Studies on Biology of Brinjal Fruit and Shoot Borer, *Leucinodes orbonalis* (Guenee) under Laboratory Condition

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Abstract

Brinjal (*Solanum melongena* L.) is cultivated extensively in different parts of India and considered to be one of the most remunerative vegetables. However, the brinjal growers suffer from severe yield loss mainly due to brinjal fruit and shoot borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). Therefore, an attempt has been made to study the growth and development along with life tables of this noxious insect in the laboratory at 27±1^{0}C and 80±5% RH. as these types of information are very much useful in formulating a stable pest management programme. The experimental findings revealed that larval period, pupal period, adult longevity and mean length of generation were 16.2, 7.6, 3.8 and 26.9 days, respectively. The above biological parameters indicated that the insect could complete a generation within a month. Percent adult emergence was relatively low (16.7) which badly affected the growth index (0.68) and suitability index (0.05) of the insect. Results on life tables indicated that age specific survival (lx) of insect was gradually decreased with the advancement of time. Expectancy of life also revealed similar trend. Natality rate showed no similarity during whole reproductive period which was continued up to 2.7 days with a fecundity of 35.4 eggs female^{-1} while net reproductive rate was estimated 7.93 females female^{-1}. The approximate rate of increase (r_{approx}) was slightly lesser than actual rate of natural increase ($r_{accurate}$) indicated the population trends towards overlapping generations. Finite rate of increase, potential fecundity and monthly rate of increase were 1.07 females female^{-1} day^{-1}, 79.0 females female^{-1} and 7.61 females female^{-1}, respectively. Beside these, time required for the population to double was 10.25 days. Results on stable-age distribution indicated that on reaching stable age, maximum contribution to the population distribution was made by larval stage (61.70%) followed by egg stage (30.45%) and on reaching $r_{accurate}$ the percent distribution of this insect population decreased gradually with the increase of developmental periods.

1. Introduction

Brinjal (*Solanum melogena* L.) is the third most important vegetable crop grown all the year round in different parts of India and contributes to 17.8% of the total production of vegetables in the country (Prasanna and Kumar, 2008). However, the productivity of brinjal is still below the expected due to various constraints of which insect and non-insect pests that attack the crop at various physiological growth stages from nursery stage to harvest considered to be major one. Brinjal fruit and shoot borer, *Leucinodes orbonalis* (Guenee) (Lepidoptera: Pyralidae) is reported most destructive (Srinivasan, 2008) as the pest species may cause fruit damage as high as 95% and losses up to 70% in commercial plantings (ISAAA, 2007). After hatching, the larvae of this insect remain outside the plant for a very brief period of time. Once they bore into the plant, they are very difficult to control. The brinjal growers in general used to resort frequent sprays of pesticides to kill the borer larvae (Alam et al., 2003). This result in increase costs of production, environmental pollution, outbreak of secondary pests, development of pesticide resistance in insect, adverse effects on beneficial insects, wild life and ultimately to human being through food chains. To overcome these problems as well as to develop sustainable management practices, a thorough knowledge on the biology of the internal feeder is urgently needed. Keeping the aforesaid reasons in view, the present study was concentrated on the growth and development, survivorship pattern, fertility potential of female along with stable-age distribution during the whole life span of this insect under laboratory condition.

2. Materials and Methods

2.1. Rearing for ovipositional studies

Brinjal var. *Sati* (local variety) was cultivated in farmer's field near Sriniketan of Birbhum district of red lateritic zone of West Bengal. The infested fruits with borer larvae were collected from the field and kept in glass jars (8″ diam. and 12″ long) till adult emergence. The fruits (food) were changed whenever required to avoid decomposition. The larvae were gently taken out with the help of a fine camel brush during the food change and placed them to the fresh foods. After pupation, the insect was placed on a cotton pad kept in glass jar with great care and top of the jar was covered with muslin cloth. After adult emergence the insect was paired separately in different glass jars (6″ diam. and 10″ long) lined with black papers on inner wall with muslin cloths on the tops. Fresh brinjal leaves plugged with water soaked cotton were kept on the bottom of the jars to provide natural ovipositional site. Every day the leaves were checked minutely under simple microscope for eggs laid by the female. Mean ovipositional period and average number of eggs laid by the female insect was calculated after their mortality.

2.2. Growth and development

Hundred newly hatched (0-12 h old) larvae of the lepidopteran borer were taken from nucleus culture and reared individually on sliced brinjal kept in labeled plastic container (2″ diam. and 4″ long) having screw cap fitted with fine wiremess to facilitate aeration in the laboratory at 27±1^{0}C and 80±5% RH. Food was given *ad libitum.* After pupation they were also placed separately on cotton pad kept on the bottom of the container. Date of pupation and adult emergence were noted down. Observations continued till the mortality of all emerged adults. Growth index (G.I.) and suitability index (S.I.) were calculated using the formulae proposed by Pant (1956) and Howe (1971), respectively.

2.3. Age-specific survivorship, female-fertility and stable-age distribution

The adult moths were collected from nucleus culture and kept in rearing jars for oviposition in the laboratory at 27±1^{0}C and 80±5% RH. Initially, 90 eggs in groups of ten were kept in nine vials (3 cm diam.x 10 cm) till hatching. Thereafter, first instar larvae were kept separately in between two fresh slices of brinjal fruit. The food (slice) was changed daily to avoid any type of contamination till pupation. After adult emergence, cotton pad soaked in 5% sugar solution was kept on the bottom of rearing jars as supplementary food. The observations for survival of the insect were recorded every day at regular interval till the mortality of all adults. Same age groups of ten male and female moths were collected from survivorship experiment. They were paired separately and numbers of egg laid by each female during the entire ovipositional period were kept in separate vials (1.5 cm diam.x 4 cm) to observe hatching. In this way, all the fertile eggs were recorded and average rate of egg laying female^{-1} day^{-1} was calculated. Thus, the data obtained from the above experiments were used to construct the age-specific survivorship and female-fertility life tables as proposed by Howe (1953); Choudhary and Bhattacharya (1986). These life table data were also used to calculate the stable-age distribution (Atwal and Bains, 1974) of the insect.

3. Results and Discussion

3.1. Growth and development

Perusal of Table 1 revealed that larval period of the insect was 16.2 days while pupal period and adult longevity were 7.6 and 3.8 days, respectively. Suresh et al. (1996) recorded that egg, larval and pupal period lasted for 5 to 7, 15 to 27 and 8 to10 days, respectively under the laboratory conditions at 27.25±4.24˚C and 68.5±10.5% RH. while Singh and Singh (2001) reported that average lifespan of the male moth was 3.53 days while that of the female moth was 5.80 days. They also observed that total duration of life cycle of the insect was 27.07±0.75 days. The above results were in corroboration with the present findings. The per cent adult formation was relatively low (16.7%) due to mortality of early instar larvae, formation of larval-pupal condition in fair proportion of the population and failure of some pupae to emerge as adults. These phenomena ultimately badly affected the growth index (0.68) and suitability index (0.05) though the crop was major food plant for this insect. The above findings indicated that the insect was highly vulnerable at those stages of its life cycle. The reproductive period of the female insect was continued up to 2.7 days while fecundity was 35.4 eggs female^{-1}. Mehta et al. (1983) under laboratory conditions recorded that pre-oviposition and oviposition period of the female moth ranged from 1.2 to 2.1 and 1.4 to 2.4 days, respectively. The average fecundity ranged from 34.5 in January to 25.3 in May per female which was in conformity with the present findings.

Table 1: Different growth parameters of *L. orbonalis* on brinjal.

Growth parameters	
Larval period (days)	16.2
Adult period (days)	3.8
Pupal period (days)	7.6
Adult formation (%)	16.7
Growth index (G.I)	0.68
Suitability index (S.I.)	0.05
Reproductive period (days)	2.7
Fecundity (Eggs female^{-1})	35.4

3.2. Age-specific survivorship

More or less gradual decrease of age specific survival (lx) of *L. orbonalis* was recorded during the whole experimental period except the period between 16 to 17 days. A sharp decline in survival of the insect was observed in those two days. This might be due to death of the larvae which failed to pupate or death inside the pupal case. This stage is highly vulnerable to the insect as a slight disturbance in this period may result in failure to complete the generation. Confirmation of pupal mortality within the pupal case is difficult. Hence, similar to embryonic mortality, pupal mortality was also assumed homogenous throughout the pupal period. As a result, a steady decline in insect population was recorded during this period. Thereafter, mortality of the insect slightly slowed down for a short period due to survival of neonate adults. But during post-oviposition period survival again started to decline at a regular basis till mortality of all the survived adults (Table 2 and Figure 1). The survivorship curve was found to be similar to that of stair step type curves recorded for holometabolous insects by Odum (1971) was intermediate to Type I and Type II survivorship curves described by Slobodkin (1962) and Deevey (1947). Choudhary and Bhattacharya (1986) recorded similar type of survival pattern in *Creatonotus grangis* and *Spodoptera litura* on winged bean while Chenchiah et al. (2007) in *C. gangis* on artificial diet.

Table 2 and Figure 1 reveal that life expectancy (ex) of *L. orbonalis* gradually decreased with the advancement of age. The expectancy of life was quite higher at early age and at the beginning of life ex was estimated 16.46 days. However, at 16 days it came down to 6.24. Thereafter, the expectancy slightly increased as a large number of insect succeeded to complete pupation. After 18 days, ex again started to decline at a regular pace due to constant pupal mortality and finally came down to 0.5 days on cessation of life of all the survived adults. These findings were corroborated with Chalam et al. (2003) and Shah et al. (2007).

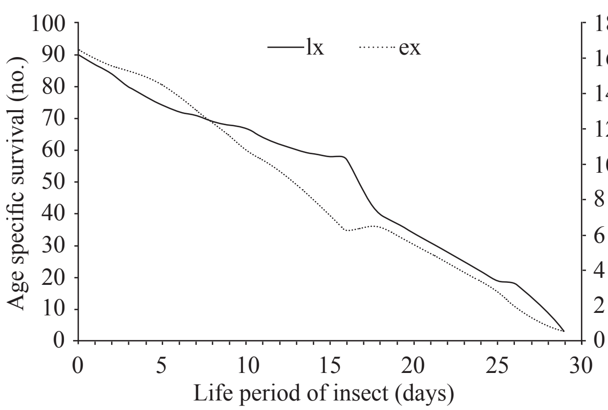

Figure 1: Age specific survivorship (lx) and life expectancy (ex) of *L. orbonalis* on brinjal during whole life period

Table 2: Age specific survivorship of *L. orbonalis* on brinjal

X	lx	dx	100qx	Lx	Tx	ex
0	90.0	3.0	3.33	88.50	1481.0	16.46
1	87.0	3.0	3.45	85.50	1392.5	16.01
2	84.0	4.0	4.76	82.00	1307.0	15.56
3	80.0	3.0	3.75	78.50	1225.0	15.31
4	77.0	3.0	3.90	75.50	1146.5	14.89
5	74.0	2.0	2.70	73.00	1071.0	14.47
6	72.0	1.0	1.39	71.50	998.0	13.86
7	71.0	2.0	2.82	70.00	926.5	13.05
8	69.0	1.0	1.45	68.50	856.5	12.41
9	68.0	1.0	1.47	67.50	788.0	11.59
10	67.0	3.0	4.48	65.50	720.5	10.75
11	64.0	2.0	3.13	63.00	655.0	10.23
12	62.0	2.0	3.23	61.00	592.0	9.55
13	60.0	1.0	1.67	59.50	531.0	8.85
14	59.0	1.0	1.69	58.50	471.5	7.99
15	58.0	1.0	1.72	57.50	413.0	7.12
16	57.0	10.0	17.54	52.00	355.5	6.24
17	47.0	7.0	14.89	43.50	303.5	6.46
18	40.0	3.0	7.50	38.50	260.0	6.50
19	37.0	3.0	8.11	35.50	221.5	5.99
20	34.0	3.0	8.82	32.50	186.0	5.47
21	31.0	3.0	9.68	29.50	153.5	4.95
22	28.0	3.0	10.71	26.50	124.0	4.43
23	25.0	3.0	12.00	23.50	97.5	3.90
24	22.0	3.0	13.64	20.50	74.0	3.36
25	19.0	1.0	5.26	18.50	53.5	2.82
26	18.0	4.0	22.22	16.00	35.0	1.94
27	14.0	5.0	35.71	11.50	19.0	1.36
28	9.0	6.0	66.67	6.00	7.5	0.83
29	3.0	3.0	100.0	1.50	1.5	0.50

x: Age of the insect in days; lx: No. surviving at the beginning of each age interval x; dx: No. dying within age interval x to x + 1; 100qx: Mortality rate at the age interval x to x + 1; Lx: Avg. number survives at the age interval x to x + 1; ex: Expectation of life at the beginning of each age interval x.

3.3. Female-fertility

Results presented in the Table 3 revealed that immature stages including the pre-reproductive period of *L. orbonalis* was 25.5 days and oviposition period is only three days. At the beginning of egg laying, survival fraction of female (lx) i.e. proportional survival of female at

the age x was 0.14. As the adults grew older, lx decreased steadily due to death of female moths while natality rate (mx)

Table 3: Female-fertility life table of *L. orbonalis* on brinjal

x	lx	mx	lx.mx	x.lx.mx	$e^{-rx.lx.mx}$ (r=0.0768)	% cont
0.5 to 25.5 days immature stages and pre-reproductive period						
26.5	.14	31.5	4.410	116.865	0.5759	57.656
27.5	.09	35.0	3.150	86.6250	0.3810	38.138
28.5	.03	12.5	0.375	10.6875	0.0420	4.204

Σ x. lx.mx	214.17
Net reproductive rate (R_0) = Σ lx.mx	7.93 f f^{-1}
Mean length of generation (T) = Σ x.lx.mx/ Σ lx.mx	26.9 days
Approximate rate of increase (r_{approx}) = $\log_e R_o/T$	0.0767 f f^{-1} day^{-1}
Actual rate of natural increase ($r_{accurate}$)	0.0768 f f^{-1} day^{-1}
Finite rate of increase ()= $e^{r(accurate)}$	1.07 f f^{-1} day^{-1}
Potential fecundity (Pf)= λ mx	79.0 f f^{-1}
Doubling time (DT) = $\log_e 2 / \log_e \lambda$	9.02 days
Monthly rate of increase (MRI) = λ^{30}	7.61 f f^{-1}

x: Pivotal age in days; lx: Survival fraction of females; mx: Natality rate; % cont: % contribution of each group towards 'r'; f f^{-1}: females/ female

i.e. number of female off-springs produced per female at the age x did not show any similarity during the whole length of reproductive period. These results were in conformity with Shah et al. (2007). The net reproductive rate (R_o) was estimated 7.93 females $female^{-1}$ while mean length of generation (T) was 26.9. The net reproductive period and approximate length of generation time for *Aphis gossypii* on okra was 25.62 females $female^{-1}$ $generation^{-1}$ and 11.09 days, respectively (Shah et al., 2007) while corrected mean generation time of *Myzus persicae* on cauliflower was 18.92 (Bijaya et al., 2002).

The approximate rate of increase (r_{approx}) was slightly lesser than actual rate of natural increase ($r_{accurate}$) indicated the population trends towards overlapping generations (Southwood, 1978). The finite rate of increase (λ) was 1.07 females $female^{-1}$ day^{-1}, potential fecundity (Pf) was 79.0 females $female^{-1}$ and monthly rate of increase (MRI) was 7.61 females $female^{-1}$ while time required for population to double (DT) was 10.25 days (Table 3). The approximate capacity for increase, true intrinsic rate of increase, daily finite rate of increase, weekly multiplication and doubling time for *A. gossypii* on okra was 0.292 females $female^{-1}$ day^{-1}, 0.321 females $female^{-1}$ day^{-1},1.379 females $female^{-1}$ day^{-1}, 9.493 times and 2.155 days, respectively (Shah et al.,2007).

3.4. Stable-age distribution of L. orbonalis

The findings of the results on stable-age distribution of the insect on brinjal indicated that on reaching the stable age, the maximum contribution to the population distribution was made by larval stage (61.70%) followed by egg stage (30.45%) while per cent contribution by both pupal and adult stages was far lower than the above two stages.

It is well understood that the natural rate of increase of any biological population always tends to reach at highest level to make the population stable in the nature. In the present investigation, it was observed that on reaching $r_{accurate}$ the per cent distribution of this insect population decreased gradually with the increase of developmental periods (Table 4). The

Table 4: Stable-age distribution of *L. orbonalis* on brinjal

X	Lx	$e^{-r(x+1)}$ (r =0.0732)	Lx. $e^{-r(x+1)}$	%Distribution	
0	0.885	0.9260	0.8195	11.32	Egg (30.45)
1	0.855	0.8576	0.7332	10.14	
2	0.820	0.7942	0.6512	8.99	
3	0.785	0.7355	0.5773	7.98	Larva (61.70)
4	0.755	0.6811	0.5142	7.12	
5	0.730	0.6307	0.4604	6.37	
6	0.715	0.5841	0.4176	5.78	
7	0.700	0.5409	0.3786	5.24	
8	0.685	0.5009	0.3431	4.75	
9	0.675	0.4639	0.3131	4.33	
10	0.655	0.4296	0.2814	3.89	
11	0.630	0.3978	0.2506	3.47	
12	0.610	0.3684	0.2247	3.12	
13	0.595	0.3412	0.2030	2.81	
14	0.585	0.3160	0.1848	2.56	
15	0.575	0.2926	0.1682	2.33	
16	0.520	0.2710	0.1409	1.95	
17	0.435	0.2509	0.1091	1.50	Pupa (6.96)
18	0.385	0.2324	0.0894	1.23	
19	0.355	0.2152	0.0764	1.05	
20	0.325	0.1993	0.0647	0.89	
21	0.295	0.1845	0.0544	0.75	
22	0.265	0.1709	0.0453	0.62	
23	0.235	0.1583	0.0372	0.51	
24	0.205	0.1466	0.0300	0.41	
25	0.185	0.1357	0.0251	0.34	Adult (0.89)
26	0.160	0.1257	0.0201	0.27	
27	0.115	0.1164	0.0339	0.18	
28	0.060	0.1078	0.0064	0.08	
29	0.015	0.0998	0.0014	0.02	

x: Pivotal age in days; Lx: Survival fraction of females; Figures in parentheses indicate % distribution of different age groups present findings were in conformity with Bijaya et al. (2002), Shevale (2003) and Shah et al. (2007).

4. Conclusion

For sustainable management of any insect pest it is necessary to know its different vital statistics of life such as larval period, pupal period, per cent adult emergence, survival pattern, potential fecundity, natality rate, intrinsic rate of increase etc. Studies on growth and development along with life tables thus have immense important to find out such types of information particularly for the insect like *L. orbonalis* which has internal feeding habit. Beside this, studies on stable-age distribution of the insect also gave an idea about the share of different age groups in population build up of a particular generation.

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