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Life Table of Pod Borer, *Helicoverpa armigera* (Hubner) on Pigeonpea

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***Abstract*:** Life-table of *H. armigera* on pigeonpea was studied under laboratory condition. The output showed that out of total 100 eggs only the 89 eggs, 77 larvae and 70 pupae survived and finally emerged in to adults. The maximum durations of egg, larva, and pupa was 6, 20 and 8 days, respectively with pre-oviposition period varied from 33rd to 35th days of pivotal age. Female started laying eggs after 35th days and ceased after 47th days with lx (survival of female) values of 0.70 and 0.31 respectively. Females produced the maximum progenies (mx = 48.09) on the 38th day of pivotal age. The net reproductive rate (Ro) was 142.07 times multiplication of population per generation. Adults contributed only 0.76 percent of the population of stable age whereas eggs, larvae, and pupae contributed 59.31, 37.68 and 2.26 per cent, respectively. The expectancy of further life was 4.76 days at the time of adult emergence which showed that life expectancy of *H. armigera* declined with the advancement of development.

***Keywords*:** *H. armigera,* Adults, Female, Eggs, Larvae, Pupae, Progenies, Legume, Life table

Pigeonpea [*Cajanus cajan* (Linnaeus) Millspaugh] is an important grain legume crop of the tropics and subtropics. Globally, pigeonpea is grown in an area of 6.03 million hectares with a production of 5.33 million tonnes and productivity of 883.40 kg/ha (FAO 2022). In India, it is grown on 5.05 million hectares with an annual production and productivity of 4.34 million tonnes and 859 kg/ha, respectively (Anonymous 2022). Among several insect pests infesting pigeonpea the lepidopteran pest *viz*., pod borer, *Helicoverpa armigera* (Hubner) is most serious. In India, the pod damage caused by *Melanogromyza obtusa*, *H. armigera* and *Maruca vitrata* was reported as 34.4 to 49.9, 9.4 to 18.1 and 5.7 to 12.4 per cent, respectively (Keval et al 2017). The maximum damage was recorded due to pod borer, *H. armigera* (34.90 %) followed by pod fly, *M. obtusa* spotted pod borer, *M. vitrata* and tur plume moth, *Exelastis atomosa* up to 23.64, 14.09 and 5.60 per cent, respectively (Muchhadiya et al 2024). Considering the above facts, the present investigation was carried out.

MATERIAL AND METHODS

To construct the life-table, the culture of *H. armigera* was maintained on pigeonpea tender plant for two consecutive generations at room temperature during October to March, 2021-22. The adults obtained from the culture were used for the further study. The freshly emerged male and female moth were kept for egg laying in wooden cages. The sides of the cage were covered with muslin cloth and the tender pigeonpea branches were provided for egg laying. In order to construct life table, freshly laid 100 eggs were collected from the cage with the help of wet camel hair brush and placed in ten petri plate (10.0 cm diameter × 1.5 cm height) in batches of 10 (ten) were observed closely for recording the hatching percentage. After hatching, the first instar larvae were transferred individually into plastic vials. Fresh food was provided daily in morning. Vials were kept clean by removing frasses. Took daily observations on larval development, formation of pupae, emergence of adult and fecundity were recorded. Age-specific mortality in several developmental stages such as egg, larva, pupa and adult were also documented. To establish age-specific fertility, the total number of adults that emerged on the same day were placed in a cage for oviposition. Pigeonpea branches with leaves, buds, and pods were placed in conical flasks with fresh water and kept in cages until oviposition. The twigs were replaced every day and the number of eggs laid on the twigs, buds, pods and muslin material inside the cage were noted. Observations on fecundity were recorded until the female died. Assuming a 1:1 sex ratio, the number of eggs collected per female was divided by two to get the number of female births (mx). The methodology for life table as proposed by Howe (1953) followed by Atwal and Bains (1974), Dabhi et al (2009a), Dabhi et al (2009b), Patel et al (2016), Singh et al (2022) and Chaudhari et al (2023) was adopted. The stable age distribution was determined by observing the population schedule of birth and death rates (mx and lx) when grown in a

limited amount of time. The methodology for the construction of the life table proposed by Howe (1953) followed by Atwal and Bains (1974) was used in this study. The same is as under:

x = Pivotal age in days

lx = Survival of female at age 'x'

mx = Age schedule for female birth at age 'x'

Net reproductive rate (Ro): The values of 'x', 'lx', and 'mx' were calculated using the data provided in the life tables. The sum total of the products 'lxmx' is the net reproductive rate (Ro). The Ro is the rate of multiplication of population in generation measured in terms of females produced per generation. The formula used to compute the number of times a population would multiply per generation is as follows: $Ro = \Sigma lxmx$

Mean duration of generation (T): The approximate value of generation time (T) (the mean age of the mother in a cohort at the birth of female offspring) was calculated by using following formula (Atwal and Bains 1974)

$$T = \frac{\Sigma x\, lxmx}{Ro}$$

Innate capacity for increase in numbers (rm): At each age interval, the total number of survivors and the average number of females emerged were recorded. The arbitrary value of 'rm (rc)' was determined from these data using the following formula (Loughlin, 1965 and Atwal and Bains 1974)

$$rm = \frac{\log e^{Ro}}{T}$$

Where,

e = 2.71828

T = Mean generation time

The intrinsic rate increase (rm) was calculated subsequently from the arbitrary 'rm' by taking two trial values; arbitrary selected on either side of it, differing in the second decimal place by establishing the following relationship as suggested by Atwal and Bains (1974).

$\Sigma e^{7-rmx}.\ lxmx = e^{7} = 1097.00$

Where,

e = 2.71828

The precise generation time (T) was calculated by using the following formula:

$$T = \frac{\log e^{Ro}}{Rm}$$

Finite rate of natural increase (λ): The number of females per female per day *i.e.* finite rate of increase was determined as:

$\lambda = \text{anti}\log e^{rm}$

From this data the weekly multiplication of the population was calculated. Hypothetical F_2 females were also be worked out with the formula $(Ro)^2$.

Stable age distribution: The stable age distribution (per cent distribution of various age groups) of *H. armigera* on pigeonpea was calculated using the knowledge of 'rm' and age-specific mortality of the immature and mature stages. The stable age distribution table was created using the methods proposed by Andrewartha and Birch (1954) and Atwal and Bains (1974). The 'Lx' (life table age distribution) was calculated from the 'lx' table using the following formula:

$$Lx = \frac{lx + (lx + 1)}{2}$$

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 were worked out.

RESULTS AND DISCUSSION

The study on the life table, age-specific distribution and life expectancy of *H. armigera* on pigeonpea were carried out at laboratory of Entomology from October to March during 2021-22 at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The 89 per cent egg survived and 70 per cent reached the adult stage (Table 1). The longest durations of egg, larva, and pupa were 6, 20 and 8 days, respectively.

In the past, Deb and Bharpoda (2016) at Anand reported that total 92 eggs survived and 71 per cent reached adults. Basavaraj et al (2018) at Raichur (Karnataka) reported that 77 per cent survived from egg to adult emergence. The maximum duration of egg, larva and pupa was as 6, 28 and 9

Table 1. Survival of different life stages of *H. armigera* during development on pigeonpea (Based on 10 eggs)

Egg	Larva	Pupa
	Number survived	
9	7	6
8	7	6
9	8	6
10	8	7
8	7	7
9	7	7
8	7	6
9	8	8
10	9	8
9	9	9
89	77	70

days, respectively. Thus, the findings of the current study are more or less consistent with those of the previous researchers. The pre-oviposition period occurred between the 33rd and 35th days of pivotal age (Table 2). Female began depositing eggs after 35th days and ceased after 47th days with lx of 0.70 and 0.31 respectively. Females produced the most progenies (mx = 48.09) on the 38th day of pivotal age, which declined day by day, thereafter.

The net reproductive rate (Ro) was 142.07 with a mean length of generation (Tc) 38.35 days. The intrinsic rate of natural increase in number (rm) was 0.1292 females per female per day with finite rate of increase (γ) 1.14 females/female/day and the population was multiplied 2.48 times per week. The hypothetical F2 females were calculated to be 20183.8849 (Table 3).

Basavaraj et al (2018) reported that mean length of generation (T) was 41.40 days. The innate capacity (rm) and finite rate (λ) of the in number was 0.13 and 1.14 females per female per day, respectively. Fathipour et al (2020) reported

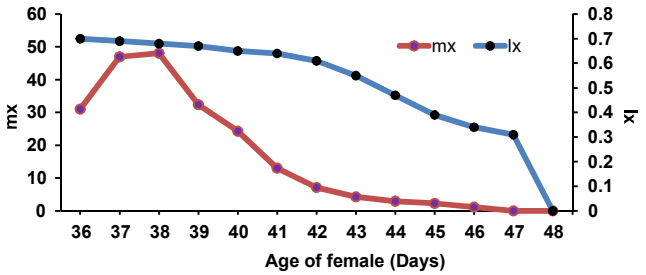

Fig. 1. Survivorship curve (lx) and age specific fecundity (mx) of *H. armigera* on pigeonpea

Table 2. Life table (Female) and age specific fecundity for *H. armigera*on pigeonpea

Pivotal age in days (x)	Survival of female at different age interval (lx)	Age schedule for female births (mx)	lxmx	xlxmx
0-33		Immature stages		
33-35		Pre-oviposition stages		
36	0.70	31.03	21.72	781.96
37	0.69	46.99	32.42	1199.65
38	0.68	48.09	32.70	1242.65
39	0.67	32.38	21.69	846.09
40	0.65	24.31	15.80	632.06
41	0.64	13.03	8.34	341.91
42	0.61	7.12	4.34	182.41
43	0.55	4.31	2.37	101.93
44	0.47	2.94	1.38	60.80
45	0.39	2.31	0.90	40.54
46	0.34	1.17	0.40	18.30
47	0.31	0.00	0.00	0.00
			lxmx = 142.07	xlxmx = 5448.30

Table 3. Mean length of generation, innate capacity for increase in numbers and finite rate of increase in numbers of *H. armigera*on pigeonpea

Population growth statistics	Formula	Calculated values
Net reproductive rate	Ro = lxmx	142.07
Mean length of generation (days)	Tc = xlxmx/Ro	38.3494
Innate capacity for increase in numbers (Females/female/day)	rm = $\log e^{Ro}$/Tc	0.1292
Arbitrary 'rm' (rc)	0.12 and 0.13	
Corrected 'rm' (Females/female/day)	$e^{7 - rmx. lxmx}$	0.1299
Corrected generation time (days)	T = $\log e^{Ro}$/rm	38.1342
Finite rate of increase in numbers (Females/female/day)	(λ) = antilog e^{rm}	1.1387
Weekly multiplication of population (times/week)	$(\lambda)^7$	2.4820
Hypothetical F_2 females	$(Ro)^2$	20183.8849

Table 4. Stable age specific distribution of *H. armigera*on pigeonpea (rm = 0.1299)

Pivotal age in days 'x'	Lx	$e^{-rm(x+1)}$	Lx. $e^{-rm(x+1)}$	Percentage distribution
0	1.00	0.8781	0.8781	13.3646
1	1.00	0.7711	0.7711	11.7357
2	1.00	0.6771	0.6771	10.3054
3	1.00	0.5946	0.5946	9.0494
4	1.00	0.5221	0.5221	7.9464
5	0.99	0.4585	0.4539	6.9082
Eggs				59.3097
6	0.89	0.4026	0.3583	5.4534
7	0.88	0.3535	0.3111	4.7350
8	0.82	0.3104	0.2546	3.8744
9	0.81	0.2726	0.2208	3.3607
10	0.81	0.2394	0.1939	2.9511
11	0.81	0.2102	0.1703	2.5914
12	0.80	0.1846	0.1477	2.2475
13	0.80	0.1621	0.1297	1.9736
14	0.79	0.1423	0.1124	1.7114
15	0.78	0.1250	0.0975	1.4838
16	0.78	0.1098	0.0856	1.3029
17	0.77	0.0964	0.0742	1.1295
18	0.77	0.0846	0.0652	0.9918
19	0.77	0.0743	0.0572	0.8709
20	0.77	0.0653	0.0502	0.7648
21	0.77	0.0573	0.0441	0.6716
22	0.77	0.0503	0.0387	0.5897
23	0.77	0.0442	0.0340	0.5178
24	0.77	0.0388	0.0299	0.4547
Larvae				37.6759
25	0.77	0.0341	0.0262	0.3993
26	0.77	0.0299	0.0230	0.3506
27	0.77	0.0263	0.0202	0.3079
28	0.77	0.0231	0.0178	0.2704
29	0.77	0.0203	0.0156	0.2374
30	0.77	0.0178	0.0137	0.2085
31	0.77	0.0156	0.0120	0.1831
32	0.77	0.0137	0.0106	0.1608
33	0.77	0.0120	0.0093	0.1412
Pupae				2.2591
34	0.75	0.0106	0.0079	0.1207
35	0.70	0.0093	0.0100	0.1522
36	0.70	0.0082	0.0057	0.0869
37	0.69	0.0072	0.0049	0.0752
38	0.68	0.0063	0.0043	0.0651
39	0.67	0.0055	0.0037	0.0563
40	0.65	0.0048	0.0032	0.0480
41	0.64	0.0043	0.0027	0.0415
42	0.61	0.0037	0.0023	0.0347
43	0.55	0.0033	0.0018	0.0275
44	0.47	0.0029	0.0014	0.0206
45	0.39	0.0025	0.0010	0.0150
46	0.34	0.0022	0.0008	0.0115
Adult				0.7553

Table 5. Life table for computing life expectancy of *H. armigera*on pigeonpea

Pivotal age (Days)	Number surviving to the beginning of age interval	Number dying during 'x'	Mortality rate per hundred alive at beginning of age interval [dx.100/lx]	Alive between age 'x' and 'x + 1' [lx + (lx+1)]/2	No. of the individual's life days beyond 'x'	Expectation of further life (Tx / lx) × 2
(x)	(lx)	(dx)	(100 qx)	(Lx)	(Tx)	(ex)
0-5	100	11	11.00	100.50	689.00	13.78
5-10	89	8	8.99	89.50	610.50	13.72
10-15	81	3	3.70	81.50	537.00	13.26
15-20	78	1	1.28	78.50	461.50	11.83
20-25	77	0	0.00	77.50	385.00	10.00
25-30	77	0	0.00	77.50	307.50	7.99
30-35	77	7	9.09	77.50	230.00	5.97
35-40	70	5	7.14	70.5	166.50	4.76
40-45	65	26	40.00	65.5	106.00	3.26
45-50	39	8	20.51	39.5	92.50	4.74
50-55	31	0	0.00	0.00	0.00	0.00

that the net reproductive rate (Ro) was 147.40 female offspring. The mean length of generation (T) was 37.90 days. The innate capacity (rm) and finite rate (λ) of the in number was 0.126 and 1.131 females per female per day, respectively. Maity et al (2020) reported that the net reproductive rate (Ro) was 133.83female offspring. The mean length of generation (T) was 43.7days. The innate capacity (rm) and finite rate (λ) of the in number was 0.112 and 1.118 females per female per day, respectively. In current findings are similar trend was observed. The impact of each developmental stage and the stable age distribution indicated that adults showed just 0.76 per cent of the population of stable age whereas eggs, larvae and pupae contributed 59.31, 37.68 and 2.26 per cent, respectively (Table 4).

The life expectancy demonstrated that *H. armigera* life expectancy decreased significantly as development progressed. The life expectancy of newly placed eggs was 13.78 days (Table 5). The expectancy of further life was 4.76 days at the time of adult emergence.

CONCLUSION

Females produced the maximum progenies (mx = 48.09) on the 38th day of pivotal age. The net reproductive rate (Ro) was 142.07 times multiplication of population per generation. Adults contributed only 0.76 per cent of the population of stable age, whereas, eggs, larvae, and pupae contributed 59.31, 37.68 and 2.26 per cent, respectively. The expectancy of further life was 4.76 days at the time of adult emergence which showed that life expectancy of *H. armigera* was declined with the advancement of development. It is important to increase the egg mortality and minimize the population of *H. armigera*.

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