Int.J.Curr.Microbiol.App.Sci (2019) Special Issue-9: 1-12

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-9 pp. 1-12**
Journal homepage: http://www.ijcmas.com

Original Research Article

Life Table Evaluation of *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) on Groundnut

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A B S T R A C T

Life table of *Spodoptera litura* (Fabricius) on groundnut was undertaken to study the different population growth statistics. The results on number of individuals survived during development revealed that there was 10 percent mortality during egg stage and the maximum duration of egg, larva and pupa was 3, 19 and 10 days, respectively. The number that survived from 100 eggs to adult emergence was 73 individuals. Females contributed highest number of progeny (mx=338.13) in the life cycle on the 41st day of pivotal age. The net reproductive potential (Ro) obtained was 735.34 females with the mean length of generation period (Tc) 40.86 days. The innate capacity for increase (rm) and finite rate of increase (λ) were found to be 0.1615 and 1.17females/ female/day, respectively with a weekly multiplication rate $(\lambda)^7$ of 3.09 times. Results on per cent contribution of eggs, larvae, pupae and adults were 50.25, 48.14, 1.39 and 0.20, respectively at stable age distribution of *S. litura* on groundnut.

Keywords

Net reproductive rate, Innate capacity for increase, Finite rate of natural Increase

Introduction

Groundnut (*Arachis hypogaea* L.) is an annual, herbaceous legume and important oil seed crop. Among crop plants, peanut pods develop underground rather than above ground. It is this character that the botanist Linnaeus used to assign the specific name *hypogaea*, which means "under the earth." In India, groundnut is grown on an area of 4.5 million hectares with a production of 6.7 million tonnes of pods per annum. The average productivity of groundnut in India is about 1465 kg/ha (Anonymous, 2015-16) as against the world's average yield of 1600 kg/ha (Anonymous, 2015). Tobacco caterpillar, *Spodoptera litura* (Fab.) is one of the important pest, infesting more than 290 species of plants belonging to 99 families (Wu *et al.*, 2004). Moths are found primarily active during the night and due to its high mobility, female oviposit on a wide range of host plants, which promotes or even ensures the survival of *S. litura* individual over a broad range of environmental conditions (Chelliah, 1985). The outbreaks of this pest occur due to resistance to insecticide, favourable weather conditions, cyclonic weather and heavy rainfall after a long dry spell (Thanki *et al.*, 2003).

In ecological study, life-table is an important analytical tool, which provides detailed information of population dynamics. It also gives a comprehensive description of the survivorship, development and expectation of life. Life table is a concise summary of

certain vital statistics of a population beginning with a cohort, whose members start life together, the number of deaths (dx), the survivors remaining (lx), the rate of mortality (qx) and the expectation of further life (ex) where 'x' stands for age and the age structures (lx).

Life-table, studies provide an opportunity to assess and evaluate the impact of specific mortality factors acting on insect population. Life-tables constructed using laboratory data collected under controlled conditions are useful in revealing the maximal growth potential of a population. The construction of several life-tables may be possible to prepare a predictive model which can be tested against natural population fluctuations. So the study was conducted to determine age specific survivals, fecundity and different population growth statistics of *Spodoptera litura* on groundnut.

Materials and Methods

Survival of different developmental stages of *S. litura* on groundnut

To construct life and fertility tables, 10 pairs of newly emerged adults were enclosed for oviposition in wooden cages of size 45×45×60 cm, these adults were obtained from laboratory reared population. Fresh and healthy groundnut leaves were provided for oviposition along with cotton swab dipped in 10 per cent honey solution to serve as food for the adults. After egg laying by the female moths, batches of 100 eggs each were collected carefully with the help of wet camel hair brush and placed in ten plastic containers (8.0×4.5 cm) in ten batches of each. Immediately after hatching, the larvae were transferred individually to groundnut leaves and fresh food was provided daily. Observations on hatching, larval development, formation of pupae, successful emergence of adults and fecundity were recorded on a daily basis. Age-specific mortality in different developmental stages like eggs, larvae, pupae and adults was recorded and appropriate reasons for unsuccessful development was assigned.

Age-specific fecundity life tables for *S.litura*

To determine the age-specific fecundity, the adults emerged on the same day were caged for oviposition. The leaf provided for oviposition was replaced daily and the number of eggs laid on subsequent days was recorded. The observations on fecundity was continued until all the female moths died. As the sex ratio will be 1:1, the number of eggs obtained per female was divided by two to get the number of female birth (mx).

Preparation of age-specific life tables

The column headings for the life fecundity tables as proposed by Howe (1953) was utilized for this study.

X= pivotal age in days

Lx= survival of female at age 'x'

mx= age schedule for female births at age 'x'

Ro= net reproductive rate

rm= innate capacity for increase in number

Tc= mean duration of generation

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) (Lokta, 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 the following formula:

$Ro = \sum lx.mx$

Mean duration of generation (Tc)

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

$$Tc = \frac{\sum x.lx.mx}{Ro}$$

Innate capacity for increase in number (rm)

Total number of individuals survived and mean number of female offspring births were recorded at each age interval. From these data, the arbitrarily value of 'rm' was derived by the following formula:

$$rm = \frac{\log_e Ro}{Tc}$$

Where,

e = 2.71828

Tc = Mean generation time

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

$$e^{7-rmx.lxmx} = e^{7} = 1097$$

Such tables were constructed separately for each host with the help of 'x' and '1xmx' for each trial of 'rm'. The values of $e^{7-rmx.lxmx}$ obtained from the two trials were plotted against their respective arbitory 'rm' which give a straight line. The straight line was intersected by a vertical line drawn from the described values of $e^{7-rmx.lxmx}$=1097. The points of intersection gave the value of true 'rm' accurate to four decimal points. The precise generation time (T) was 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:

λ = antilog e^{rm}

From this data, the weekly multiplication of the population was calculated. The 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 *S. litura* on ground nut was worked out with 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 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 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 expectancy of *S. litura*

Life expectancy of the pest 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'

$$100qx = \frac{dx.100}{lx}$$

Mortality rate per hundred alive at the beginning of the age interval

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

, Alive between x and x + 1

Tx = Number of individual's life days beyond 'x'

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

Expectation of further life

Results and Discussion

Survival of different life stages of *S. litura*

The survival of different life stages of *S. litura* on groundnut was worked out by taking 100 eggs in 10 replications. The results indicated that the maximum duration of different developmental stages of *S. litura* *i.e.*, egg, larva and pupa were 3, 19 and 10 days, respectively. Out of 100 eggs 90 eggs hatched successfully into larva, 79 larvae successfully formed pupa out of 90 larvae and totally 73 adults successfully emerged from 79 larvae. So mortality during egg stage was 10per cent; mortality during larval and pupal stage was 21 and 27 per cent, respectively. Totally 73 individuals successfully emerged as adults from 100 eggs (Table 1). The present results were in accordance with the findings of Patil *et al.*, (2014) on tobacco, results indicated that the maximum duration of egg, larval and pupa was 4, 18 and 13 days, respectively and Maghodia and Koshiya (2008) who worked on *S. litura* on cotton, the results showed that feeding the 1st, 2nd and 3rdgenerations of the immature stage of *S. litura* showed total duration from egg to adult stage was 29.6 days as against 31.9 days for diet-1.

Life table and age-specific fecundity of *S. litura*

Life table for computing age-specific fecundity to determine the survival of female (lx) and age schedule for birth at age x (mx). The age-specific fecundity data presented in the (Table 2) indicated that pre-oviposition period of *S. litura* ranged from 35th to 37th day of pivotal age. Females deposited the first batch of eggs on the 38th day (mx=37.60) and it was continued up to 44th day (mx=62.00) with lx values being 0.73 and 0.30, respectively. The first female mortality was observed on the 6th day after the emergence of adult female i.e., on the 40th day of pivotal age (lx=0.71) and mortality increased slowly, indicated by a gradual decrease in the lx values after the 40th day of pivotal age (Fig. 1). The females contributed maximum mean progeny production per day (mx=338.13) on the 41st day of pivotal age which declined (mx=56.06) on the 44th day. Summation of

lx.mx gives the net reproductive rate (Ro) and summation of x.lx.mx was 30049.68, this value was used to calculate mean length of generation. The present findings were in accordance with the results of Gagandeep *et al.,* (2001) who recorded fecundity of *S. litura i.e*., 1305, on cotton. Similar trend was reported by Patil *et al.,* (2014) where the pre-oviposition period ranged from 36th to 37th days of pivotal age. Females contributed highest number of progeny (mx=508.92) in the life cycle on the 41st day of pivotal age.

Mean length of generation, innate capacity for increase in number and finite rate of increase in numbers of *S. litura*

The net reproductive rate (Ro), representing the ratio of total female birth in one generation was 735.34. The data on mean length of generation time (Tc) was 40.86 days (Table 3). The intrinsic rate of natural increase in number (rm) was 0.1615 females per female per day with a daily finite rate of increase in number (λ) 1.17 females per female per day and population of *S. litura* would be able to multiply 3.09 times per week under the given set of conditions. The hypothetical female's population in F2 generation was found to be 540724.91 and the potential fecundity was 1205.44 eggs per female. The present findings were in agreement with the results of Sooravan *et al.,* (2005) where the intrinsic rate of natural increase (rm) of the population on the host plant ranges from 0.153 to 0.195 females /female/day. Similarly, the results of Tuan *et al.,* (2013) on peanuts in laboratory reared *S. litura* indicated that the intrinsic rate of increase was 0.1828 females /female/day.

Table.1 Survival of different developmental stages of *S. litura* on groundnut

Replication	No. of eggs	Egg stage (0 to 3 days)	Larval stages (4 to 23 days)	Pupal stages (24 to 34 days)
Duration of growth stages in days	-	**3**	**19**	**10**
1	10	8	7	6
2	10	9	8	8
3	10	10	10	9
4	10	10	9	8
5	10	9	8	8
6	10	10	7	7
7	10	7	6	6
8	10	10	8	8
9	10	9	9	7
10	10	8	7	6
Total	**100**	**90**	**79**	**73**
Cumulative mortality (%)	-	**10**	**21**	**27**

Table.2 Life-table and age-specific fecundity of *S. litura*on groundnut

Pivotal age in days (x)	Survival at different age intervals (lx)	Age schedule for birth at age x (mx)	lx.mx	x.lx.mx
0-34	0.73	-	-	Immature
35	0.73	-	0.73	25.55
36	0.73	-	0.73	26.28
37	0.73	-	0.73	27.01
38	0.73	37.60	27.44	1043.02
39	0.73	119.13	86.96	3392.63
40	0.71	228.06	161.92	6476.90
41	0.66	338.13	223.16	9151.79
42	0.54	292.26	157.82	6628.45
43	0.44	134.20	59.04	2538.06
44	0.30	56.06	16.81	739.99
45	0.22	0.00	0.00	0.00
			$R_0=\sum$lx.mx = 735.34	$\sum$x.lx.mx = 30049.68

Table.3 Mean length of generation, innate capacity for increase in number and finite rate of increase in number of *S. litura* on groundnut

Population growth statistics	**Formula**	**Calculated value**
Net reproductive rate	$R_o = \sum lx.mx$	735.34
Mean length of generation	$Tc = \sum x.lx.mx / R_o$	40.86 days
Innate capacity for increase in number	$rm = Log_e R_o / T_c$	0.1615 females/female/day
Finite rate of increase in number	λ=antilog e^{rm}	1.17 females/female/day
Arbitary 'rm' (rc)	-	0.16 or 0.17
Weekly multiplication of population	$= (\lambda)^7$	3.09
Doubling time (DT)	$= \log_e 2/rm$	4.29 days
Potential fecundity (Pf)	$= \sum mx$	1205.44
Hypothetical F_2 females	$= (R_0)^2$	540724.91

Table.4 Age-specific distribution of *S. litura* on groundnut

Pivotal age (in days) x	lx	X+1	rm*(x+1)	exp(rm*x+1)	Lx(exp(rm*x+1)	% contribution	
0	1	1	-0.1615	0.8508	0.8508	15.7499	
1	1	2	-0.3230	0.7239	0.7239	13.4010	**Eggs**
2	1	3	-0.4845	0.6160	0.6160	11.4025	
3	1	4	-0.6460	0.5241	0.5241	9.7020	**50.25**
4	1	5	-0.8075	0.4459	0.4459	8.2551	
5	1	6	-0.9690	0.3794	0.3794	7.0240	
6	0.90	7	-1.1305	0.3228	0.2905	5.3788	
7	0.90	8	-1.2920	0.2747	0.2472	4.5766	
8	0.88	9	-1.4535	0.2337	0.2057	3.8076	
9	0.88	10	-1.6150	0.1988	0.1750	3.2397	
10	0.88	11	-1.7765	0.1692	0.1489	2.7566	
11	0.87	12	-1.9380	0.1439	0.1252	2.3188	**Larvae**
12	0.85	13	-2.0995	0.1225	0.1041	1.9276	
13	0.85	14	-2.2610	0.1042	0.0886	1.6401	
14	0.85	15	-2.4225	0.0887	0.0753	1.3955	
15	0.82	16	-2.5840	0.0754	0.0618	1.1455	
16	0.82	17	-2.7455	0.0642	0.0526	0.9747	
17	0.81	18	-2.9070	0.0546	0.0442	0.8192	
18	0.81	19	-3.0685	0.0464	0.0376	0.6970	
19	0.81	20	-3.2300	0.0395	0.0320	0.5931	
20	0.81	21	-3.3915	0.0336	0.0272	0.5046	
21	0.81	22	-3.5530	0.0286	0.0231	0.4293	**48.14**
22	0.79	23	-3.7145	0.0243	0.0192	0.3563	
23	0.79	24	-3.8760	0.0207	0.0163	0.3031	
24	0.79	25	-4.0375	0.0176	0.0139	0.2579	
25	0.79	26	-4.1990	0.0150	0.0118	0.2195	
26	0.77	27	-4.3605	0.0127	0.0098	0.1820	
27	0.77	28	-4.5220	0.0108	0.0083	0.1548	**Pupae**
28	0.76	29	-4.6835	0.0092	0.0070	0.1300	
29	0.76	30	-4.8450	0.0078	0.0059	0.1106	
30	0.76	31	-5.0065	0.0066	0.0050	0.0941	
31	0.75	32	-5.1680	0.0056	0.0042	0.0790	
32	0.75	33	-5.3295	0.0048	0.0036	0.0672	**1.39**
33	0.73	34	-5.4910	0.0041	0.0030	0.0557	
34	0.73	35	-5.6525	0.0035	0.0025	0.0474	
35	0.73	36	-5.8140	0.0029	0.0021	0.0403	
36	0.73	37	-5.9755	0.0025	0.0018	0.0343	
37	0.73	38	-6.1370	0.0021	0.0015	0.0292	
38	0.73	39	-6.2985	0.0018	0.0013	0.0248	**Adult**
39	0.73	40	-6.4600	0.0015	0.0011	0.0211	
40	0.71	41	-6.6215	0.0013	0.0009	0.0174	
41	0.66	42	-6.7830	0.0011	0.0007	0.0138	
42	0.54	43	-6.9445	0.0009	0.0005	0.0096	**0.20**
43	0.44	44	-7.1060	0.0008	0.0003	0.0066	
44	0.30	45	-7.2675	0.0006	0.0002	0.0038	
				Total	**5.4023**	**100.00**	**100.00**

Table.5 Life table for computing life expectancy of *S. litura* on groundnut

Pivotal age (Days) 'x'	**Number Surviving to the beginning of the age interval**	**Number dying during 'x'**	**Mortality rate per hundred alive at beginning of the age interval** $\frac{(dx.100)}{lx}$	**Alive between age 'x' and 'x+1'** $\frac{lx+(lx+1)}{2}$	**No. of the individuals life days beyond 'x'**	**Expectation of further life** $\frac{Tx}{lx}$ **x2**
(x)	**(lx)**	**(dx)**	**(100 qx)**	**(Lx)**	**(Tx)**	**(ex)**
0-5	100	10	10.0	95.0	702.0	14.04
5-10	90	3	3.33	88.5	607.0	13.48
10-15	87	5	5.74	84.5	518.5	11.90
15-20	82	1	1.21	81.5	434.0	10.58
20-25	81	3	3.70	79.5	352.5	8.70
25-30	78	4	3.61	76.0	273.0	7.00
30-35	74	3	5.12	72.5	197.0	5.32
35-40	71	2	2.81	70.0	124.5	3.50
40-45	69	49	71.01	44.5	54.5	1.56
45-50	20	18	90.00	10.0	10.0	1.00

Fig.1 Age-specific survival and fecundity of *S. litura* on groundnut

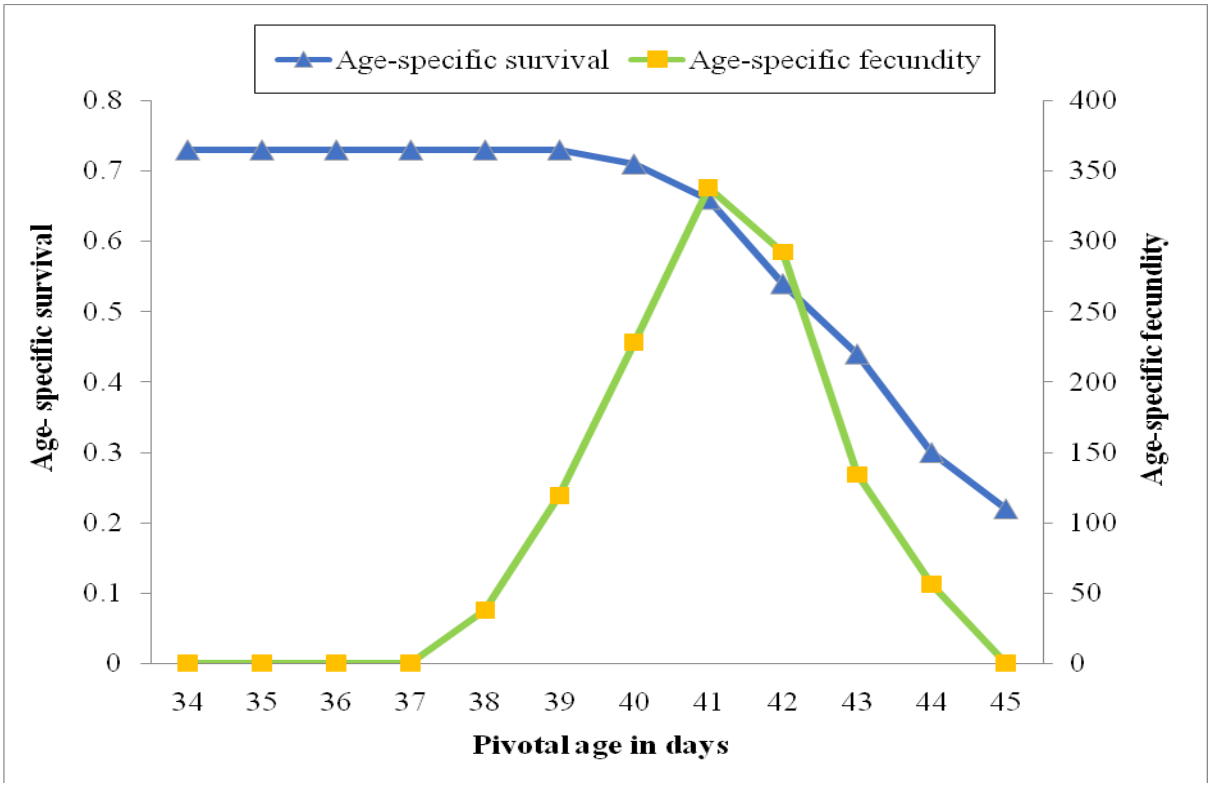
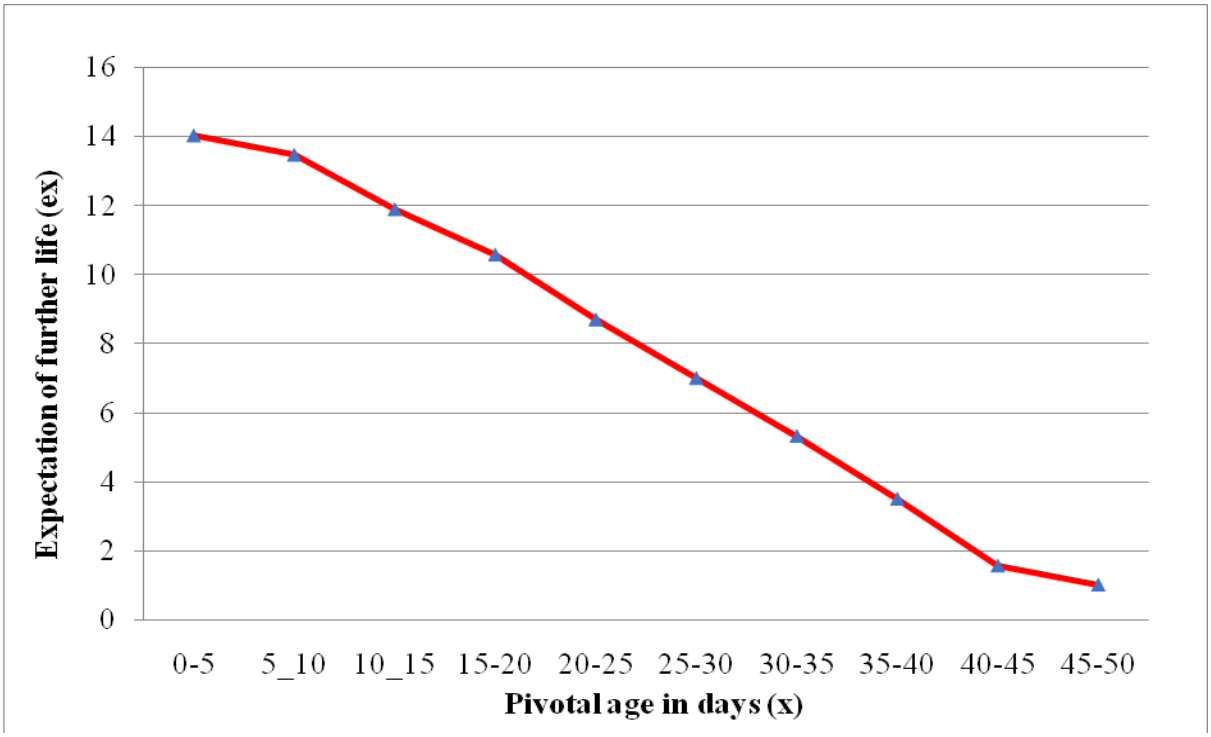


Fig.2 Life expectancy of *S. litura* on groundnut



Age-specific distribution of *S. litura* on groundnut

The investigation on the contribution of each developmental stage of *S. litura* on groundnut towards the stable age distribution was calculated by observing the age schedule of birth rate and death rate (mx and lx). The results revealed that adults contributed only 0.20 per cent to the population of stable age, whereas eggs, larvae and pupae contributed 50.25, 48.14 and 1.39 per cent, respectively (Table 4). This indicates that immature stages contributed highest to the stable age distribution of the population. Similar observations were reported earlier by Gedia *et al.*, (2008a) where the contribution of eggs, larvae, pupae and adults of *S. litura* were 52.0, 46.4, 1.3 and 0.3 per cent, respectively on groundnut. Gedia *et al.*, (2008b) reported that the contribution of eggs, larvae, pupae and adults of *S. litura* were 54.4, 42.4, 2.6 and 0.4, per cent, respectively in cotton.

Life expectancy of *S. litura*

The life expectancy (ex) of *S. litura* declined gradually with the advancement of the life expectancy (ex) of *S. litura* declined gradually with the advancement of development (Table 5). The life expectancy of newly deposited eggs was 14.04 days. The mortality rate (dx) increased gradually which is indicated by a decrease in the lx values and mortality was comparatively high at the age of 40-45 days of pivotal age, then the expectation of further life was reduced to 1.00 days from 13.30 days in the beginning (Fig. 2). Present results were in agreement with the results of Maghodia and Koshiya (2008) and reported that life expectancy of *S. litura* eggs was 17.34, 17.44, 16.39, 17.45 and 17.98 on castor, tobacco, groundnut, cotton and cabbage, respectively and Dhabi *et al.*, (2009) reported similar results, where the expected further life of *S. litura* at the age of 15 to 20 days was reduced to 7.08 from 12.82 days.

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