh, S. P. and Jalali, S.K. 1994. Production and use of Chrysopid predators, Technical Bulletin No. 10, Project Directorate of Biological Control, Bangalore. Pp14.

Subhan, S., Shetgar, S.S., Badgujar, A.G., Dhurgude, S.S. and Patait, D.D. 2009. Life-fecundity tables of *Chrysoperla carnea* (Stephens) on *Corcyra cephalonica* (Stainton). *Journal of Entomological Research,* **33**:355-360.

Sultan, A., Khan, M.F., Siddique, S., Akbar, M.F. and Manzoor, A. 2017. Biology and life table parameters of the predator, *Chrysoperla carnea* (Stephens, 1836) (Neuroptera: Chrysopidae) on Sugarcane whitefly, Sugarcane stem borer and Angoumois grain moth. *Egyptian Journal of Biological Pest Control,* **27:** 7-10.

Southwood, T. R. E. 1978. Ecological Methods. Methugen and Co. Ltd., London. Pp 391.

Principi, M.M. and Canard, M. 1984. Feeding habits. In: *Biology of Chrysopidae,* (eds). Canard M, Semeria ,Y and New ,T.R. The Hague: Dr W. Junk Publishers. Pp76-91.

Venkatesan, T., Poorani , J., Murthy, K. S., Jalali, S.K., Kumar, G.A., Lalitha, Y. and Rajeshwari, R. 2008. Occurrence of *Chrysoperlazastrowiarabica* (Henry *et al.*) (Neuroptera: Chrysopidae), a cryptic song species of *Chrysoperla* (carnea-group), in India. *Journal of Biological Control,* **22**:143–147.

Timke, S. H., Shetgar, S.S., Khandare, R.Y., Surwase, S.R. and Bhosale, A. B. 2016. Life-fecundity tables of *Chrysoperla carnea* (Stephens) on *Corcyra cephalonica* (Stainton) at different temperature levels. *Journal of Entomological Research,* **40**:105-108.

Khan, J., Haq. E. U., Mahmood, T., Rasool ,A., Aslam, N., Shah ,H., Blouch, A., Mahmood, M.M and Ahmad, I. 2017. Life table attributes of *Chrysoperla carnea* (Neuroptera: Chrysopidae) reared on *Corcyra cephalonica* (Lepidoptera: Pyralidae) eggs under laboratory condition. *International Journal of Biosciences,* **10**:52-59.

Mhaske, S.H., Shetgar, S.S and Dake, R.B. 2018. Life-fecundity tables of *Chrysoperla zastrowi sillemi* (Esben-Petersen) on mealy bugs and aphid. *International Journal of Current Microbiology and Applied Sciences,* **6**:2408-2413.

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