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LIFE-TABLE PARAMETERS OF FRUIT BORER, *HELICOVERPA ARMIGERA* (HUBNER) HARDWICK IN TOMATO, *LYCOPERSICON ESCULENTUM* MILL

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ABSTRACT
Pre-oviposition period of *H. armigera* was at 44th and 45th day of pivotal age. Female started laying eggs after 45th day and stopped it after 54th day, with lx values being 0.71 and 0.11, respectively. The females contributed the highest (mx = 45.55) number of progeny on 50th day of pivotal age. The net reproductive rate (Ro) was 160.53 obtained with a mean length of generation (Tc) 49.03 days. The intrinsic rate of natural increase in number (rm) was 0.1045 females per female per day with finite rate of increase of 1.34 females/ female/ day and the population would be able to multiply 8.60 times per week. The hypothetical F_2 females were worked out to be 25769.88. Adults contributed only 0.06 per cent to the population of stable age and that of eggs, larvae and pupae were 69.32, 30.23 and 0.39 per cent, respectively. The life expectancy of newly deposited eggs was 14.07 days. The expectancy of further life was 2.83 days at the time of adult emergence which clearly indicated that life expectancy of *H. armigera* declined gradually with the advancement of development.

INTRODUCTION

Fruit borer, *Helicoverpa armigera* (Hubner) Hardwick is the most destructive insect pest causing considerable losses in quantity as well as quality of tomato fruits (Reddy and Zehr, 2004) leading to up to 55 per cent yield loss (Selvanarayanan, 2000). Worldwide annual crop loss due to *H. armigera* alone was approximately 5 billion US dollar (Sharma, 2001). In India, the yield loss due to this devastating pest was to the tune of 38 per cent (Dhandapani *et al*., 2003 and Selvanarayanan and Narayanasamy, 2006).

Population parameters are important in measurement of population growth capacity of species under specified conditions. These parameters are also used as indices of population growth rates responding to selected conditions and as bioclimatic indices in assessing the potential of a pest population growth in a new area (Southwood and Henderson, 2000). Life table is an appropriate tool to study the dynamics and management of pest populations, because this tool can provide very important demographic parameters (Maia *et al*., 2000) which includes analysing population stability and structure, estimating extinction probabilities, predicting life history evolution, predicting outbreak in pest species, and examining the dynamics of colonizing or invading species (Haghani *et al*., 2006). Demographic information may also be useful in constructing population models (Carey, 1993) and understanding the relationship of development and survival of the life stages any insect pest (Birch, 1948 and Howe, 1953), interactions with other insect pests and natural enemies (Omer *et al*., 1996). There was little information on the life table parameters of *H. armigera* on tomato. Therefore, the present study provides novel information on the life table parameters of *H. armigera* on tomato.

MATERIALS AND METHODS

The studies on life table, age specific distribution and life expectancy of *H. armigera* on tomato were carried out at a constant temperature of 26 + 1ºC during the month of October to January of the year 2013-14 at the Department of Entomology, B. A. College of Agriculture, AAU, Anand.

To construct the life-table, the culture of *H. armigera* was maintained on tomato leaves for two consecutive generations at constant temperature (26 ± 1ºC) using B.O.D. incubator. The adults obtained from the culture were used for the further study. The male and female moth pairs were kept for egg laying in wooden cages measuring 30 × 30 × 45cm. The sides of the cage were covered with muslin cloth and the source of tomato branch was kept 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 plastic containers (5.0 cm diameter × 5.5 cm height) in batches of 10 each. The eggs were glued with the diluted gum on the slides in one row to facilitate the observations on hatching. On hatching, the larvae were transferred individually into plastic vials containing food. Fresh food was provided daily in morning. Observations on hatching, larval development, formation of pupae and successful emergence of adult and fecundity of female were recorded daily. Age specific mortality in different developmental stages like eggs,

larvae, pupae and adult were also recorded. With a view to determine the age specific fecundity, total number of adult emerged on the same day was kept in cage for oviposition. Healthy and fresh twigs with tomato leaves were fixed in the conical flasks containing fresh water and kept in the cages for oviposition. The twigs were replaced daily and number of eggs laid on subsequent days on the twigs and muslin cloth were recorded. Observations on fecundity were continued till death of the female. As the sex ratio is 1:1, the numbers of eggs obtained per female was divided by two to get the number of female birth (mx).

The column heading for the construction of the life fecundity tables proposed by Howe (1953) and 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 births at age 'x'

Net reproductive rate (Ro)

The values of 'x', 'lx' and 'mx' were calculated from the data given in life tables. The sum total of the products 'lxmx' is the net reproductive rate (Ro) (Lotka, 1925). The Ro is the rate of multiplication of population in generation measured in terms of females produced per generation. The number of times a population would multiply per generation was calculated by using following formula:

$$Ro = \sum lxmx$$

Mean duration of generation (Tc)

The approximate value of generation time (Tc) (the mean age of the mother in a cohort at the birth of female offspring) was calculated by using following formula

$$Tc = \frac{\sum x\, lxmx}{Ro}$$

Innate capacity for increase in numbers (rm)

Total numbers of individuals survived and mean numbers of female offspring birth were recorded at each age interval. From these data the arbitrary value of 'rm (rc)' was derived by using the following formula:

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

Where,

e = 2.71828

Tc = 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 (Atwal and Bains, 1974).

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

Where,

e = 2.71828

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

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

The finite rate of natural increase (λ)

The number of females per female per day *i.e.* finite rate of increase was determined as.

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

From this data the weekly multiplication of the population was calculated. Hypothetical F_2 females were also 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 tomato was worked out with the knowledge of 'rm' and the age specific mortality of the immature and mature stages. The stable age distribution table was constructed by following the method of Andrewartha and Birch (1954) and Atwal and Bains (1974). The 'Lx' (Life table age distribution) was calculated from the 'lx' table by using the following formula:

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

Per cent distribution of each age group (x) was calculated by multiplying the L_x 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 of *H. armigera*

Life expectancy for tomato was 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

$$100\ qx = \frac{dx.\ 100}{lx}$$ mortality rate/ 100 alive at beginning of age interval

$$Lx = \frac{lx + (lx + 1)}{2}$$ Alive between x and x + 1

Tx = Number of individual's life days beyond x

$$ex = \frac{Tx}{lx}$$ 2, Expectation of further life

RESULTS AND DISCUSSION

An attempt was made to work out the number of individuals survived during development on tomato leaves and fruits. The results (Table 1) indicated that total 92 eggs were survived out of 100 eggs, whereas, total 71 individuals survived from 100 eggs to adult's emergence. The maximum duration of egg, larva and pupa was recorded as 6, 28 and 9 days, respectively.

The present findings are more or less in accordance with the report of Patel and Koshiya (1998) who reported the survival of *H. armigera* from egg to adult was 85 per cent on soybean. According to Dabhi and Patel (2004), the maximum duration of *H. armigera* eggs, larvae and pupae on lucerne was 3, 17 and 15 days, respectively, whereas, on chickpea it was 3, 17

and 16 days, respectively and in case of sorghum, it was 4, 16 and 16 days, respectively. The survival of the immature stages from egg to adult on lucerne, chickpea and sorghum was 64, 64 and 66 per cent, respectively. Singh and Yadav (2009) reported the number of *H. armigera* individuals those survived from egg to adults was 78 individuals. Thus, the present results are in close agreement with the earlier reports.

Life fecundity table of *H. armigera* on tomato was constructed to determine the survival of female (lx) and age specific fecundity (mx). Close perusal of the data (Table 2 and Fig. 1) showed that pre-oviposition period was 44th and 45th day of pivotal age. Female started laying eggs after 45th day and stopped it after 54th day, with lx values being 0.71 and 0.11, respectively. The females contributed the highest (mx = 45.55) number of progeny on 50th day of pivotal age, which decreased day by day.

Dhurgude *et al*. (2010) revealed that pre-oviposition period (3 days) of *H. armigera* was observed in three chickpea cultivars (Virat, G-12 and BDN-9-3) with the highest female birth (147.34, 76.35 and 50.73) at 47th, 50th and 55th day of pivotal age by recording lx value of 0.29, 0.26 and 0.20, respectively.

The net reproductive rate (Ro) was 160.53 obtained with a mean length of generation (Tc) 49.03 days. The intrinsic rate of natural increase in number (rm) was 0.1045 females per female per day with finite rate of increase of 1.34 females/ female/ day and the population would be able to multiply 8.60 times per week. The hypothetical F_2 females was worked out to be 25769.88 (Table 3).

In support of the present findings, Dabhi and Patel (2004) reported the net reproductive rate (R_0) of *H. armigera* and intrinsic rate of natural increase in numbers (rm) on lucerne were 193.73 and 0.1281 females/ female/ day, respectively.

Singh and Yadav (2009) also reported that the population of *H. armigera* increased with infinitesimal rate (rm) of 0.135 and finite rate (λ) 1.1459 females/ female/ day. Further, similar result was also noticed by Choudhury *et al*. (2013) who reported that the intrinsic rate of increase of population of *H. armigera* on chickpea in the first year (0.1125 females/ female/ day)

Table 1: Survival of different life stages of H. armigera during development on tomato

No. of eggs	Number of different stages survived in days		
	Egg (0-6)	Larval(7-34)	Pupal(35-43)
10	9	8	8
10	10	8	7
10	9	7	7
10	9	7	7
10	9	8	7
10	10	8	7
10	9	8	7
10	9	7	7
10	10	7	7
10	8	7	7
100	92	75	71

Table 2: Life table (for female) and age specific fecundity for *H. armigera* in tomato

Pivotal age in days(x)	Survival of female at different age interval (lx)	Age schedule for female births (mx)	lxmx	xlxmx
0-43	Immature stages			
44-45	Pre-oviposition stages			
46	0.71	21.52	15.28	702.75
47	0.71	31.14	22.11	1039.30
48	0.71	38.07	27.03	1297.26
49	0.71	40.17	28.52	1397.55
50	0.71	45.55	32.34	1617.12
51	0.62	33.48	20.76	1058.69
52	0.54	19.48	10.52	546.89
53	0.32	11.46	3.67	194.39
54	0.11	2.83	0.31	16.83
			Σ = lxms160.53	Σ xlxmx = 7870.77

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

Sr. No.	Population growth statistics	Formula	Calculated values
1.	Net reproductive rate	$Ro = \sum lxmx$	160.53
2.	Mean length of generation	$Tc = \frac{\sum xlxmx}{Ro}$	49.03 days
3.	Innate capacity for increase in numbers	$rm = \frac{\log e^{Ro}}{Tc}$	0.1036 Females/female/day
4.	Arbitrary 'rm' (rc)	0.10 and 0.11	
5.	Corrected 'rm'	$\lambda e^{7 - rmx. lxmx}$	0.1045Females/female/day
6.	Corrected generation time	$T = \frac{\log e^{Ro}}{rm}$	48.59 days
7.	Finite rate of increase in numbers	$(\lambda) = \text{antilog } e^{rm}$	1.3430 Females/female/day
8.	Weekly multiplication of population	$(\lambda)^7$	8.61 times
9.	Hypothetical F_2 females	$(Ro)^2$	25769.88

Table 4: Age specific distribution of *H. armigera* on tomato (rm = 0.1045)

Pivotal age in days 'x'	Lx	$e^{-rm(x+1)}$	Lx. $e^{-rm(x+1)}$	Percentage distribution
0	1.00	0.8568	0.8568	15.3540
1	1.00	0.7341	0.7341	13.1556
2	1.00	0.6290	0.6290	11.2720
3	0.99	0.5390	0.5336	9.5615
4	0.95	0.4618	0.4387	7.8615
5	0.92	0.3957	0.3640	6.5232
6	0.92	0.3390	0.3119	5.5892
				69.32
7	0.89	0.2905	0.2585	4.6328
8	0.89	0.2489	0.2215	3.9695
9	0.89	0.2133	0.1898	3.4011
10	0.85	0.1827	0.1553	2.7832
11	0.85	0.1566	0.1331	2.3847
12	0.85	0.1341	0.1140	2.0433
13	0.85	0.1149	0.0977	1.7507
14	0.80	0.0985	0.0788	1.4118
15	0.80	0.0844	0.0675	1.2097
16	0.78	0.0723	0.0564	1.0106
17	0.78	0.0619	0.0483	0.8659
18	0.78	0.0531	0.0414	0.7419
19	0.78	0.0455	0.0355	0.6357
20	0.78	0.0390	0.0304	0.5447
21	0.78	0.0334	0.0260	0.4667
22	0.78	0.0286	0.0223	0.3999
23	0.78	0.0245	0.0191	0.3426
24	0.78	0.0210	0.0164	0.2936
25	0.78	0.0180	0.0140	0.2515
26	0.75	0.0154	0.0116	0.2072
27	0.75	0.0132	0.0099	0.1776

Table 4: Continue.....

Pivotal age in days 'x'	Lx	$e^{-rm(x+1)}$	Lx. $e^{-rm(x+1)}$	Percentage distribution
28	0.75	0.0113	0.0085	0.1521
29	0.75	0.0097	0.0073	0.1303
30	0.75	0.0083	0.0062	0.1117
31	0.75	0.0071	0.0053	0.0957
32	0.75	0.0061	0.0046	0.0820
33	0.75	0.0052	0.0039	0.0703
34	0.75	0.0045	0.0034	0.0602
	30.23			
35	0.75	0.0038	0.0100	0.1792
36	0.75	0.0033	0.0025	0.0442
37	0.73	0.0028	0.0021	0.0369
38	0.73	0.0024	0.0018	0.0316
39	0.73	0.0021	0.0015	0.0271
40	0.72	0.0018	0.0013	0.0229
41	0.72	0.0015	0.0011	0.0196
42	0.71	0.0013	0.0009	0.0166
43	0.71	0.0011	0.0008	0.0142
	0.39			
44	0.71	0.0010	0.0007	0.0122
45	0.71	0.0008	0.0006	0.0104
46	0.71	0.0007	0.0005	0.0089
47	0.71	0.0006	0.0004	0.0076
48	0.71	0.0005	0.0004	0.0065
49	0.71	0.0004	0.0003	0.0056
50	0.71	0.0004	0.0003	0.0048
51	0.62	0.0003	0.0002	0.0036
52	0.54	0.0003	0.0001	0.0027
53	0.32	0.0002	0.0001	0.0014
54	0.11	0.0002	0.0000	0.0004
				0.06

Table 5: Life table for computing life expectancy of *H. armigera* reared on tomato

Pivotal age (Days)	Number surviving to the beginning of age interval	Number dying during 'x'	Mortality rate/ hundred alive at beginning of age interval $\frac{[dx .100]}{Lx}$	Alive between age 'x'and 'x + 1' $\frac{lx + (lx + 1)x2}{2}$	No. of the individual's life days beyond 'x'	Expectation of further life $\frac{Tx \times 2}{lx}$
(x)	(lx)	(dx)	(100 qx)	(Lx)	(Tx)	(ex)
0-5	100	8	8.00	100.50	703.50	14.07
5-10	92	7	7.61	92.50	619.00	13.46
10-15	85	5	5.88	85.50	540.50	12.72
15-20	80	2	2.50	80.50	465.00	11.63
20-25	78	3	3.85	78.50	388.50	9.96
25-30	75	2	2.67	75.50	316.00	8.43
30-35	74	1	2.70	74.50	240.50	6.41
35-40	72	1	1.39	72.50	171.00	4.75
40-45	71	0	0.00	71.50	100.50	2.83
45-50	71	60	84.51	71.50	29.00	0.82
50-55	11	0.00	0.00	0.00	0.00	0.00

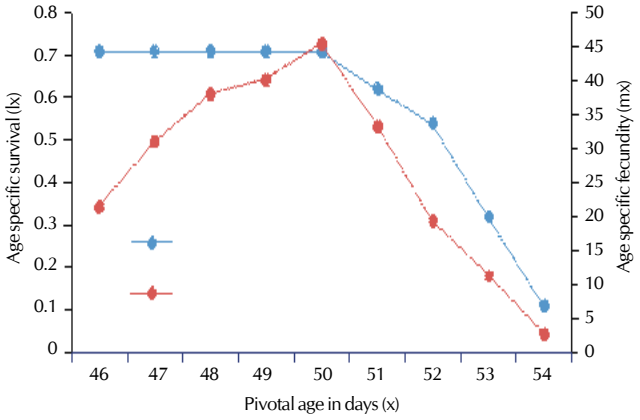

Figure 1: Daily age specific survival and fecundity of *H. armigera* on tomato

than second year (0.1059). Thus, the present findings are more or less in conformity with the earlier reports.

However, Patel and Koshiya (1998) reported the population of *H. armigera* on soybean increased at an infinitesimal rate (rm) of 0.1569 and finite rate (λ) of 1.172 females per female per day. The net reproductive rate (R_o) was 432.06 and it took 38.68 days to complete one generation. Dabhi and Patel (2004) also reported the net reproductive rate (R_0) of *H. armigera* and intrinsic rate of natural increase in numbers (rm) on chickpea were 361.84 and 0.1302, respectively. The present findings are somewhat deviated from the earlier results which might be accounted due to the variations in the crops and varieties.

In present investigation, the contribution of each developmental stage and the stable age distribution were also calculated (Table 4). The data showed that the adults contributed only 0.06 per cent to the population of stable age and that of eggs, larvae and pupae were 69.32, 30.23 and 0.39 per cent, respectively.

These observations are in agreement with Patel and Koshiya (1998) who reported that the *H. armigera* population on soybean comprised approximately 99 per cent immature stages on reaching a stable age-distribution. As per the report of Dabhi and Patel (2004), the adults of *H. armigera* contributed 0.57 per cent of stable age distribution on lucerne, whereas the contribution of eggs, larvae and pupae were 41.33, 52.95 and 5.14 per cent, respectively.

The life expectancy data (Table 5) clearly indicated that life expectancy of *H. armigera* declined gradually with the advancement of development. The life expectancy of newly deposited eggs was 14.07 days. The expectancy of further life was 2.83 days at the time of adult emergence.

The present findings are in close agreement with the report of Patel and Koshiya (1998) who reported the expectation of further life at the age interval of 40-45 days was reduced to 1.53 from 15.63 in the beginning. Similarly, Dabhi and Patel (2004) reported the expectation of further life of newly deposited ova and adults of *H. armigera* on lucerne were 16.32 and 5.16 days, respectively. They also reported the expectation of *H. armigera* for further life was 15.84 days on chickpea.

REFERENCES

Andrewartha, H. C. and Birch, C. C. 1954. The Distribution and Abundance of Animals. *University of Chicago Press, Chicago.* pp. 782.

Atwal, A. S. and Bains, S. S. 1974. Applied Animal Ecology, *Kalyani Publishers*, Ludhiana, pp. 11-35.

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

Carey, J. R. 1993. Applied demography for biologists, with special emphasis on insects. *Oxford University Press,* U.K. p. 211.

Choudhury, R. A., Rizvi, P. Q., Ali, A. and Ahmad, S. K. 2013. Age specific life table of *Helicoverpa armigera* on *Cicer arietinum* under natural conditions. *Ann. Plant Prot. Sci.* **21(1):** 57-61.

Dabhi, M. V. and Patel, C. C. 2004. Life table of *Helicoverpa armigera* (Hubner) on Lucerne, chickpea and sorghum. *Insect Environ.* **10(4):** 159-161.

Dhandapani, N. U., Shekhar, R. and Murugan, M. 2003. Bio-intensive pest management (BIPM) in major vegetable crops: an Indian

perspective. *Food Agric. Environ*. **1:** 333-339.

Dhurgude, S. S., Shetgar, S. S., Badgujar, A. G., Patait, D. D. and Subhan, S. 2010. Life fecundity tables of *Helicoverpa armigera* (Hubner) on chickpea. *Indian J. Ent.* **72(4):** 379-382.

Haghani, M., Fathipour, Y., Talebi, A. A. and Baniameri, V. 2006. Comparative demography of *Liriomyza sativae* Blanchard (Diptera: Agromyzidae) on cucumber at seven constant temperatures. *Insect Sci*. **13:** 477-483.

Howe, R. W. 1953. The rapid determination of intrinsic rate of increase of an insect population. *Ann. Appl. Biol*. **40:** 134-135.

Lotka, A. J. 1925. Elements of Physical Biology. Williams and Wilkins, Battimore.

Maia, A. H. N., Luiz, A. J. B. and Campanhola, C. 2000. Statistical inference on associated fertility life table parameters using jackknife technique: computational aspects. *J. Econ. Ent.* **93:** 511-518.

Omer, A. D., Johnson, M. W. and Tabashnik, B. E. 1996. Demography of the leafminer parasitoid, *Ganaspidium utilis* Beardsley (Hymenoptera: Eucoilidae) at different temperatures. *Biol. Control.* **6:** 29-34.

Patel, C. C. and Koshiya, D. J. 1998. Life table of *Helicoverpa armigera* on soybean. *Indian J. Ent.* **60(4):** 396-401.

Reddy, K. V. S. and Zehr, M. 2004. Novel strategies for overcoming pests and diseases in India. *Maharashtra Hybrid Seeds Co. Ltd., India.* http://www.mahyco.com.

Selvanarayanan, V. 2000. Host plant resistance in tomato against fruit borer, *Helicoverpa armigera* (Hubner). *Ph. D. Thesis. Annamalai University, Annamalainagar, India.*

Selvanarayanan, V. and Narayanasamy, P. 2006. Assessment of Tomato Germplasm for Resistance to Fruit Borer, *Helicoverpa* (=*Heliothis*) *armigera* Hubner. *J. Veg. Sci.* **12(1):** 71-79.

Sharma, H. C. 2001. Cotton bollworm/legume pod borer, *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera): *Biology and management*. *Crop Prot.* Compend. CAB *Int.*, Wallingford, pp. 70.

Singh, S. K. and Yadav, D. K. 2009. Life table and biotic potential of *Helicoverpa armigera* (Hubner) on chick pea pods. *Ann. Plant Prot. Sci.* **17(1):** 90-93.

Southwood, T. R. E. and Henderson, P. A. 2000. Ecological methods. 3rd ed. *Blackwell Sciences, Oxford*, p. 592.