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Life table and biotic potentialof *Maruca vitrata* (Geyer) (Lepidoptera: Crambidae) on chickpea artificial diet

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Abstract
Life table studies of *Maruca vitrata* (Geyer) carried out on chickpea artificial diet under controlled environmental condition of 26 ± 1°C temperature with a photoperiod of 14:10 L:D and 60 ± 10% relative humidity at Agriculture Research Station, Kalaburagi, during 2015-16. Results revealed that high mortality was observed at egg, 1st instar and pupal stages which indicated minimum survival fraction at these stages and maximum at 4th and 6th larval instars. The number that survived from egg to adults was 78 individuals. Investigation on life fecundity tables and age specific distribution revealed that the expectancy of newly laid eggs was 332.43. The survival of different life stages of *Maruca vitrata* on pigeonpea diet was found to be 3, 14 and 8 days in egg, larval and pupal stages, respectively. The number that survived from egg to adults was 78 individuals. The main length of generation was (Tc) 31.23 days and (T) 31.35 days. The intrinsic rate of increase was examined to be 0.12females/female/day, repetitively. Under sufficient food supply, the population of *Maruca vitrata* increased with and infinitesimal rate (rm) of 0.12 and finite rate (λ) 1.14 females/female/day. A generation was completed in 31.23 days. The population of *M. vitrata* was capable to multiply 2.44 times/week under the given set of conditions. The population on reaching a stable age distribution comprised approximately 42.92% of immature stage. Age distribution of this pest on chick pea manifested that eggs and larvae contributed the highest to the population of stable age, where as the contribution of pupa was negligible.

Keywords: Life table, *Maruca vitrata*, chickpea artificial diet

1. Introduction

Pigeonpea (*Cajanus cajan* L. Mill sp.) is an important pulse crop in the semi-arid tropics and subtropical farming systems, providing high quality vegetable protein, animal feed and Pigeonpea (*Cajanus cajan* L. Mill sp.) is an important pulse crop in the semi-arid tropics firewood [7]. It is most important delicious pulse of the entire country known by more than 350 dialect names, in vernacular *viz.*, red gram, arhar, tur. After gram, arhar is the second most important pulse crop of India, it ranks fourth in importance as edible legume in the world and it has special role in meeting the protein requirement of predominantly vegetarian population and staple diet in most parts of India and is consumed as green peas as well as dry seeds [14] In India pigeonpea ranks second in area and production and contribute about 85 to 90% of the world's pulse production and it is grown on 4.42 million ha with an annual production of 4.23 million tonnes with 552 kg ha-1 productivity. Net daily pulses availability for Indians has increased slightly from 41.9 g per capita in 2012 to 47 g per capita in 2015 (Directorate of Economics and Statistics, Department of Agriculture and Cooperation 2016).

The pigeonpea production in recent years is not able to meet the requirements of growing population necessitating the losses and constraints to be curbed. The crop yields are generally hampered by many pests, which are problematic over years [5]. Major constraint in the production of pigeon pea is the damage caused by insect pests with avoidable losses extending up to 78 per cent in India [7]. Nearly 300 species of insects are known to infest pigeon pea crop at its various growth stages in India although only a few of these cause significant and consistent damage to crop [6]. Among all insects the pod borers have been identified as the major constraints in increasing the productivity of pigeonpea [11] among them legume pod borer, *Maruca vitrata* (Fabricius) (Lepidoptera: Pyralidae) is a serious pest of pigeonpea in tropic and subtropics, because of its extensive host range, destructiveness and distribution on cowpea, mungbean, urdbean and field bean [13]. This is becoming predominant insect pest in recent years in all pigeonpea growing areas of India and particularly in Kalaburagi district of

Karnataka which supplies highest production and this region is well known as Pigeonpea Bowl.

This pest is a single major factor responsible for heavy loss in early and medium late maturing pigeon pea genotypes [12, 13]. In India, The infestation levels range from 9-51 per cent [17] with record of 84 per cent pod borer damage in pigeonpea [3]. They damage flowers causing discoloration and shedding and damaged pods have small darkened entry holes on the surface and borers inside. Many a times leaves, flower buds and flowers are stuck together by webbing with signs of surface feeding resulted no reproductive parts on plants [14]. 70 to 80 per cent yield loss in pigeonpea [15], where as it was 17 – 53 per cent in cowpea [6] and 100 per cent in urd bean [4]. Effective management strategies have to be developed to reduce the losses caused by the pest. From a pest management standpoint, it is very useful to know when and why a pest population suffers high mortality. This is usually the time, when it is the most vulnerable. By knowing such vulnerable stages from life table, we can make time based application of insecticide for the management of insect pests, to conserve the natural parasites and predators and to reduce the environmental pollution. Hence, the present investigation has been carried out to study the *life table studies* of legume pod borer in of pigeonpea under laboratory conditions.

2. Materials and methods

The studies were carried out at Agricultural Research Station, Kalaburagi, during 201*5*-1*6*. The detailed *life table studies were* studied in the laboratory of Walk in Growth chamber, Department of Entomology, Kalaburagi. For conducting life table of *Maruca vitrata* under ambient condition *the* larvae were collected from pigeon pea field and reared in *l*aboratory For the study, 10 pairs of newly emerged adults were kept for egg laying in wooden cages of size 45 × 45 × 60 cm, these adults were maintained on the host plants for two consecutive generations at constant temperature of 26 ± 1 ºC temperature, 60 ± 10 % relative humidity, and 14h: 10h L:D, photoperiod regime were maintained in growth chambers. Fresh and healthy pigeon pea twigs were dipped in conical flasks containing water and exposed for oviposition along with cotton swab dipped with 10 per cent honey solution to serve as food for the adults. In order to construct the life tables, batches of 100 eggs each were collected carefully from the cage with the help of camel hair brush and placed in ten plastic containers (8.0 × 4.5 cm) in ten batches of each. These eggs were kept in petri dishes provided with slightly moistened filter papers and allowed to hatch. From these batches 100 newly emerged larvae were selected and shifted in petri plates with the help of camel hair brush. Each petri plates were provided with artificial diet as a larval food and some population were shifted to the cages containing tender pigeon pea pods. All transferred larvae were checked daily and their moulting to the next stage or mortality were recorded carefully. Observations on hatching, larval development, formation of pupae, successful emergence of adults and fecundity were recorded daily. Age specific mortality in different developmental stages like eggs, larvae, pupae and adults were recorded and appropriate reasons for unsuccessful development were assigned. Larval mortality was recorded by grouping the larvae into three groups, since there was no apparent difference between first and second instar larvae, they were considered as larval phase I. The third and fourth instar larvae were characterized by pair of dark spots in each segments which is dirty white and hence these two instars were considered as larval phase II. The fifth instar larva was creamy white to brownish green and plumy and it was considered as larval phase III.

After the emergences of adults, male and female were separated, ten pairs were released in separate oviposition cages. Adults were provided with special diet that includes water and 10 per cent honey. Small pieces of cotton soaked in the 10 per cent honey were placed in the oviposition cages until the adults die. Dead males were replaced with the new ones.

Fecundity and survival rate of each female were recorded until their death. The intrinsic rate of increase (rm), net reproductive rate (RO) and mean generation time(TC) were basic parameters used to assess the population growth. Stable age-distribution (%distribution of various stages) was also worked out by calculating the population schedule of birth rate and death rate (mx & lx) *and* Corrected rm. Corrected rm (intrinsic rate of natural increase was computed by trial and error method as depicted in Table 4.

2.1 Preparation of life tables

The column headings used in the present study of life table was according to the format suggested by Morris and Miller (1954).

1. x = Stage or age interval at which the sample was taken ; egg, larva and pupa
2. lx = The number surviving at the beginning of the stage stated in the x-column
3. dx = The number dying within the age interval stated in the x – column
4. dxf = The mortality factors responsible for dx
5. 100qx = Percentage mortality (dx as percentage of lx)
6. Sx = Survival rate within the stage mentioned in the x column To calculate ex, two other parameters like Lx and Tx were also computed
7. Lx = Number of individuals alive between age x and x+1
8. Lx = lx+1 (x+1)/2
9. Tx = The total number of individual of x age units beyond the age x
10. Tx = lx + (lx+1) + (lx+2)………..+ lw
11. Here, lw = Last age interval
12. ex = Expectation of life or mean life for individuals of age x, which was calculated by using following equation
13. ex = Tx/lx

3. Results and Discussion

The survival of different life stages of *Maruca vitrata* on pigeonpea diet was found to be 3, 14 and 8 days in egg, larval and pupal stages, respectively. There was 14 per cent mortality in egg stage, whereas mortality during larval and pupal stages was six and two per cent, respectively.*T*he immature stages lasted for *24* days. The pre-oviposition period ranged from *26*thto *2*8th days of pivotal age. The first female mortality within the co-heart occurred on *31*stday (lx=0.74) after the emergence of adult and mortality increased thereafter. The female deposited first batch of egg on 29thday and it was continued up to *35*th days of pivotal age. The maximum mean progenies production (mx)/day was25.24females/female on the 31stday of pivotal age that declined to 2.00 (mx) on *35*th day. The net reproductive rate (RO), representing the total female birth in one generation was 53.641 *(Table 1 and 2).*These findings were contradictory with Chetana [2] and Chaitanya *et al.* [1] they reported that the pre-ovoposition, oviposition and post oviposition period of female moth were 10.66±1.52, 3.56±0.40 and 4.83±1.04 days respectively. Fecundity per female moth on an average about 28.66±7.02 eggs, however per cent hatching of those eggs were about 83.66 ± 5.13.

It is apparent that the intrinsic rate of natural increase in number (Rm) was 0.12females/female/day within finite rate of increase (l) 1.14females/female/day. The population would multiply 2.44times every week. The mean generation time was 31.23 days. The hypothetical female population in F2 generation was 2877.38(Table *3*).

The contribution of different developmental stages towards the stable age, distribution was determine It was observed that on reaching the stable age distribution, the population of *M. vitrata* in its various stages *viz*., eggs, larvae, pupae and adult contributed to the extent at42.92*,* 49.31*,* 5.63 *and* 2.13%respectively, which clearly indicate that immature stages contributed the maximum towards the stable age distribution. A clear insight of the table further illustrate that the population on reaching the stable distribution, the immature stages *viz*., eggs and larvae contributed the highest, whereas it was the lowest by pupae and the adults(Table *5*).

Table 1: Survival of different developmental stages of *Marucavitrata*during 2015-2016

Replications	No. of eggs	Egg stage (0 to 3 days)	Larval stages (4 to 17 days)	Pupal stages (18 to 25 days)
1	10	9	7	7
2	10	9	9	8
3	10	8	9	9
4	10	7	7	7
5	10	8	8	8
6	10	9	8	8
7	10	9	7	7
8	10	9	8	8
9	10	9	8	8
10	10	9	9	8
Total	100	86	80	78

Table 2: Life-table and age specific fecundity of *Maruca Vitrata* during 2015-2016

Pivotal age in days (x)	Survival of at different age interval (lx)	Age schedule for birth at age x (mx)	lx.mx	x.lx.mx
0-25	0.78	-	-	IMMATURE
26	0.78	-	0.78	20.28
27	0.78	-	0.78	21.06
28	0.78	-	0.78	21.84
29	0.78	5.12	3.99	115.81
30	0.78	9.23	7.20	215.98
31	0.74	25.24	18.68	579.01
32	0.70	15.38	10.77	344.51
33	0.68	10.12	6.88	227.09
34	0.65	4.22	2.74	93.26
35	0.52	2.00	1.04	36.40
36	0.20	0.00	0.00	0.00
37	0.15	0.00	0.00	0.00
38	0.12	0.00	0.00	0.00
39	0.10	0.00	0.00	0.00
			$R_0=\sum lx.mx$ = 53.641	$\sum x.lx.mx$= 1675.249

Table 3: Mean length of generation, innate capacity for increase in number and finite rate of increase in number of *Maruca Vitrata* during 2015-2016

Population growth statistics	Formula	Calculated value
Net reproductive rate	$(R_o)= \sum lx.mx$	53.641
Mean length of generation	$(Tc)= \sum x.lx.mx/ R_o$	31.23 days
Innate capacity for increase in number	$(rm)= Log_e R_o/T_c$	0.12 females/female/day
Arbitary 'rm' (rc)	-	0.12 or 0.13
Corrected generation time(T)	$T= log_e R_o/rm$	31.35 days
Finite rate of increase in number	(λ)=antilog e^{rm}	1.14 females/female/day
Weekly multiplication of population	$= (\lambda)^7$	2.44
Hypothetical F_2 females	$= (R_o)^2$	2877.38

Table 4: Intrinsic rate of natural increases (rm) of *Maruca Vitrata* during 2015-2016

S. No	Pivotal age	rm = 0.12			rm = 0.13	
		lx.mx	e^{-7rmx}	$e^{-7rmx.lmx}$	e^{-7rmx}	$e^{-7rmx.lmx}$
1	26	0.78	48.424	37.771	37.338	29.123
2	27	0.78	42.948	33.500	32.786	25.573
3	28	0.78	38.092	29.712	28.789	22.456
4	29	3.9936	33.784	134.921	25.280	100.957
5	30	7.1994	29.964	215.724	22.198	159.812
6	31	18.6776	26.576	496.372	19.492	364.062
7	32	10.766	23.571	253.761	17.116	184.268
8	33	6.8816	20.905	143.862	15.029	103.425
9	34	2.743	18.541	50.859	13.197	36.200
10	35	1.04	16.445	17.102	11.588	12.052
11	36	0	14.585	0.000	10.176	0.000
12	37	0	12.936	0.000	8.935	0.000
13	38	0	11.473	0.000	7.846	0.000
				$\Sigma e^{-7rmx.lmx}$ =1413.583		$\Sigma e^{-7rmx.lmx}$ = 1037.928

Table 5: Age specific distribution of *Maruca Vitrata* during 2015-2016

Pivotal (in days) x	lx	x+1	rm* (x+1)	exp (rm*x+1)	lx (exp (rm*x+1)	% Contribution	
0	1	1	-0.1280	0.8799	0.8799	12.9227	
1	1	2	-0.2560	0.7741	0.7741	11.3701	
2	1	3	-0.3840	0.6811	0.6811	10.0040	
3	0.98	4	-0.5120	0.5993	0.5873	8.6260	42.92
4	0.98	5	-0.6400	0.5273	0.5167	7.5896	
5	0.98	6	-0.7680	0.4639	0.4547	6.6777	
6	0.94	7	-0.8960	0.4082	0.3837	5.6356	
7	0.91	8	-1.0240	0.3592	0.3268	4.8003	
8	0.91	9	-1.1520	0.3160	0.2876	4.2235	
9	0.90	10	-1.2800	0.2780	0.2502	3.6753	
10	0.90	11	-1.4080	0.2446	0.2202	3.2337	
11	0.88	12	-1.5360	0.2152	0.1894	2.7819	
12	0.88	13	-1.6640	0.1894	0.1667	2.4477	
13	0.86	14	-1.7920	0.1666	0.1433	2.1047	
14	0.86	15	-1.9200	0.1466	0.1261	1.8518	
15	0.86	16	-2.0480	0.1290	0.1109	1.6293	
16	0.85	17	-2.1760	0.1135	0.0965	1.4169	
17	0.85	18	-2.3040	0.0999	0.0849	1.2467	49.31
18	0.85	19	-2.432	0.0879	0.0747	1.0969	
19	0.83	20	-2.560	0.0773	0.0642	0.9424	
20	0.83	21	-2.688	0.0680	0.0565	0.8292	
21	0.80	22	-2.816	0.0598	0.0479	0.7032	
22	0.81	23	-2.944	0.0527	0.0427	0.6264	
23	0.81	24	-3.072	0.0463	0.0375	0.5512	
24	0.79	25	-3.200	0.0408	0.0322	0.4730	
25	0.78	26	-3.328	0.0359	0.0280	0.4109	5.63
26	0.78	27	-3.456	0.0316	0.0246	0.3615	
27	0.78	28	-3.584	0.0278	0.0217	0.3181	
28	0.78	29	-3.712	0.0244	0.0191	0.2799	
29	0.78	30	-3.840	0.0215	0.0168	0.2462	
30	0.78	31	-3.968	0.0189	0.0148	0.2166	
31	0.74	32	-4.096	0.0166	0.0123	0.1808	
32	0.70	33	-4.224	0.0146	0.0102	0.1505	
33	0.68	34	-4.352	0.0129	0.0088	0.1286	
34	0.65	35	-4.480	0.0113	0.0074	0.1082	
35	0.52	36	-4.608	0.0100	0.0052	0.0762	
36	0.20	37	-4.736	0.0088	0.0018	0.0258	
37	0.15	38	-4.864	0.0077	0.0012	0.0170	
38	0.12	39	-4.992	0.0068	0.0008	0.0120	
39	0.10	40	-5.120	0.0060	0.0006	0.0088	2.13
				Total	6.8086	100.00	100.00

4. Conclusion

In the present research work, the survival of different life stages of *Maruca vitrata* was found to be 3, 14 and 8 days in egg, larval and pupal stages, respectively the pre oviposition period of *Maruca vitrata* ranged from 26th to 28th day of pivotal age. The first female mortality was observed on 31st day (lx=0.74) after the emergence of adult female and mortality increased thereafter. The female contributed highest births mx/day which was 25.24 females/female in its life cycle on 31st day of pivotal age it declined to 2.00 (mx) on 35th day. The net reproductive rate (RO), representing the total female birth in one generation was 53.64. The stable age distribution of *Maruca vitrata* during 2015-16 of adults contributed only 2.13 per cent to the population of stable age, whereas eggs, larvae and pupae contributed 42.92, 49.31 and 5.63 per cent, respectively.

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