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Field life table studies of *Helicoverpa armigera* (Hubner) infesting chickpea in Saurashtra conditions, Gujarat, India

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Abstract
Field life table studies of *Helicoverpa armigera* (H.) infesting chickpea were undertaken during 2016-17 at Department of Entomology, Junagadh Agricultural University, Gujarat. Field life table of *H. armigera* on chickpea constructed under field condition to determine the key mortality factors indicated that the mortality in younger group larvae, older group larvae, pupal stage and deformities in the adult stage were 0.57%, 28.75%, 4.83% and 1.68%, respectively. In older group larvae the highest mortality was due to two key mortality factors *viz.*, NPV (16.43%) and *Tachinid* fly (7.56%). Generation survival (SG) was found to be 0.66 and value of the trend index (I) was calculated to the tune of 0.012. 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.

Keywords: field life table, helicoverpa armigera, chickpea

Introduction
Chickpea is the most important crop with high acceptability and wider use. In India, the area under chickpea is 8.35 million hectares with a production of 7.17 million tonnes with productivity of 859 kg/ha during *rabi*, 2015-16 (Anonymous, 2017) [1] and incase of gujarat, area under chickpea was 0.12 million hectares with total production of 0.15 million tonnes and productivity of 1330 kg/ha during *rabi,* 2015-16 (Anonymous, 2017) [1]. The production of cereals has increased manifold in the recent past but that of pulses has remained more or less static. *H. armigera* is widely distributed throughout the world by menacing due to its polyphagous feeding (a typical of noctuidae).The young larvae feed on the buds, flowers and pods of pigeon pea, Chickpea, tomato, sunflower etc. due to that the aim of study was that the life-table was a table of statistics of probability of life. It provides essential information regarding the schedule of mortality for a known cohort of individuals. A life table was a kind of book- keeping system that ecologists often used to keep track of stage specific mortality in the population they study. A life describes for successive age intervals, the number of deaths, the survivors, the rate of mortality and the expectation of further life. They are one of the most useful tools in the study of insect population dynamics. These tables record a series of sequential measurements that reveal population change throughout the life cycle of a species in its natural environment. When these measurements are related to the several causes of mortality, the life-table forms a budget of successive processes that operate in a given population (Harcourt, 1969) [8].

Materials and Methods
The present investigations on field life table of *Helicoverpa armigera* (Hub.) infesting chickpea were carried out during 2016-17 at Department of Entomology, Junagadh Agricultural University, Gujarat.

Sampling procedure
The population study was conducted at Instructional farm, Department of Agronomy for collection of natural population of the pest, while rest of the research work was carried out at, Department of Entomology, College of Agriculture, JAU, Junagadh. As the pest was polyphagous, it’s having overlapping generations instead of distinct generations. Hence, the life table was prepared for the season instead of generation. The pest was sampled from the ten

quadrates (1 m x 1 m) at weekly interval and then it was computed on hectare basis.

Stage sampled
Since the generations were overlapping and the pest also surviving in other crops, the eggs could not be collected from the field. Thus, the younger larvae (I and II instar) and older or grown up larvae (III to V or VI instar) were collected at weekly interval from the 10 quadrate.

Mode of observations
The larvae collected at weekly interval were reared in the laboratory on chickpea 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, used for the construction of the life tables in the present study, were those proposed by Morris and Miller (1954) [10] and Harcourt (1969) [8] are as under:

Column Heading	Denotion
X=	The age interval, egg, larva, pupa or adult
Lx=	The number surviving at the beginning of stage noted in the 'x' column
Dx=	The number dying within age interval stated in the 'x' column
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) [7] and Atwal and Bains (1974) [1] for computing and filling the data in life table for different age intervals (stages) were 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 by *H. armigera* on chickpea. Mortality of eggs was determined on the basis of 500 laboratory collected eggs and 'dx' value was 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 quadrate and computed on hectare basis.

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

Pupae
The 'lx' was derived after deducting the mortality due to parasitoids, virus 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 parasitoids and unknown causes was deducted from 'lx' of pupae.

Females x 2 were 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 budget was 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) [15] was followed to find out the 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 was also worked out by taking the difference between the logarithms of population density before and after its action. The total killing power (K) was computed by taking the sum of killing power of K's.

$$K = k0 + k1 + k2 \ldots kn$$

Where, k0, k1, k2,kn were the k-values at egg, first instar, second instar, third instar, fourth instar, pupal stages.

Results and Discussion
Field life table was constructed to understand the role of various mortality factors of *H. armigera*. The investigations were carried out under field as well as laboratory condition during the year 2016-17 on chickpea crop at College of Agriculture, Junagadh. Life table and budget were also worked out to find out the key mortality factors that influence the population of this pest.
Field life table of *H. armigera* on chickpea was constructed by counting the absolute larval population at weekly interval. The data for life table of *H. armigera* on chickpea are given in the Table 1 and 2, which showed natural and sequential mortality in the field population during the crop season. The per cent mortality in the eggs contributed around 20%, which was mainly due to sterility. Larval mortality was recorded by grouping the larvae into two group, younger larval group (I and II instar) and older group (III to VI instar).
The results (Table-1) revealed that there were 0.57 and 28.75 per cent mortality in the younger and older larval groups, respectively. The results further revealed that the mortality in the younger group larvae was mainly due to bacterial infection and unknown factors. The larval population of older group declined by 28.75 per cent owing to different diseases *viz*., NPV (16.34), *N. riley* (0.62), *B. bassiana* (2.98), parasitoids like *Bracon* spp. (0.53) and *Tachinid* maggot (7.56). The present findings are in conformity with the results obtained by Bhatnagar *et al*., (1982) [3] recorded the parasites attacking *H. armigera* on sorghum in a sorghum/pigeonpea intercrop (mainly *Trichogramma sp.* and *Campoletis chlorideae*) did not parasitize *H. armigera* on the later maturing pigeonpea, where parasitism was chiefly by the *Tachinid*.

During pupal stage, unknown diseases and unknown factors were the major mortality factors operating under field condition. The mortality in pupal stage was mainly due to unknown diseases, contributed around 3.40 and unknown reasons contributed around 1.43 per cent mortality. Generation survival (SG) was worked out and it was found 0.66. Value of trend index (I) was calculated to the tune of 0.012. 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.

Table 1: Key mortality factors of *H. armigera* on chickpea during *rabi,* 2016-17

Age interval n(x)	No. alive/ha (lx)	Factors responsible for dx (Dxf)	No. dying during x (dx)	Mortality per cent (100qx)	Survival within s (Sx)
Younger group larvae (N_1)	21840				
1st and 2nd instars larvae		Unknown reasons	67	0.31	1.0
		Bacterial infections	57	0.26	
		Total	124	**0.57**	
Older group larvae	21716				
3rd to 6th instars larvae		**Diseases**			0.71
		NPV	3568	16.43	
		N. rileyi	135	0.62	
		B. bassiana	648	2.98	
		Unknown factors	76	0.35	
		Parasitoids			
		Tachinid maggot	1642	7.56	
		Bracon spp.	116	0.53	
		Unknown factors	58	0.27	
		Total	6243	28.75	
Pupae	15473				
		Unknown disease	526	3.40	0.95
		Unknown reasons	221	1.43	
		Total	747	4.83	
Moths	14726				
		Deformed adults	247	1.68	0.98
		Total	247	1.68	
Females x 2	14479	**(Reproducing Females- 7239.5)**			
Normal females x 2 (N_3)	14479				1.0
Generation total	7361			35.82	

Expected eggs [(N_3/2) x Fecundity]	1882270
No of dead/ sterile eggs	376454
Viable eggs	1505816
Expected number of younger larvae	1505816
Actual number of younger larvae (N_2)	260
Trend index (N_2/ N_1)	0.012
Generation survival (SG= N_3/ N_1)	0.66

Table 2: Budget for *H. armigera* on chickpea

Age interval	No./ ha	Log No. / ha	K's
Actual no of younger larvae	**21840**	**4.3393**	
After mortality due to			
Unknown factors	21773	4.3379	0.0013
Bacterial infections	21716	4.3368	0.0025
	Total		0.0038
Older group larvae	21716	4.3368	
After mortality due to			
Diseases	17289	4.2378	0.0990
Parasitoids	15473	4.1896	0.1472
	Total		0.2462
Pupae	15473	4.1896	
After mortality due to			
Unknown diseases	14947	4.1746	0.0150
Unknown reasons	14726	4.1681	0.0215
	Total		0.0365
Moth (Adult)	14726	4.1681	
Deformed adults	14479	4.1607	0.0073
	Total		0.0073
Reproducing females	7239.5	3.8597	0.3010
	Total		0.3010
		K's =	0.5876

Results of key factor (Table 1 and 2) revealed that maximum mortality was occurred in the older group larvae as the highest value of 'k' was obtained for this group. It was also observed that among the different mortality factors Parasitoids (*Tachinid* maggot, *Bracon* spp., Unknown factors) caused the maximum mortality (k= 0.1472). In addition to parasitoids, diseases had also played an important role in causing the mortality. Mortality in the pupal stage was attributed due to unknown disease and unknown reasons. The 'k' values of these factors were 0.0150 and 0.0215, respectively.

Thus, the data revealed that among the different life stages of the pest, the maximum population was declined in larval stage as the 'k' value for this stage was to the tune of 0.2462.

The present findings are more or less similar with Solsoloy *et al*. (2004) [13], Sugawe and Bilapate (2007) [14] and Bisane *et al*. (2009). The pupal mortality was due to undefined disease and unknown cause, this inference was apparently supported by Paras and Rakesh (1999). Younger larval stages and pupal stage indicated higher survival fraction and older larval stages suffered higher key mortality factor, which was in conformity with the studies conducted by Khande *et al*. (2009) [9] and Rummana *et al*. (2012) [12]. The most vulnerable suppression was due *Tachinid* fly (7.56%) and NPV (16.43%) in older group larvae was in conformity with Bisane and Deotale (2008) [4] and Bisane *et al*. (2009) [6].

Conclusion

Ecological life table of *H. armigera* on chickpea were constructed under lab as well as field condition to determine the key mortality factors. The data indicated that various factors like bacterial infection and unknown reasons in the younger group larvae, diseases caused by NPV, *N. rileyi* and *B. bassiana* and parasitoids like *Bracon* spp. and *Tachinid* maggot in the older group larvae, unknown diseases and unknown reasons in the pupal stage and deformities in the adult stage were found to be the most effective in reducing the pest population.

Results reveal that mortality in the younger group larvae was 0.57 per cent, older group larvae was 28.75 per cent, pupal stage was 4.83 per cent and deformities in the adult stage was 1.68 per cent. Generation survival (SG) was worked out and it was found to be 0.66. Value of trend index (I) were calculated to the tune of 0.012. 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.

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