# LIFE- FECUNDITY TABLES OF *CRYPTOLAEMUS MONTROUZIERI* (MULSANT) ON *MACONELLICOCCUS HIRSUTUS* (GREEN)

**[1]S. R. SURWASE, [2]S. S. SHETGAR, [3]A. A. MOTAPHALE**

[1,2,3]Department of Agricultural Entomology, College of Agriculture, Latur – 413 512,
(Vasantrao Naik Marathwada Agricultural University), Parbhani, Maharashtra, India
E-mail: [1]surwaseseema333@rediffmail.com, [2]sharadshetgar@rediffmail.com, [3]dr.ashvini24@gmail.com

**Abstract—** The laboratory experiment was conducted to study the life-fecundity of *Cryptolaemus montrouzieri* (Mulsant) on *Maconellicoccus hirsutus* (Green) at biocontrol laboratory, Department of Agricultural Entomology, College of Agriculture, Latur during 2013-14. The net reproductive rate ($R_0$), the precise generation time (T) and innate capacity for increase in number ($r_m$) of C. *montrouzieri* (Mulsant) on *M. hirsutus* was observed to be 64.38 females per female per generation, 62.09 days and 0.0710 female per female per day, respectively.

**Keywords—** life fecundity, *Cryptolaemus montrouzieri*, *Maconellicoccus hirsutus.*

## I. INTRODUCTION

Mealy bugs have been reported as serious pest of grapevine in India. Grape production is often adversely affected due to the mealy bugs to the extent of damage being as much as 100 per cent in extreme cases in India (Babu and Azam, 1989). It is very difficult to get perfect control of the mealy bugs with conventional insecticides due to their concealed habitat and waxy coating over their bodies. The continuous usage of insecticides results into the outbreak of the mealy bugs (Manjunath, 1985). Biological control is considered as effective long term solution to mealy bug infestation, apart from environmental and health risks associated with repeated exposures to chemical insecticides or its residues, pest resistance and pest resurgence. The biological control of mealy bugs through coccinellid predators is one of the best alternatives. Both larval and adult stages of this predator attack all stages of mealy bugs (Gautam, 1996).

The Coccinellids have emerged as strong and potent biocontrol agent and result oriented researches are further needed continuously to ascertain their efficiency in the integrated pest management programme. Hence keeping this in view, the investigations on life-fecundity of *Cryptolaemus montrouzieri* (Mulsant) on *Maconellicoccus hirsutus* (Green) were conducted during 2013-2014.

## II. MATERIAL AND METHODS

The culture of *C. montrouzieri* available with the National Bureau of Agriculturally Important Insects, Bangalore was used for these studies.

**Mass multiplication of *M. hirsutus* on pumpkins-**

The laboratory technique of rearing of mealy bugs on ripe red pumpkins, *Cucurbita maxima* standardized by Chacko *et al.* (1978) and Singh (1978) was used. The red ripe pumpkins having ridges and grooves with small stalk were used for multiplication of mealy bugs. The pumpkins were washed with tap water to remove dust particles and then dipped in a solution of Bavistin 0.1 per cent to kill the pathogens. The injured pumpkins were discarded and minor wounds were plugged with hot paraffin wax and then dried. For shallow grooveless pumpkins, a simple roping technique was followed. This facilitated rapid multiplication of mealy bugs on shallow grooves and groovless pumpkins. Care was taken to treat the ropes “Sutali” with Bavistin solution. The rearing cages having size of 30 x 30 x 30 cm with slanting glass top were used for multiplication of mealy bugs. All other sides of cages were fitted with 40 guage nylon mesh with the provision of sleeve on front side. The care was taken to close all cracks and crevices of the wooden cages to prevent escape of early instars of the mealy bugs.

**Inoculation of egg masses of mealy bug on pumpkins-**

The pumpkins were inoculated with egg masses of *M. hirsutus* with the help of wet camel hair brush. Number of egg sacs placed on each pumpkin varied according to size of pumpkin. The pumpkins were then kept in wooden cages. The inoculation was done with ovisacs of *M. hirsutus* throughout period of study. The ambient temperature and relative humidity of the laboratory ranged from $25^0$C to $30^0$C and 65 to 75 per cent, respectively.

**Experimental design-**

The studies on life-fecundity of *C. montrouzieri* on *M. hirsutus* was carried out in a completely randomized design replicated five times at the temperature of 25 ± $2^0$C maintained in BOD incubator by studying 100 eggs in a group of 20 in each replication. All the grubs soon after hatching were reared individually. The observations were made daily on egg hatching, larval and pupal development, successful adult emergence, fecundity and age-specific mortality in eggs, larvae, pupae and adults. Adults emerged on a particular day were transferred into a petridish in the ratio of 1:1 for determining the age-specific fecundity. The third instar nymphs of *M. hirsutus* w provided daily to the adults as food.

**Statistical Analysis**

Age-specific survival and life-fecundity table was constructed using pivotal age in days (x), survival of females at age 'x' ($l_x$), age schedule for female births at age 'x ($m_x$) (Andrewartha and Brich, 1954). Several population growth parameters including net reproductive rate ($R_0$), finite rate of increase (λ), mean generation time ($T_c$), and intrinsic rate of increase ($r_m$) were estimated based on the recorded data on life-fecundity and survival schedule.

**Equation used-**

| | |
|---|---|
| 1. Net reproductive rate: | $R_0 = \sum l_x m_x$ |
| 2. Mean generation time: | $T_c = \frac{\sum l_x m_x x}{R_o}$ |
| 3. Innate capacity for increase in numbers: | $r_c = \frac{\text{Log}_e R_o}{T_c}$ |
| 4. The precise generation time (T): | $T = \frac{\text{Log}_e R_o}{r_m}$ |
| 5. The finite rate of natural increase (λ): | $\lambda = \text{Anti log}_e r_m$ |
| 6. Stable age-distribution: | $L_x = \frac{l_x + (l_x + 1)}{2}$ |

## III. RESULTS AND DISCUSSION

The results presented in Table 1 indicated that the survival of *C. montrouzieri* on third instar nymphs of *M. hirsutus* was 91, 91 and 85 per cent in respect of egg, larval and pupal stages, respectively in a cohort of 100 eggs. During the course of rearing from egg to adult emergence 41 and 43 per cent male and female adults, respectively were emerged successfully. The male to female sex ratio was 1:1.04. The data (Table 2) showed that the survival of immature stages ($l_x$) was 0.85 per individual within a pivotal age of 42 days on *M. hirsutus.* The pre-oviposition period ranged from 43 to 49 days of pivotal age. The highest female births (5.15) was observed on $18^{th}$ day of oviposition at $67^{th}$ day of pivotal age and thereafter female births decreased. The first female mortality was observed on $62^{nd}$ day ($l_x$=0.84) of pivotal age. The female laid eggs for 34 days. The net reproductive rate ($R_o$) representing the total females per female per generation was 82.16 Thus the population of *C. montrouzieri* was able to multiply 82.16 times per generation on *M. hirsutus.*

The results (Table 3) revealed that the mean length of generation ($T_c$) was found to be 64.38 days. The arbitrary value for intrinsic rate of increase ($r_c$) was 0.068 female per female per day. The precise generation time (T) was 62.09 days, while the finite rate of increase in numbers (λ) was 1.07 females per female per day. The corrected innate capacity for increase in numbers ($r_m$) was 0.0710 female per female per day. It is evident from Table 4 that on reducing stable age- distribution, population of *C. montrouzieri* on *M. hirsutus* in egg, larval, pupal and adult stages was distributed to the extent of 48.37, 45.65, 1.54 and 0.59 per cent, respectively.

The findings on life-fecundity tables of *C. montrouzieri* are in good line with the data reported by Persad and khan (2002) who found that the net reproductive rate (Ro), the generation time (T) and the finite rate of increase ($\lambda$) of *C. montrouzieri* was observed to be 227.18, 40.13 days and 1.14, respectively. The egg stage contributed 52.30 per cent while the combined larval, pupal and the adult stages contributed 45.91, 1.44 and 0.35 per cent to the stable age- distribution, respectively (when $r_m$ $_=$0.135).

According to Birch (1948), the comparison of two or more population by means of their net reproductive rates may be quite misleading unless the mean length of generation are the same. Two or more populations may have the same reproductive rate but their intrinsic rates of increase may be quite different because of different length of their generations.

## REFERENCES


[1] Andrewardha, H. G. and Birch, H. C. 1954. The distribution and abundance of Animals. Univ. of Chicago Press. Chicago PP : 782.

[2] Babu, T. R. and Azam, K. M. 1989. Biological control of grape mealy bug, *Maconellicoccus hirsutus* (Green). *Indian J. Pl. Prot.*, **17** (1) : 123-126.

[3] Birch, L. C. 1948. The intrinsic rate of natural increase of an insect population. *J. Anim. Ecol.*, **17** : 15-26.

[4] Chacko, M. J., Bhat, P. K., Ananda Rao, L. V., Deepak Singh, M. B., Ramanarayana, E.P. and Sreedharan, K. 1978. The use of lady bird-beetle *Cryptolaemus montrouzieri* for the control of Coffee mealy bugs. *J. Coff. Res.*, **8 :** 14-19.

[5] Gautam, R. D. 1996. Reports on the use of coccinellid predators for the management of Hibiscus (pink) mealy bug in the Caribbean. Centeno (Trinidad and Tobago): Ministry of Agriculture, Land and Marine Resources Central Experiment Station. vp. (07774/H10.G3).

[6] Manjunath, T. M. 1985. *Maconellicocus hirsutus* on grapevine. FAO *Plant Prot. Bull.*, **33** (2) : 74.

[7] Persad. A. and Khan, A. 2002. Comparision of life-table parameters for *Maconellicocus hirsutus, Anagyrus kamali, Cryptolaemus montrouzieri* and *Scymnus coccivora. BioControl,* **47** : 137-149, 2002.

[8] Singh, S. P. 1978. Propagation of coccinellid beetle for biological control of citrus and coffee mealy bugs. *Scientific conference,* CPA, Dec., 1978, PP : 2.

**Table 1 : Survival of life-stages of *C. montrouzieri* on *M. hirsutus***

| Number of eggs observed | Number of survived life-stages | | | | |
|---|---|---|---|---|---|
| | Eggs (0-5 days duration) | Larvae (6-31 days duration) | Pupae (32-42 days duration) | Adults | |
| | | | | Male | Female |
| 20 | 18 | 18 | 16 | 07 | 09 |
| 20 | 16 | 16 | 14 | 06 | 08 |
| 20 | 20 | 20 | 18 | 12 | 06 |
| 20 | 18 | 18 | 18 | 07 | 11 |
| 20 | 19 | 19 | 18 | 09 | 09 |
| 100 | 91 | 91 | 85 | 41 | 43 |

**Table 2 : Life-table and age-specific fecundity of *C. montrouzieri* on *M. hirsutus***

| Pivotal age in days | Survival of females at different age intervals | Age schedule for female birth | | |
|---|---|---|---|---|
| X | $l_x$ | $m_x$ | $l_xm_x$ | $l_xm_xX$ |
| 0-42 | 0.85 | Immature stages | | |
| 43-49 | 0.85 | Pre-oviposition period | | |
| 50 | 0.85 | 2.45 | 2.08 | 104.13 |
| 51 | 0.85 | 2.75 | 2.34 | 119.21 |
| 52 | 0.85 | 2.80 | 2.38 | 123.39 |
| 53 | 0.85 | 2.85 | 2.42 | 128.86 |
| 54 | 0.85 | 2.90 | 2.47 | 133.11 |
| 55 | 0.85 | 3.10 | 2.64 | 144.93 |
| 56 | 0.85 | 3.05 | 2.59 | 145.18 |
| 57 | 0.83 | 4.05 | 3.44 | 196.22 |
| 58 | 0.85 | 3.00 | 2.55 | 147.90 |
| 59 | 0.85 | 3.60 | 3.06 | 180.54 |
| 60 | 0.85 | 3.45 | 2.93 | 175.95 |
| 61 | 0.85 | 3.60 | 3.06 | 186.66 |
| 62 | 0.84 | 4 .05 | 3.40 | 210.92 |
| 63 | 0.84 | 4.15 | 3.49 | 219.62 |
| 64 | 0.84 | 4.20 | 3.53 | 225.79 |
| 65 | 0.84 | 4.25 | 3.57 | 232.05 |
| 66 | 0.84 | 4.45 | 3.74 | 246.71 |
| 67 | 0.84 | **5.15** | 4.33 | 289.84 |
| 68 | 0.84 | 3.60 | 3.02 | 205.03 |
| 69 | 0.81 | 3.40 | 2.75 | 190.03 |
| 70 | 0.76 | 3.25 | 2.47 | 172.90 |
| 71 | 0.76 | 2.75 | 2.09 | 148.39 |
| 72 | 0.76 | 2.80 | 2.13 | 153.22 |
| 73 | 0.72 | 2.75 | 1.98 | 144.54 |
| 74 | 0.72 | 2.70 | 1.94 | 143.86 |
| 75 | 0.72 | 2.50 | 1.80 | 135.00 |
| 76 | 0.71 | 2.40 | 1.70 | 129.50 |
| 77 | 0.71 | 2.40 | 1.70 | 131.21 |
| 78 | 0.67 | 2.20 | 1.47 | 114.97 |
| 79 | 0.67 | 2.05 | 1.37 | 108.51 |
| 80 | 0.67 | 2.05 | 1.37 | 109.88 |
| 81 | 0.65 | 1.80 | 1.17 | 94.770 |
| 82 | 0.65 | 0.90 | 0.59 | 47.970 |
| 83 | 0.65 | 0.90 | 0.59 | 48.560 |
| | | $\sum l_xm_x =$ **82.16** | | $\sum l_xm_xX=$ 5289.8 |

**Table 3 :The mean length of generation, innate capacity for increase in numbers and finite rate of increase in numbers of *C. montrouzieri* on *M. hirsutus***

| Population growth statistics | |
|---|---|
| Mean length of generation | |
| $T_c = \frac{\Sigma\ l_x m_x X}{R_0}$ | 64.38 days |
| Innate capacity for increase in numbers | |
| $r_c = \frac{Log_e\ R_o}{T_c}$ | 0.068 female/female/day |
| Arbitrary $r_m$ ($r_c$), 0.07, 0.08, 0.09 | |
| Corrected $r_m$ $\sum^{7-ermx} l_x m_x$ = 1096.6 | 0.0710 female/female/day |
| Corrected generation time | |
| $T = \frac{Log_e\ R_o}{r_m}$ | 62.09 days |
| Finite rate of increase in numbers ( λ ) | |
| λ = antilog$_e r_m$ | 1.07 females/female/day |

**Table 4 : Stable age-distribution of *C. montrouzieri* on *M. hirsutus* when $r_m$ = 0.0710**

| Age group in days (x) | Survival of individual at different age intervals ($l_x$) | Stable age-distribution $L_x = \left[\frac{l_x + (l_x+1)}{2}\right]$ | $e^{7-rm}_{(x+1)}$ | $L_x.e^{-rm}_{(x+1)}$ | Percentage distribution | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | |
| 0 | 1.00 | 1.00 | 0.8918 | 0.8918 | 10.53 | Egg 48.37 |
| 1 | 1.00 | 1.00 | 0.7953 | 0.7953 | 9.3926 | |
| 2 | 1.00 | 1.00 | 0.7093 | 0.7092 | 8.3764 | |
| 3 | 1.00 | 1.00 | 0.6325 | 0.6325 | 7.4702 | |
| 4 | 1.00 | 1.00 | 0.5641 | 0.5641 | 6.6620 | |
| 5 | 1.00 | 1.00 | 0.5031 | 0.5030 | 5.9412 | |
| 6 | 1.00 | 1.00 | 0.4487 | 0.4486 | 5.2985 | Larvae 45.65 |
| 7 | 1.00 | 1.00 | 0.4001 | 0.4001 | 4.7252 | |
| 8 | 1.00 | 1.00 | 0.3568 | 0.3568 | 4.2140 | |
| 9 | 1.00 | 1.00 | 0.3182 | 0.3182 | 3.7581 | |
| 10 | 1.00 | 1.00 | 0.2838 | 0.2837 | 3.3515 | |
| 11 | 1.00 | 1.00 | 0.2531 | 0.2530 | 2.9889 | |
| 12 | 1.00 | 0.99 | 0.2257 | 0.2234 | 2.6389 | |
| 13 | 0.98 | 0.98 | 0.2013 | 0.1972 | 2.3296 | |
| 14 | 0.98 | 0.98 | 0.1795 | 0.1795 | 2.0776 | |
| 15 | 0.98 | 0.98 | 0.1601 | 0.1568 | 1.8528 | |
| 16 | 0.98 | 0.98 | 0.1428 | 0.1399 | 1.6524 | |
| 17 | 0.98 | 0.97 | 0.1273 | 0.1235 | 1.4586 | |
| 18 | 0.96 | 0.96 | 0.1136 | 0.1090 | 1.2874 | |
| 19 | 0.96 | 0.96 | 0.1013 | 0.0972 | 1.1481 | |
| 20 | 0.96 | 0.96 | 0.0903 | 0.0866 | 1.0239 | |
| 21 | 0.96 | 0.96 | 0.0805 | 0.0773 | 0.9131 | |
| 22 | 0.96 | 0.96 | 0.0718 | 0.0689 | 0.8143 | |
| 23 | 0.96 | 0.96 | 0.0641 | 0.0614 | 0.7262 | |
| 24 | 0.96 | 0.94 | 0.0571 | 0.0536 | 0.6342 | |
| 25 | 0.92 | 0.92 | 0.0509 | 0.0468 | 0.5535 | |
| 26 | 0.92 | 0.92 | 0.0454 | 0.0417 | 0.4936 | |
| 27 | 0.92 | 0.92 | 0.0405 | 0.0372 | 0.4402 | |
| 28 | 0.92 | 0.895 | 0.0361 | 0.0323 | 0.3891 | |
| 29 | 0.87 | 0.87 | 0.0322 | 0.0280 | 0.3311 | |
| 30 | 0.87 | 0.87 | 0.0287 | 0.0250 | 0.2953 | |
| 31 | 0.87 | 0.87 | 0.0256 | 0.0222 | 0.2633 | |
| 32 | 0.87 | 0.87 | 0.0229 | 0.0198 | 0.2348 | |
| 33 | 0.87 | 0.87 | 0.0204 | 0.0117 | 0.2094 | |
| 34 | 0.87 | 0.87 | 0.0182 | 0.0158 | 0.1868 | Pupae 1.54 |
| 35 | 0.87 | 0.86 | 0.0162 | 0.0162 | 0.1656 | |
| 36 | 0.86 | 0.86 | 0.0145 | 0.0140 | 0.1468 | |
| 37 | 0.86 | 0.86 | 0.0129 | 0.0124 | 0.1310 | |
| 38 | 0.86 | 0.86 | 0.0115 | 0.0110 | 0.1168 | |
| 39 | 0.86 | 0.86 | 0.0103 | 0.0098 | 0.1042 | |
| 40 | 0.86 | 0.86 | 0.0091 | 0.0088 | 0.0929 | |
| 41 | 0.86 | 0.85 | 0.0082 | 0.0078 | 0.0824 | |
| 42 | 0.85 | 0.85 | 0.0073 | 0.0069 | 0.0730 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 43 | 0.85 | 0.85 | 0.0065 | 0.0061 | 0.0651 | |
| 44 | 0.85 | 0.85 | 0.0058 | 0.0055 | 0.0581 | |
| 45 | 0.85 | 0.85 | 0.0052 | 0.0049 | 0.0518 | |
| 46 | 0.85 | 0.85 | 0.0046 | 0.0043 | 0.0462 | |
| 47 | 0.85 | 0.85 | 0.0041 | 0.0039 | 0.0412 | |
| 48 | 0.85 | 0.85 | 0.0033 | 0.0034 | 0.0367 | |
| 49 | 0.85 | 0.85 | 0.0029 | 0.0031 | 0.0328 | |
| 50 | 0.85 | 0.85 | 0.0026 | 0.0027 | 0.0292 | |
| 51 | 0.85 | 0.85 | 0.0023 | 0.0024 | 0.0261 | **Adult** |
| 52 | 0.85 | 0.85 | 0.0021 | 0.0022 | 0.0232 | 0.59 |
| 53 | 0.85 | 0.85 | 0.0018 | 0.0019 | 0.0207 | |
| 54 | 0.85 | 0.85 | 0.0016 | 0.0017 | 0.0185 | |
| 55 | 0.85 | 0.85 | 0.0015 | 0.0015 | 0.0165 | |
| 56 | 0.85 | 0.85 | 0.0013 | 0.0013 | 0.0147 | |
| 57 | 0.85 | 0.85 | 0.0012 | 0.0012 | 0.0131 | |
| 58 | 0.85 | 0.85 | 0.0011 | 0.0011 | 0.1170 | |
| 59 | 0.85 | 0.85 | 0.0009 | 0.0009 | 0.0104 | |
| 60 | 0.85 | 0.85 | 0.0008 | 0.0008 | 0.0093 | |
| 61 | 0.85 | 0.84 | 0.0007 | 0.0007 | 0.0082 | |
| 62 | 0.84 | 0.84 | 0.0006 | 0.0006 | 0.0073 | |
| 63 | 0.84 | 0.84 | 0.0006 | 0.0006 | 0.0065 | |
| 64 | 0.84 | 0.84 | 0.0007 | 0.0007 | 0.0058 | |
| 65 | 0.84 | 0.84 | 0.0006 | 0.0005 | 0.0052 | |
| 66 | 0.84 | 0.84 | 0.0005 | 0.0004 | 0.0046 | |
| 67 | 0.84 | 0.84 | 0.0005 | 0.0003 | 0.0041 | |
| 68 | 0.84 | 0.82 | 0.0004 | 0.0003 | 0.0036 | |
| 69 | 0.81 | 0.78 | 0.0004 | 0.0003 | 0.0031 | |
| 70 | 0.67 | 0.76 | 0.0003 | 0.0002 | 0.0026 | |
| 71 | 0.72 | 0.76 | 0.0003 | 0.0002 | 0.0024 | |
| 72 | 0.72 | 0.74 | 0.0002 | 0.0001 | 0.0020 | |
| 73 | 0.72 | 0.72 | 0.0002 | 0.0001 | 0.0018 | |
| 74 | 0.72 | 0.72 | 0.0002 | 0.0001 | 0.0016 | |
| 75 | 0.72 | 0.71 | 0.0002 | 0.0001 | 0.0016 | |
| 76 | 0.71 | 0.71 | 0.0001 | 0.0001 | 0.0012 | |
| 77 | 0.71 | 0.69 | 0.0001 | 9.1235 | 0.0011 | |
| 78 | 0.67 | 0.67 | 0.0001 | 7.9006 | 0.0009 | |
| 79 | 0.67 | 0.67 | 0.0001 | 7.0459 | 0.0008 | |
| 80 | 0.67 | 0.66 | 0.0001 | 6.1898 | 0.0007 | |
| 81 | 0.65 | 0.65 | 0.0001 | 5.436 | 0.0006 | |
| 82 | 0.65 | 0.65 | 0.0001 | 4.8483 | 0.0006 | |
| 83 | 0.65 | 0.32 | 1.0000 | 0.3250 | 3.8381 | |

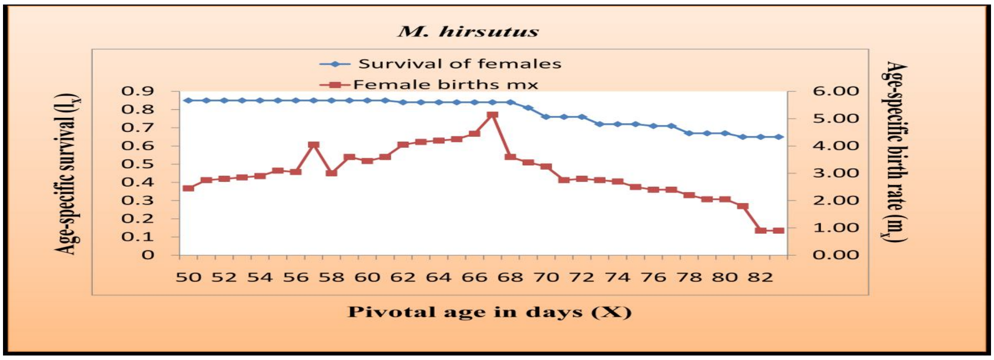


**Fig 1- Daily age-specific survival (lx) and birth rate (mx) of *C. montrouzieri* on *M. hirsutus***

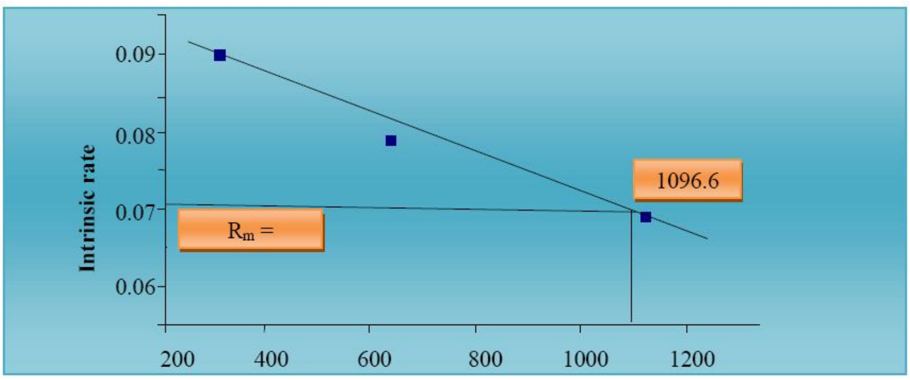


**Fig. 2 : Determination of the intrinsic rate of increase ($r_m$) of *C. montrouzieri* on *M. hirsutus***

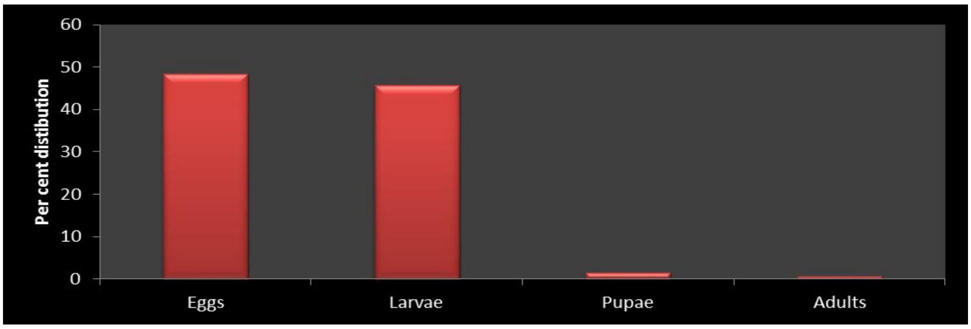


**Fig3 –Contribution of various life stages of *C. montrouzieri* towards stable age distribution on *M. hirsutus***

★★★