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# Life table of diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) on Cauliflower (*Brassica oleracea var botrytis* L.)

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**Abstract**
The diamondback moth, *Plutella xylostella* (L.), (Lepidoptera: Plutellidae) were studied in laboratory condition at 25±1 $^0$C on cauliflower during the year 2016. The results on number of individuals survived during the development revealed that there was no mortality of egg stage and the durations of egg, larva and pupa were 3, 19 and 22 days, respectively. The pre-oviposition period was 24 to 26 days. Females contributed highest number of progeny (mx) 21.66 in the life cycle on the 6$^{th}$ day of pivotal age. The net reproductive rate (Ro) was 90.34 females with the mean length of generation period (Tc) of 29.57 days. The innate capacity for increase (rm) and finite rate of increase (λ) were found to be 0.1523 and 1.3998 females/ female/ day, respectively. The population was multiplied $(\lambda)^7$ 4.8650 times per week. The hypothetical F2 females were found to be 8161.31. The expected further life at the age of 10 to 15 days was reduced to 8.53 from 12.17 days.

**Keywords:** *Plutella xylostella,* developmental stages, population dynamics, crucifer crops

## 1. Introduction
The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is one of the most destructive insect of cruciferous plants throughout the world. *P. xylostella* occurs wherever crucifer crops are grown and is believed to be the most universally distributed of all Lepidoptera [1, 2]. Life table and population studies showed that rainfall, temperature, natural enemies, as well as host plants influenced the survival and reproduction of diamondback moth [3, 4]. A development of life tables for diamondback moth on different host plants will help to assess the relative contribution made by the various hosts to the local adult population pool. Knowledge of life table parameters of diamondback moth and the resistance susceptibility characteristics of *Brassica* crops will enable growers to employ the most appropriate control tactics towards integrated crop management of a particular *Brassica* crop [5].
The age specific survival ($l_x$) and fecundity ($m_x$) at each pivotal age (x) were worked out daily for the entire reproductive period to prepare fertility and life table statistics as outlined [6]. Life table studies are useful in determining the stage in the life cycle of the pest, which contributes to the trend of population. It also determines the reproductive ability and biotic potential, in addition to development of statistics to explain population increase [7, 8]. In the present study reports on the life table parameter were calculated from the data of *P. xylostella* on cauliflower.

## 2. Material and Methods
### Life table studies
To construct the life table, the culture of *P. xylostella* was maintained at a constant temperature of 25 + 1 $^0$C on cauliflower during the year 2016. Adult pairs were kept for egg laying in 30 x 30 x 25 cm net cages. The eggs laid on leaves of cauliflower and muslin cloth were collected Petri dish in batches of 10 each for hatching. The observations on hatching, larval development, formation of pupae and successful emergence of adults and fecundity of females were recorded daily. Age specific mortality in different developmental stages like egg, larva, pupa and adult were also recorded. To determine the age specific fecundity, total number of adults emerged on the same day were caged in oviposition cage (30 x 30 x 25 cm) for oviposition. The numbers of eggs obtained per female were divided by two to get the number of female birth (mx). Life tables were constructed according to the methods of [7, 8, 9].

Stable age distribution was worked out by observing the population schedule of birth rate and death rate. Life expectancy was computed by using the method suggested [9, 10].

**Net Reproductive Rate (Ro)**

The values of 'x' and 'mx' were calculated from the data given in life tables. The sum total of the products 'lxmx' is the net reproductive rate (Ro) [11]. The 'Ro' is the rate of multiplication of population in generation measured in terms of female produced per generation. The number of times a population would multiply per generation was calculated using the formula:

$$Ro = lxmx$$

**Mean Duration of Generation (Tc)**

The appropriate value of generation time (Tc) *i.e.* the mean age of the parenti a cohort at the birth of female offspring was calculated by using the formula:

$$Tc = \sum xlxmx/Ro$$

**Innate Capacity for Increase (rm)**

Total number of individuals survived and mean number of female offspring birth was recorded at each age interval. From these data, the arbitrarily value of 'rm (rc)' was calculated by using the formula:

$$Rm = logeRo/Tc$$

The intrinsic rate of increase (rm) was subsequently calculated from the arbitrarily 'rm' by taking 2 trial values selected on either side of it differing in the second decimal place and substituting in the formula $\sum e^{7-rmx.lxmx}$ [8]. The values of e7–rmxlxmx obtained from the two trials were plotted against their respective arbitrarily 'rm' which give a straight line. The two point of intersection gave the accurate 'rm' value. The precise generation time (T) was calculated by using the formula:

$$T = logeRo/rm.$$

**The Finite rate of Natural Increase (λ)**

The number of females per female per day i.e. finite rate of increase was determined as $\lambda = antilog\ e^{rm}$. From this date, the weekly multiplication of the population was calculated. The hypothetical F2 females were also worked out with the formula (Ro) [2].

**Stable Age Distribution**

The stable age distribution (percent distribution of various age group) of *P. xlostella*. The knowledge of 'rm' and the age specific mortality of the immature and mature stages were also calculated. The stable age distribution table was constructed by following the method of [9, 12]. The 'Lx' (Life table age distribution) was calculated from the 'lx' table by using the formula:

$$Lx = lx + (lx + 1)/2$$

Per cent distribution of each age group (x) was calculated by multiplying the Lx with e–rm (x + 1). By putting together the percentage under each stage viz., egg, larval, pupal and adult stages, the expected per cent distribution was worked out.

**Life Table for computing life expectancy**

Life expectancy of worked out by using columns x, lx, dx, 100qx, Lx, Tx and ex. Where, x = Pivotal age (days); lx = Number of surviving at the beginning of age interval out of 100; dx = Number dying during 'x'; 100qx = dx.100 /lx, Mortality rate per hundred alive at the beginning of age interval; Lx = lx + (lx + 1) /2, Alive between x and x + 1; Tx = Number of individual's life days beyond 'x' and calculated by using the formula:

$$Ex = \frac{Tx}{lx} \times 2$$

Equations were formulated after processing the data of MS-Excel.

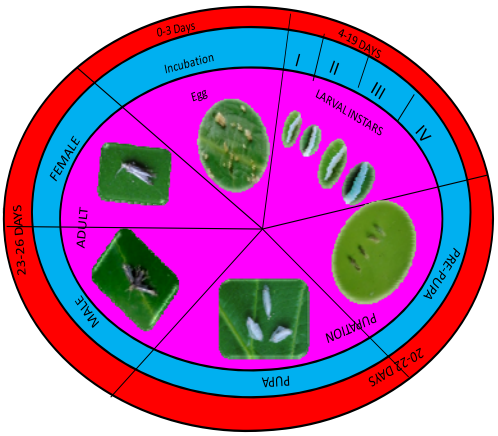


**Fig 1:** Development of different life stages in *P. xylostella*

## 3. Results and Discussion

The number of survived from 100 eggs to adult emergence was 96 individuals. The results on number of individuals survived during the development revealed that there was no mortality of egg stage and the durations of egg, larva and pupa were 3, 19 and 22 days, respectively (Table-1). The life fecundity table was constructed to determine the survival of female (lx) and age specific fecundity (mx). The data indicates that pre-oviposition period was between 23rd and 26th days of pivotal age. Female's deposit eggs on 27th day and after38th day with lx values being 0.96 and 0.16, respectively (Table-2). The females highest number of progeny (mx= 21.66) in the life cycle on the 29th day of pivotal age, which decreased day by day. The net reproductive rate (Ro) was worked as 90.34 and the mean length of generation (Tc) was 29.57 days. The intrinsic rate of increase in number (rm) and finite rate of increase in numbers (λ) as 0.1523 and 0.3363 females per females per day, respectively. This finding is in agreement with report of Justin *et al*., (2001) from Coimbatore [13]. The hypothetical $F_2$ females were worked out to be 9087.80. Similar results were also reported the studies on *P. xylostella* life tables [14]. The weekly multiplication of population was calculated 4.8650 times per week. The hypothetical F2 females were worked out to be 8161.31 (Table-3). The contribution of stable age distribution revealed that the egg stage contributed was maximum 59.67%. The stable age distribution of larvae, pupae and adults were 41.68, 4.23 and 1.47, respectively. The population in its various stages eggs, larvae, pupae, and adults contributed to the extent of 52.64, 45.86, 1.36 and 0.12 per cent, respectively. Similar results were also reported with their

studies on *P. xylostella* feeding on cauliflower [15, 16]. The studied clearly indicated that the mortality rate was comparatively high at the age of 10 to 15 days. The expectancy of further life was reduced to 8.53 days from 12.17days in the beginning (Table-4). The development of mature stage of *P. xylostella* was completed in 34.13 days [17]. It was concluded that shortest development time and greater total oviposition on the host reflected suitability of the host plant [18].

The life table parameters of *P. xylostella* on different host plants and found that the highest $r_m$ occurred when the insect fed on cauliflower [19]. The expectation of further life was reduced to 2.83 days from 16.19 days in the beginning. Almost similar observation of *S. litura* was recorded on tobacco [11, 20, 21] also found more or less similar observation on life fecundity tables when *S. litura* reared on different tobacco hosts.

**Table1:** Survival of different life stages of *P. xylostella*

| No. of eggs | Egg stage (0-3 days) | Larval stage (4 -19 days) | Pupal stage (20 – 22 days) |
|---|---|---|---|
| 10 | 10 | 9 | 9 |
| 10 | 10 | 10 | 10 |
| 10 | 10 | 9 | 9 |
| 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 |
| 10 | 10 | 9 | 9 |
| 10 | 10 | 9 | 9 |
| 10 | 10 | 10 | 10 |
| 100 | 100 | 96 | 96 |

**Table 2:** Age specific fecundity and Life table (for females) for *P. xylostella*

| X | Ix | Mx | Ixmx | xIxmx |
|---|---|---|---|---|
| 0-23 Immature stages | | | | |
| 24-26 Pre-oviposition stages | | | | |
| 27 | 0.96 | 18.05 | 17.32 | 467.64 |
| 28 | o.93 | 12.10 | 11.25 | 315.00 |
| 29 | 0.93 | 21.66 | 20.14 | 584.06 |
| 30 | 0.88 | 16.74 | 14.73 | 441.90 |
| 31 | 0.88 | 12.41 | 10.92 | 338.52 |
| 32 | 0.72 | 9.42 | 6.78 | 216.96 |
| 33 | 0.79 | 7.33 | 5.79 | 191.07 |
| 34 | 0.61 | 4.99 | 3.04 | 103.36 |
| 35 | 0.55 | 3.69 | 0.02 | 0.7 |
| 36 | 0.41 | 0.53 | 0.21 | 7.56 |
| 37 | 0.25 | 0.41 | 0.10 | 3.7 |
| 38 | 0.16 | 0.25 | 0.04 | 1.52 |
| | | | $\sum$Ixmx= 90.34 | $\sum$xIxmx=2671.99 |

X- Pivotal age in days
Ix -Survival of female at different age interval
Mx -Age schedule for female births

**Table 3:** Mean length of generation, innate capacity for increase in numbers and finite rate of increase in numbers of *P. xylostella*

| S. No. | Population growth statistics | formula | Statistical values |
|---|---|---|---|
| 1. | Net reproductive rate | Ro = $\sum$Ixmx | 90.34 |
| 2. | Mean length of generation | Tc = $\frac{\sum Ixmx}{Ro}$ | 29.57 days |
| 3. | Innate capacity for increase in numbers | rm= $\frac{\log eRo}{Tc}$ | 0.1523 Females/day |
| 4. | Arbitrart 'rm' (rc) 0.15 and 0.16 | | |
| 5. | Corrected 'rm' | $\sum e^{7-rmx.Ixmx}$ | 1.3998 |
| 6. | Corrected generation time | T = $\frac{\log eRo}{rm}$ | 3.21days |
| 7. | Finale rate of increase in numbers | ($\lambda$) = antiloge$^{rm}$ | 0.3363 Females/day |
| 8. | Weekly multiplication of population | $(\lambda)^7$ | 4.8650times |
| 9. | Hypothetical F2 females | $(Ro)^2$ | 8161.31 |

**Table 4:** Life table for computing life expectancy of *P. xylostella*

| X | Ix | dx | 100qx | Lx | Tx | Ex |
|---|---|---|---|---|---|---|
| 0-5 | 100 | 1 | 1.0000 | 100.50 | 612.00 | 12.17 |
| 5-10 | 99 | 3 | 3.0303 | 99.50 | 511.50 | 10.28 |
| 10-15 | 96 | 5 | 5.2083 | 96.50 | 412.00 | 8.53 |
| 15-20 | 91 | 7 | 7.6923 | 91.50 | 315.50 | 6.89 |
| 20-25 | 84 | 13 | 15.4761 | 84.50 | 224.00 | 5.30 |
| 25-30 | 71 | 23 | 32.3943 | 71.50 | 139.50 | 3.90 |
| 30-35 | 48 | 29 | 60.4166 | 48.50 | 68.00 | 2.80 |
| 35-40 | 19 | 00 | 0.0000 | 19.50 | 19.50 | 2.00 |

X -Pivotal age (days)
Ix-Number surviving to the beginning of age interval
Dx- Number dying during 'x'
100qx- Mortality rate per hundred alive at beginning of age interval
Lx-Alive between Age 'x' and 'x+1'
Tx - No. of the individuals life days beyond 'x'
Ex -Expectation of further life x= $T_x/l_x$ X 2

## 4. Conclusion

In conclude the knowledge of Brassica host plant quality influences the life table parameters of diamondback moth can help to understand the population dynamics and the measures in management of this insect. The life expectancy of beneficial insects can be calculated and biological control program by predicting natural things in particular instar within the maximum mortality of the insect ecofriendly control.

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