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NS Rode
Department of Agril, Entomology, MGM, NK College of Agriculture, Gandheli, Aurangabad, Maharashtra, India

MF Acharya
Department of Entomology, Junagadh Agricultural University, Junagadh, Gujarat, India

PS Wadaskar
Department of Entomology, Junagadh Agricultural University, Junagadh, Gujarat, India

PM Sangle
Department of Agril, Entomology, RMCA, Navha, Dist. Jalna, Maharashtra, India

Corresponding Author:
NS Rode
Department of Agril, Entomology, MGM, NK College of Agriculture, Gandheli, Aurangabad, Maharashtra, India

Ecological life table of *Earias vittella* on okra under field condition

NS Rode, MF Acharya, PS Wadaskar and PM Sangle

Abstract
Field life table of *Earias vittella* indicated that egg stage contributed 20 per cent mortality mainly due to egg sterility. Younger and older larval group contributed 25.94 and 8.73 per cent mortality, respectively. Viral, bacterial, fungal infection, *Cotesia sp, etc.* was key mortality factors operating under field conditions. The value of generation survival and trend index was found 0.44811 and 0.0166, respectively. In immature stages the maximum mortality was recorded during pupal stage which was recorded 0.1637 value of 'K's while, lest mortality was observed in the older larval group with a 0.0645 'K's value.

Keywords: Life table, *Earias vittella*, okra fruit and shoot borer, etc.

Introduction
Okra is widely grown vegetable crop in India for its immature tender fruits. According to Dhamdhere *et al.* (1984) [2] and Jagtap *et al.* (2007) [5], the crop is attacked by several species of insect pests causing considerable damage. The shoot and fruit borer, *Earias vittella* (Fabricius) is an important insect pest of okra in India, South-East Asia and Africa (Sohi, 1964; Reed, 1974; Saini and Singh, 1999) [14, 10, 11] attacking all the stages of okra. It has been estimated that nearly 40 to 80 per cent loss is caused by this pest only (Samarjit, 1983) [12]. The ecological life table of *E. vittella* for key mortality factor requires a measurement of population density. It will be found to provide good predictability in the analysis of certain long term population data.
Life tables are one of the most important tools in pest management as they reveal the most opportunate periods and vulnerable stages of the insect species. Series of life tables of the pest increase the understanding about pest dynamics and key mortality factors (Reddy *et al*., 2004) [9]. Life tables also provide an important clue on relationship of biotic and abiotic environmental factors and their role in fluctuation of the population as well as relative contribution of immature stage of the population of pests species. Life table is to gain understanding and valuable insight regarding the mortality and development, so that it enables us to devise an intelligent and practical manipulation of control factors for sound pest management strategy, therefore present investigation was undertaken.

Materials and Methods
To study the life table of okra fruit and shoot borer, *E. vittella* on okra, variety Gujarat Okra- 2 was sown at Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. The crop was grown in plot size of 20 m x 20 m keeping 60 cm x 30 cm spacing between row to row and plant to plant. All the agronomical operations were adopted as per the recommendations.

Sampling procedure
As the generations are overlapping and not distinct, the ecological life table was prepared for the season instead of the generation of the pest. The size of sample quadrate was 1 m×1 m for the crop. A total of 20 quadrates were maintained in the area of 20 m x 20 m.

Stage sampled
The younger larvae (I and II instars) and older or grown up larvae (III to V instars) was collected at fortnight interval from the 20 quadrate. The observations were continued till the harvest of the crop.

Mode of observations
The larvae collected at weekly interval were reared in the laboratory on okra till the adult emergence. The extent of larval and pupal parasitism and the mortality due to biotic factors was noted in different instars.

Construction of life table
The column heading, which was used for the construction of the life tables in the present study, those proposed by Morris and Miller (1954) [7] and Harcourt (1969) [4] are as under:

x	=	The age interval of egg, larva, pupa or adult
lx	=	Number surviving at the beginning of each interval x
dx	=	Number dying individuals during the age interval x
dxf	=	The mortality factor responsible for 'dx'
100qx	=	Per cent mortality
sx	=	Survival rate within the age mentioned in the 'x' column

Criteria for filling the columns of life table
The method and criteria suggested by Harcourt (1963) [3] and Atwal and Bains (1974) [1] for computing and filling the data in life table for different age intervals (stages) was followed in the present study. Procedure for computing the various columns are described below:

Eggs
The 'lx' for eggs was derived indirectly on the basis of laboratory fecundity of *E. vittella* on okra. Mortality of eggs was determined on the basis of 500 field collected eggs and the 'dx' value will be worked out.

Younger larvae
The larval group was formed by the first and second instar larvae. The 'lx' for these groups was worked out by direct sampling of the quadrates.

Older larvae
The 'lx' for grown up larvae (III to V instars) was worked out by subtracting the mortality due to parasites, viral diseases and unknown factors from younger larvae.

Pupae
The 'lx' was derived after deducting the mortality due to parasites, viral diseases and unknown causes from the population of older larvae.

Moths
The 'lx' was worked out on the basis of number of adults emerged from the pupae. Mortality in the pupal stage due to parasites and unknown causes was deducted from 'lx' of pupae.
Females x 2 was the percentage of females applied to 'lx' for moths. The data were doubled to maintain the balance in the life table.

Trend index (I)
The value of 'I' was computed by taking the 'lx' for young larvae in the new season expressed as the ratio of old.

Generation survival (SG)
This is the index of population trend without effect of fecundity. The index was worked out as a ratio of number of females x 2 (N_3) to younger larvae (N_1) i.e. N_3/N_1.

Analysis of causes of fluctuations of population and identification of key mortality factors
As the mortality factors cause population fluctuation, separate budgets will be worked out to determine the key mortality factor (K) that influenced the population trend on the crop. The method suggested by Varley and Gradwell (1963) [16] was followed to find out density relationship of mortality factors. Similarly, the value of killing power (K) of each mortality factor or the group of mortality factors in different age groups also be worked out by taking the difference between the logarithms of population density before and after its action. The total killing power (K) computed by taking the sum of killing power of K's.

Results and Discussion
Field life table of *E. vittella* was constructed by counting absolute larval population at weekly interval. The results obtained are presented in table 1 and 2 indicated, that there was natural and sequential mortality in field population during the crop season. Egg stage of *E. vittella* contributed 20 per cent mortality mainly due to egg sterility. Younger larval group contributed 25.94 per cent mortality. The reasons behind this mortality were viral infection (18.50%), bacterial infection (2.24%) and due to unknown reasons (5.20%). Whereas older larval group contributed 8.73 per cent mortality mainly due to viral infection (1.88%), bacterial infection (1.02%), fungal infection (1.63%), parasitoids like *Cotesia* sp. (0.16%) and due to unknown reasons (4.04%). During pupal stage, non emergence, development of malformed adults and unknown reasons are the main mortality factors operating under field conditions. The mortality in pupal stage was mainly due to non emergence, contributed around 9.20 per cent. Development of malformed adults contributed around 8.29 per cent mortality and unknown reasons contributed around 3.03 per cent mortality. The value of generation survival (SG) and trend index (I) also worked out which found 0.44811 and 0.0166, respectively. The positive value of the trend index indicated that the mortality factors operating during this period were not effective in suppressing the pest population in succeeding generations.
Key factor analysis data (Table 1 and 2) clearly indicated that in immature stages the maximum mortality was occurred during pupal stage as it recorded highest value of 'K's (0.1637) followed by younger larval group (0.1304) and lest mortality was observed in the older larval group with a 0.0645 'K's value. It is also observed that among the different mortality factor larval disease (viral, bacterial and fungal infection) cause maximum mortality in both larval groups. The mortality in younger larval group was attributed mainly due to viral infection, bacterial infection and unknown reasons to the tune of 0.08885, 0.01212 and 0.02946, respectively. The mortality in older group was mainly due to viral infection (0.01119) bacterial infection (0.00616), fungal infection (0.01007), parasitoid like *Cotesia* sp. (0.00108) and due to unknown reasons (0.03603). Whereas, the mortality during pupal stage was attributed due to non emergence, development of malformed adults and unknown reasons. The 'k' values of these factors were 0.06592, 0.07372 and 0.02409, respectively. Thus, the data further revealed that among the different life stages of the pest, the maximum population declined in larval stage.

Mohapatra (2007) [6] revealed that during vegetative and early flowering stage of the crop 19 to 42 per cent mortality was recorded in the egg stage. Further, he reported 37 to 77 per cent mortality in the population of larvae due to unknown factors and parasitoid. Satpute *et al.* (2005) [13] reported that sixty five per cent survived between egg and adult stage. The present reports of key mortality factors of *E. vittella* are in partial agreement with the earlier results of Nanthagopal and Uthamsamy (1989) [8] and Suryawanshi *et al.* (2001) [15]. As the abiotic factors and key mortality factors prevailing in area are different or may their species, biotypes, races, *etc.* are different.

Table 1: Field life table of *E. vittella* on okra during *kharif*

Age Interval	No of alive/ha	Factor Responsible for dx	No of Dying during X	Mortality Per Cent	Survival Within X
X	**Lx**	**Dfx**	**Dx**	**100qx**	**sx**
Younger Larvae (N1)	21200				
I and II Instrar larvae		Viral Infection	3922.45	18.50	0.74057
		Bacterial Infection	475.48	2.24	
		Un known factors	1102.08	5.20	
		Total	5500.01	25.94	
Older Larvae	15700				
II and IV instar larvae		**Disease**			0.88217
		Viral Infection	399.22	1.88	
		Bacterial Infection	215.33	1.02	
		Fungal infection	345.65	1.63	
		Un known factors	855.45	4.04	
		Parasitoids			
		Cotesia sp	34.35	0.16	
		Total	1850.00	8.73	
Pupae	13850				
		Non Emergence	1950.45	9.20	0.68592
		Un known factors/ parasitization by unidentified parasite	642.12	3.03	
		Development of Malformed adults	1757.43	8.29	
		Total	4350.00	20.52	
Moths	9499.99				1
Femalesx2 (N3)	9499.99				1
Normal Females X 2	9499.99				1
Generation total	19000.00			55.19	
Expected Eggs		=	$(N_3/2)$ x Fecundity		712499.00
No of Dead/ Strile Eggs		=			142499.90
Viable Eggs		=			569999.00
Expected No of Younger larvae		=			569999.00
Actual No of Younger larvae (N2)		=			352.00
Trend Index		=	N_2/N_1		0.0166
Generation Survival (SG)		=	N_3/N_1		0.44811

Table 2: Budget of *E. vittella* for *kharif* season on okra

Age Interval	No/ha	Log/ha	K's
Actual No of Young larvae	21200.00	4.3263	
After Mortality Due to			
Viral Infection	17277.55	4.2375	0.08885
Bacterial Infection	16802.07	4.2254	0.01212
Un known factors	15699.99	4.1959	0.02946
III and IV instar larvae	15699.99		
			0.1304
Disease			
Viral Infection	15300.77	4.1847	0.01119
Bacterial Infection	15085.44	4.1786	0.00616
Fungal Infection	14739.79	4.1685	0.01007
Un known factors	13884.34	4.1425	0.03603
Parasitoids			
Cotesia sp	13849.99	4.1414	0.00108
			0.0645
Pupae	13849.99		
Non Emergence	11899.54	4.0755	0.06592
Un known factors/ parasitization by unidentified parasite	11257.42	4.0514	0.02409
Development of Malformed adults	9499.99	3.9777	0.07372
			0.1637
Adults	9499.99	3.9777	
Reproducing Females	4750.00	3.6767	0.30103
K- value			0.66

Conclusion

Egg stage of *E. vittella* contributed 20 per cent mortality mainly due to egg sterility. Younger larval group contributed 25.94 per cent mortality. The reasons behind this mortality were viral infection, bacterial infection and unknown reasons. Whereas older larval group contributed 8.73 per cent mortality mainly due to viral infection, bacterial infection, fungal infection parasitoids like *Cotesia* sp. *etc*. During pupal stage, non emergence and development of malformed adults are the main mortality factors operating under field conditions. The mortality in pupal stage was mainly due to non emergence. Development of malformed adults contributed around 8.29 per cent mortality. Key factor analysis data clearly indicated that in immature stages the maximum mortality was occurred during pupal followed by younger larval group and lest mortality was observed in the older larval group.

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