Life Table Studies of *Helicoverpa armigera* (Hubner) on Chickpea

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SUMMARY

Life tables to assess the key mortality factors of *Helicoverpa armigera* were prepared on chickpea and artificial diet during 2004-05 and 2005-06. In life table of field collected life stages, egg unviability of 14.55% was found. Whereas in early instar larvae, 34.55% mortality was noticed, in which highest 14.89% parasitization reported due to *Eriborus argenteopilosus* Cameron and 8.94% by *Campoletis chlorideae* Uchida. In late instar and pre-pupal larvae, tachinid fly activity was highest recorded 3.73 and 6.31% parasitism, respectively. Moreover, HaNPV disease infection of 0.60 and 0.41% was observed in early and late instar larvae, respectively. Pupal stage was the most vulnerable stage than other stages and showed suppression of 35.16%, in which tachinid fly recorded the maximum 13.19% parasitization. Life table from field collected eggs revealed highest 13.47 and 13.06 per cent unviability in eggs over other stages on chickpea and artificial diet, respectively. Similarly, in life table of laboratory obtained culture eggs on chickpea and artificial diet, egg stage showed maximum population reduction of 10.00 and 11.11%, respectively over stages. After egg mortality, higher reduction found in the first instar larvae and pupae. The generation survival of *H. armigera* was superior on artificial diet than chickpea.

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Chickpea (*Cicer arietinum* L.) is an important *rabi* season pulse crop of India occupying about 6.93 million ha with average productivity of 808 kg/ha (Anonymous, 2006). Of various insect pests of chickpea, gram pod borer, *Helicoverpa armigera* (Hubner) poses a serious problem for chickpea growers and is a limiting factor in its production. A reduction in yield ranging from 40-50 per cent has been reported and may cause even total loss of the crop (Rai *et al.*, 2003). Till recently, chemical pesticides have been used for controlling *H. armigera*, but despite such a use, the pest could not be brought under control and causing harmful effect on beneficial organisms and thus responsible for ecological disturbances.

Life tables are the most important tools in the pest management, which reveal the most opportune periods and vulnerable stage of the insects in the life cycle. Such ecological life tables record a series of sequential measurements that indicate population changes throughout the life cycle of a species in its natural environment (Harcourt, 1969). Hence, an attempt had been made at Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2004-05 and 2005-06 to study the population fluctuations through life tables for identifying vital clues of population changes to be used for formulating suitable integrated management strategy under field conditions.

MATERIALS AND METHODS

Field collected life stages:

Life tables of field collected population for monitoring biotic key mortality factors of *H. armigera* were studied on chickpea (variety-ICCV-2) during two consecutive years of 2004-05 and 2005-06. Different life stages of *H. armigera* were collected from an unsprayed field of chickpea crop cultivated on a 500 sq. m. plot at Central Research Farm and reared under laboratory condition of Department of Entomology, Dr. PDKV, Akola. To record the parasitism of *H. armigera*, collection of eggs, early instar (I-III) and late instar (IV and V) larvae on chickpea were initiated with appearance of pest. For pupal study, the pre-pupal larvae were collected as soon as they appeared in field, reared till pupation, provided with sterilized soil and observation were recorded on pre-pupae, pupae and adult. The sampling of larvae was done at 7 days interval per 25 plants and reared individually in small plastic vials to avoid cannibalism. The collected larval groups were reared on chickpea pods and the food was changed regularly as and when required until pupation of pest or parasitoids observed. Similarly, pupae were kept till pest adult emergence of or parasitoids emerged. The observations on total mortality and survival as well as parasitization due to different parasitoids were recorded, separately.

The absolute population per acre was computed by multiplying pest population during season and plant population per acre of crop for preparing the life table of field collected life stages on chickpea and pooled results of 2004-05 and 2005-06 were discussed.

Field collected and laboratory culture eggs:

Life tables for field collected and laboratory culture egg population of *H. armigera* were also studied on chickpea to check the difference in the activity of parasitoids in field collected life stages and eggs stages obtained direct from field and laboratory. Known number of eggs were collected from unsprayed chickpea as well as laboratory reared culture eggs were obtained for constructing life tables. These eggs were classified into two groups, one group was reared on natural host *i.e.* chickpea and second group on artificial diet (Armes *et al.*, 1992) to test the host influence on mortality. The observations were recorded during each stage and each larval instar for mortality, survival and key mortality factors during life period by rearing them separately. From these data, life tables of *H. armigera* were constructed on chickpea and artificial diet.

The data were tabulated for collected population of various stages and the mortality occurring in each stage under the following headings (Harcourt, 1969 and Atwal and Bains, 1974).

x = Age interval
lx = No. of individuals alive at the beginning of age interval, x
dx = No. of individuals die during age interval,x
dxF = Mortality factor responsible for dx
100qx = Per cent mortality during x
Sx = Survival rate within x.

Generation survival (SG) was an index of population trend without the effect of fecundity and adult mortality.

$$\text{Generation Survival (SG)} = \frac{N_2}{N_1}$$

where,

N_2 = Population of adults in a generation
N_1 = Population of eggs in the same generation.

Separate budget was prepared to find out the key mortality factors that have influenced the population trend in different seasons. The method of key factor analysis developed by Varley and Gradwell (1960) was used to detect density relationship of mortality factors.

RESULTS AND DISCUSSION

Field collected life stages:

Life table of *H. armigera* was constructed on chickpea summarized in Table 1. Absolute population

Table 1: Life table of *H. armigera* on chickpea for field collected population (Pooled of 2004-05 and 2005-06)

Age interval	No. alive at the beginning of x	Factor responsible for dx	No. dying during	Mortality per cent	Survival rate within x	Log No./acre	'k' value
x	lx	d x F	dx	100qx	Sx		
Eggs (N1)	1,48,66,630	Unviability	21,33,328	14.35	0.86	7.1722	--
Early instar larvae (I-III	1,27,33,302	*E. argenteopilosus*	18,96,395	14.89	0.65	7.1049	0.0673
instar)		*C. chlorideae*	11,37,837	8.94			
		HaNPV	76,120	0.60			
		Unknown	12,89,637	10.13			
		Total =	43,99,989	34.55			
Late instar larvae (IV	83,33,313	Tachinid fly	3,11,079	3.73	0.89	6.9208	0.1841
and V instar)		HaNPV	34,533	0.41			
		Incomplete pupation	1,38,320	1.66			
		Unknown	4,49,399	5.39			
		Total =	9,33,331	11.20			
Pre-pupal larvae	73,99,982	Tachinid fly	4,66,666	6.31	0.82	6.8692	0.0516
		Incomplete pupation	2,66,666	3.60			
		Unknown	5,99,999	8.11			
		Total =	13,33,331	18.02			
Pupae	60,66,652	Tachinid fly	7,99,998	13.19	0.65	6.7829	0.0863
		Adults not to emerged	7,33,338	12.09			
		Pupal deformity	4,66,346	7.69			
		Unsuccessful emergence	1,33,546	2.20			
		Total =	21,33,328	35.16			
Moths	39,33,324	Sex 50% female				6.5948	0.1881
Females x 2 (N2)	39,33,324						
Reproducing female	19,66,662					5.2937	0.3011
Generation survival (N2/N1) = 0.26						K =	0.8755

revealed 14.35% egg unviability as well as 34.55 and 11.20% mortality caused in early and late instar larvae, respectively. The parasitization of early larval instar was reported due to *Eriborus argenteopilosus* Cameron (14.89%) and *Campoletis chlorideae* Uchida (8.94%) and accounted more than half of the larval mortality. Also, the disease mortality by HaNPV was 0.60% in early instar larvae. The mortality due to unknown reason was found to an extent of 10.13%. In late instar larvae, tachinid fly (Diptera: Tachinidae) was major parasitoid recorded 3.73% parasitization, whereas, HaNPV showed 0.41% disease larvae. The larval death due to incomplete pupation and unknown reason was 1.66 and 5.39%, respectively. The pre-pupae larval death was higher than bigger group larvae recorded 18.02% reduction, where tachinid fly parasitized 6.31% pre-pupae.

The population loss of the pupae to 35.16% estimated on chickpea highest over other stages in pooled data. Tachinid fly was effective parasitoid influenced pupal population reduction up to 13.19%. The pupal mortality resulted due to failure of pupae to complete development (adult not emerged) was 12.09%. Pupal deformity was 7.69% and unsuccessful adult emergence of 2.20% was observed in pupal stage. The generation survival of *H. armigera* on chickpea was 0.26.

It is evident from the budget of key mortality factors (Table 1) that the highest mortality in pooled result occurred in the pupal stage (k=0.1881), followed by early instar larvae (k=0.1841).

The activity of *E. argenteopilosus* and *C. chlorideae* on early instar larvae and tachinid fly (*Goniophthalmus halli* Mensi) on pupae reported in life table of *H. armigera* was comparable with the results of Bilapate (1981). Further, Bilapate *et al.* (1988) further, found pre-pupal mortality due to unknown reason, which is also similar with the present observations. However, Jat *et al*. (2003) observed the highest per cent mortality in small and big larvae in life table study and Reddy *et al.* (2004) stated that the early instar larvae were more vulnerable to natural mortality during life table study, which confirms the present findings.

Field collected and laboratory culture egg:

The life table of *H. armigera* from field collected eggs was studied till adult emergence under laboratory condition (Table 2). The highest mortality of 13.47 and 13.06% was observed in egg stage on chickpea and artificial diet, respectively. The pupal mortality accounted

Table 2: Life table of *H. armigera* on chickpea and artificial diet for field collected eggs (Pooled of 2004-05 and 2005-06)

Age interval	No. alive at the beginning of x		Factor responsible for dx	No. dying during x		Mortality per cent		Survival rate at age x		Log No.		'k' value	
x	lx		dxF	dx		100qx		Sx					
	N.H.	A.D.		N.H.	A.D.	N.H.	A.D.	N.H.	A.D.	N.H.	A.D.	N.H.	A.D.
Eggs (N1)	122.5	122.5	Unviability	16.5	16	13.47	13.06	0.87	0.87	2.0881	2.0881	--	--
I instar	106	106.5	Unknown	10	9.5	9.43	8.92	0.91	0.91	2.0253	2.0273	0.0628	0.0608
II instar	96	97	Unknown	7.5	4.5	7.81	4.64	0.92	0.95	1.9823	1.9868	0.0430	0.0406
III instar	88.5	92.5	Unknown	4	4	4.52	4.32	0.95	0.96	1.9469	1.9661	0.0353	0.0206
IV instar	84.5	88.5	Unknown	3	2.5	3.55	2.82	0.96	0.97	1.9269	1.9469	0.0201	0.0192
V instar	81.5	86	Unknown	2.5	1.5	3.07	1.74	0.97	0.98	1.9112	1.9345	0.0157	0.0124
			Unknown	3	2	3.80	2.37						
Pre-pupal larvae	79	84.5	Incomplete pupation	-	1.5	-	1.77	0.96	0.96	1.8976	1.9269	0.0135	0.0076
			Total =	3	3.5	3.80	4.14						
			Adults not emerged	6.5	4.5	8.55	5.56						
			Pupal deformity	1	1	0.66	1.23						
Pupae	76	81	Unsuccessful emergence	0.5	-	0.66	-	0.90	0.93	1.8808	1.9085	0.0168	0.0184
			Total =	8.0	5.5	9.87	6.79						
Adult	68.5	75.5	Deformed adults	2.5		3.65		0.96	0.95	1.8357	1.8779	0.0451	0.0305
Normal adult (N2)	66	71.5								1.8195	1.8543	0.0161	0.0236
											K =	0.2686	0.2338

N.H. = Generation survival (SG) = N2/N1 = 0.54

A.D. = Generation survival (SG) = N2/N1 = 0.58

Note: N.H. = Natural host (Chickpea) A.D. = Artificial diet

Table 3: Life table of *H. armigera* on chickpea and artificial diet for laboratory culture eggs (Pooled of 2004-05 and 2005-06)

Age interval	No. alive at the beginning of x		Factor responsible for dx	No. dying during x		Mortality per cent		Survival rate at age x		Log No.		'k' value	
x	lx		dxF	dx		100qx		Sx					
	N.H.	A.D.		N.H.	A.D.	N.H.	A.D.	N.H.	A.D.	N.H.	A.D.	N.H.	A.D.
Eggs (N1)	135	135	Unviability	13.5	15	10.00	11.11	0.90	0.89	2.1303	2.1303	--	--
I instar	121.5	120	Unknown	11.5	9	9.47	7.50	0.91	0.93	2.0846	2.0792	0.0458	0.0512
II instar	110	111	Unknown	8.5	6	7.73	5.41	0.92	0.95	2.0414	2.0453	0.0432	0.0339
III instar	101.5	105	Unknown	5	4.5	4.93	4.29	0.95	0.96	2.0065	2.0212	0.0349	0.0241
IV instar	96.5	100.5	Unknown	3	3	3.11	2.99	0.97	0.97	1.9845	2.0022	0.0219	0.0190
V instar	93.5	97.5	Unknown	3	2.5	3.21	2.56	0.97	0.97	1.9708	1.9890	0.0137	0.0132
Pre-pupal	90.5	95	Unknown	3	2.5	3.32	2.63	0.96	0.97	1.9566	1.9777	0.0142	0.0113
larvae			Incomplete pupation	0.5	--	0.55	--						
			Total =	3.5	2.5	3.87	2.63						
Pupae	87	92.5	Adults not emerged	5	4	5.75	4.33	0.93	0.95	1.9395	1.9661	0.0171	0.0116
			Pupal deformity	1	1	1.15	1.08						
			Total =	6	5	6.90	5.41						
Adult	81	87.5	Deformed adults	4	4	4.94	4.57	0.95	0.95	1.9085	1.9420	0.0310	0.0241
Normal	77	83.5								1.8865	1.9217	0.0220	0.0203
adult (N2)													
K =												0.2438	0.2086

N.H. = Generation survival (SG) = N2/N1 = 0.57

A.D. = Generation survival (SG) = N2/N1 = 0.62

Note: N.H. = Natural host (Chickpea) A.D. = Artificial diet

higher reduction on chickpea (9.87%) and first larval stage on artificial diet (8.92%) after egg stage. Fifth larval instar estimated the maximum survival both on chickpea (0.97) and artificial diet (0.98). The higher generation survival of 0.58 was seen on artificial diet over chickpea (0.54). The age-specific key mortality was highest in egg stage as 'k' value *i.e.* 0.0628, followed by pupal stage (k=0.0451) on chickpea, while it was also maximum 0.0608 in egg stage on artificial diet, followed by first instar larvae.

The laboratory culture eggs were reared on chickpea and artificial diet till adult emergence and life table were prepared on respective hosts (Table 3). The egg stage on chickpea reported highest mortality of 10.00% over other stages, followed by first instar larvae (9.47%) and second instar larvae (7.73%). Similarly, on artificial diet, egg stage showed the maximum mortality of 11.11%, followed by first instar larvae (7.50%), second and pupal stage of 5.41% by each. The late larval stage showed the maximum population survival on both hosts. The generation survival was more on artificial diet (0.62) than chickpea (0.57). Mortality due to parasitoid was not recorded in life table of both egg population studies. The budget of key mortality indicated that egg stage was more vulnerable on chickpea recorded high 'k' value of 0.0458 on chickpea and 0.0512 on artificial diet, followed by first instar larvae on both hosts.

The results on life table were reported by Nanthagopal and Uthamasamy (1989) and Singh and Mullick (1997) stated that the loss in population in life table during the first instar larvae of *H. armigera* was significantly high and unknown reasons were the key factor in population regulation, which is comparable with present findings.

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