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Studies on age specific fecundity life tables for *Helicoverpa armigera* Hub., on sunflower (*Helianthus annuus* L.)

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Abstract
The objective of the study on life fecundity tables of *Helicoverpa armigera* Hub., reared on Sunflower (*Helianthus annuus* L.) cv. KBSH-44 under controlled condition 26 ± 1 °C. The data revealed that the survival of different life stages of *H. armigera* on sunflower was found to be 3, 20 and 10 days in egg, larval and pupal stages, respectively. The number that survived from egg to adult emergence was 77 individuals. The pre-oviposition period of *H. armigera* ranged from 36th to 39th day of pivotal age. The maximum mean progeny production by female (mx) per day was 89.17 females per female in the life cycle on the 43rd day of pivotal age that declined to 9.15 females per female (mx) per day on 48th day. The net reproductive rate (R_o) was 281.011 with mean length of generation (T) was 41.40 days. The innate capacity (r_m) and finite rate (λ) of the in number was 0.13 and 1.14 females per female per day, respectively. The stable age distribution of *H. armigera* in its various stages *viz.*, eggs, larvae, pupae and adult contributed to the extent of 46.25, 50.02, 3.09 and 0.62 percent, respectively.

Keywords: Life tables, *Helicoverpa armigera*, Sunflower, fecundity, age specific table

1. Introduction

Sunflower (*Helianthus annuus* L.) is a native of Southern USA and Mexico, belonging to Asteraceae family and is one among the four major oilseed crops cultivated globally viz., soybean, Brassicas, sunflower and groundnut. It is extensively grown in Russia, Argentina, France, Spain, USA, China and India. It is a rich source of edible oil (40 to 45%) and is considered to possess good quality oil from health point of view, due to the presence of high concentration of polyunsaturated fatty acids (55 to 60% linoleic acid and 25 to 30% oleic acid) in the oil. Karnataka is the leading producer of sunflower crop in the country (accounting for more than 54% of the area and 35 percent of India's sunflower production) [1].

The highly polyphagous pest, *H. armigera* is reported to feed on 181 host plants including important crop plants such as pulses, cotton, vegetables etc. [2]. This pest alone causes upto 50 percent yield loss by directly inflicting damage to flower buds, ovaries and developing seeds [3]. Loss due to capitulum borer is more if the star bud and bloom stage of the crop coincides with peak activity of the pest. The pest directly inflicts damage to sunflower by depriving the plant of ovaries and developing seeds [4]. Even one *H. armigera* larva per capitulum could cause economic damage [5]. In Karnataka, heavy infestation of *H. armigera* (83.60%) was observed with as many as six larvae per head [6].

Application of life table, rate of increase and stable age distribution are almost as diverse as the other insects. Such life tables may be analyzed to determine which stage, the life cycle of insect, contribute the most to the population trend [7] and for determining the reproductive ability and biotic potential, statistics was developed to explain population increase [8, 9]. The statistics is the innate capacity of increase, which is also called as the true intrinsic rate of natural increase (r_m). The study determines the finite rate of increase, which signifies the number of individuals added to the population per head per unit.

Since, sunflower crop is growing very extensively in middle southern and middle part of Karnataka and no detailed information regarding life fecundity tables of sunflower head or capitulam borer *H. armigera* at constant laboratory temperature is available, keeping in view of the above facts the present study was conducted know the age specific fecundity life table of *H. armigera* on sunflower (KBSH-44).

2. Materials and Methods

The present studies on life table of capitulum borer, *Helicoverpa armigera* Hub., on sunflower were carried out during Kharif-2012 at the All India Coordinated Research Project on Sunflower (AICRP on Sunflower), Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, GKVK, Bengaluru. Bengaluru is situated in hot semi-arid eco-region of Karnataka (Agro-Climatic Zone-V) at 12058 North latitude and 77035 East longitudes at an altitude of 930 M.S.L. The mean annual rainfall of Bengaluru is about 950 mm, distributed over a period of seven to eight months.

2.1 Insect culture

The adults emerged from the field collected pupae were utilized for the construction of age specific fecundity table in the laboratory. Ten pairs of newly emerged adults were enclosed or oviposition in wooden cages of size 45 × 45 × 60 cm, Fresh and healthy sunflower inflorescences and flower buds were exposed for oviposition along with cotton swab dipped in 10 percent honey solution to serve as food for the adults. After eggs were laid by the female moths, batches of 100 eggs each were collected carefully with the help of wet camel hair brush and placed in ten plastic containers (8.0 × 4.5 cm) in batches of ten each. Immediately after hatching, the larvae were transferred individually to sunflower buds. To avoid the cannibalism, the individual larvae were enclosed in a multicavity tray containing sunflower buds. Fresh food was provided daily. Observations on hatching, larval development, formation of pupae, successful emergence of adults and fecundity were recorded on a daily basis. Age specific mortality in different developmental stages like eggs, larvae, pupae and adults were recorded and appropriate reasons for the unsuccessful development were assigned.

2.2 Age specific fecundity life tables for *H. armigera*

The adults that emerged on a particular day were released into a separate cage for oviposition. Each plastic box will be covered with black muslin cloth and provided with fresh sunflower flower buds and cotton swab dipped in 10 percent honey which served as food for adult moths. The sunflower flower buds and honey soaked cotton swab was changed daily at the time of egg counting. The number of surviving female moths and their fecundity were recorded daily till the death of the female. The number of eggs laid per female was divided by two (sex ratio 1:1) to get the numbers of female birth (mx). The data thus obtained were used for the construction of age specific fecundity table according to the format suggested by Birch [8] and Poole [10].

3. Statistical analysis

The net reproductive rate, mean duration of the generation, innate capacity for increase (r_c) and intrinsic rate of increase (r_m) were calculated. From the r_m value, the corrected generation time ($T = \log R_o/r_m$), finite rate of increase (λ), weekly multiplication rate (WMR) = $(e^{rm})^7$ and doubling time were computed by the formulae given by Birch [8], Southwood [11] and Atwal and Bains, [12]. The formulae are as furnished in table 3. Stable age-distribution (% distribution of various stages) was also worked out by calculating the population schedule of birth rate and death rate (mx and lx) when grown in a limited space.

The stable age distribution of *H. armigera* on sunflower was worked out by observing the age schedule of birth rate and death rate (mx and lx). The contribution of different developmental stages towards the stable age distribution was determined

4. Results and Discussion

4.1 Survival of different developmental stages of *H. armigera*

The survival of different life stages of *H. armigera* on sunflower was found to be 3, 20 and 10 days in egg, larval and pupal stages, respectively. The number that survived from egg to adult emergence was 77 individuals (Table 1). There was seven percent mortality in egg stage, whereas mortality during larval and pupal stages was 12 and 23 percent, respectively. The present results were in agreement with the findings of Patel and Koshyia [13] on sunflower, Acharya *et al.* [14] on cotton and Patel and Koshyia [15] on pearlmillet. The results were contradictory, inspite of that the results followed a similar trend with that of Dabhi and Patel [16] who studied the life-table of *H. armigera* on chickpea pods and found that there was 10 percent mortality in egg stage, whereas mortality during larval and pupal stages was 10 and 8.64 percent, respectively. This may be due to the differences in the host and locality which was utilized for age specific fecundity life table. Similar opinion was found in the results of Liu *et al.* [17] who reported immature survival from egg to pupa varied from 33.1 percent on cotton to 1.7 percent on hot pepper.

4.2 Life- table and age-specific fecundity of *H. armigera*

The pre-oviposition period of *H. armigera* ranged from 36th to 39th day of pivotal age. Females started ovipositing on 40th day and continued egg laying upto 48th day. The first female mortality was observed on 10th day (lx=0.65) after the emergence of adult female. The maximum mean progeny production by female (mx) per day was 89.17 females per female in the life cycle on the 43rd day of pivotal age that declined to 9.15 females per female (mx) per day on 48th day (Table 2). The present findings were in accordance with the results of Patel and Koshyia [15] who reported age specific life table of *H. armigera* on pearl millet, Patel and Koshyia [13] on sunflower in Gujarat; Reddy *et al.* [18] on sunflower in Andhra Pradesh; Acharya *et al.* [14] on cotton and Naseri *et al.* [19] on soybean on the life table parameters of *H. armigera*.

4.3 Mean length of generation, innate capacity for increase in number and finite rate of increase in numbers of *H. armigera.*

The net reproductive rate (R_o), representing the total female birth in one generation was 281.011. The mean time required to complete the generation (T) was 41.40 days (Table 3). The mean generation time (T_C) was 43.39 days. The innate capacity (r_m) and finite rate (λ) of the increase in number was 0.13 and 1.14 females per female per day, respectively. At this rate, the population of *H. armigera* was capable to multiply at the rate of 2.5935 times per week and doubling time (DT) was 2.56 under the given set of conditions. The hypothetical female population in F_2 generation was 78967.18 and the potential fecundity was 398.51 eggs per female (Table 3). The present findings were in agreement with the results of Bilapate *et al*. [20], Patel and Koshyia [13] sunflower in Gujarat; Reddy *et al.* [18] on sunflower in Andhra Pradesh, Dabhi and Patel [16] constructed life table on chickpea pods and also with that of Singh and Yadav [21].

4.4 Age-specific distribution of *H. armigera* on sunflower

The stable age distribution of *H. armigera* in its various stages *viz.*, eggs, larvae, pupae and adult contributed to the

extent of 46.25, 50.02, 3.09 and 0.62 percent, respectively, which clearly indicated that immature stages contributed the maximum towards the stable age distribution (Table 4). A clear insight of the table further illustrated 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 adults. Similar observations were reported earlier by Bilapate *et al*. [20], Patel and Koshyia [13] on sunflower, Singh and Yadav [21] on chickpea pods, Acharya *et al.* [14] on cotton, Patel and Koshyia [15] on pearl millet. Similarly the results of Dhandapani and Balasubramanian [22] who reported that *H. armigera* has got the innate capacity to increase itself on bengalgram, lab-lab and which redgram were also in agreement with present findings.

Table 1: Survival of different developmental stages of *H. armigera* on sunflower

Replications	No. of eggs	Egg stage (0 to 3 days)	Larval stages (4 to 24 days)	Pupal stages (25 to 35 days)
1	10	9	9	8
2	10	10	10	9
3	10	10	10	8
4	10	10	9	8
5	10	9	8	7
6	10	8	8	8
7	10	9	9	7
8	10	9	8	8
9	10	9	9	7
10	10	10	8	7
Total	100	93	88	77

Table 2: Life-table and age specific fecundity of *H. armigera* on sunflower

Pivotal age in days (x)	Survival at different age intervals (lx)	Age schedule for birth at age x (mx)	lx.mx	x.lx.mx
0-35	0.77	-	-	Immature
36	0.75	-	0.75	27.00
37	0.75	-	0.75	27.75
38	0.75	-	0.75	28.50
39	0.75	-	0.75	29.25
40	0.75	24.60	18.45	738.00
41	0.75	33.58	25.185	1032.59
42	0.75	51.25	38.4375	1614.38
43	0.75	89.17	66.8775	2875.73
44	0.75	71.15	53.3625	2347.95
45	0.65	43.61	32.7075	1471.84
46	0.60	40.25	24.15	1110.90
47	0.44	35.75	15.73	739.31
48	0.34	9.15	3.111	149.33
49	0.24	0.00	-	27.00
			$R_0=\sum lx.mx = 281.011$	$\sum x.lx.mx = 12192.518$

Table 3: Mean length of generation, innate capacity for increase in number and finite rate of increase in number of *H. armigera* on sunflower

Population growth statistics	Formula	Calculated value
Net reproductive rate	$(R_o)= \sum lx.mx$	281.011
Mean length of generation	$(Tc)= \sum x.lx.mx/ R_o$	43.39 days
Innate capacity for increase in number	$(r_m)= Log_e R_o/T_c$	0.13 females/female/day
Corrected generation time(T)	$T= log_e R_o/r_m$	41.40 days
Finite rate of increase in number	$(\lambda)=antilog\ e^{r_m}$	1.14 females/female/day
Arbitary 'r_m' (rc)	-	0.13 or 0.14
corrected r_m	$T= e^{7-mx.lxmx}$	0.1351 females/female/day
Weekly multiplication of population	$= (\lambda)^7$	2.5935
Doubling time (DT)	$= Log_e2/r_m$	2.56
Potential fecundity(Pf)	$= \sum mx$	398.51
Hypothetical F_2 females	$= (R_o)^2$	78967.18

Table 4: Age specific distribution of *H. armigera* on sunflower

Pivotal (in days) x	lx	x+1	rm*(x+1)	exp (rm*x+1)	lx(exp (rm*x+1)	% contribution	
0	1	1	-0.1299	0.8782	0.8782	14.3379	46.25
1	1	2	-0.2598	0.7712	0.7712	12.5913	
2	0.94	3	-0.3897	0.6773	0.6366	10.3940	
3	0.92	4	-0.5196	0.5948	0.5472	8.9337	
4	0.89	5	-0.6495	0.5223	0.4649	6.5895	50.02
5	0.89	6	-0.7794	0.4587	0.4082	6.6650	
6	0.87	7	-0.9093	0.4028	0.3504	5.7215	
7	0.87	8	-1.0392	0.3537	0.3078	4.0245	
8	0.87	9	-1.1691	0.3106	0.2703	3.7125	
9	0.77	10	-1.299	0.2728	0.2101	3.4295	
10	0.77	11	-1.4289	0.2396	0.1845	3.0118	
11	0.77	12	-1.5588	0.2104	0.1620	2.6449	
12	0.77	13	-1.6887	0.1848	0.1423	2.3227	
13	0.77	14	-1.8186	0.1623	0.1249	1.5997	
14	0.77	15	-1.9485	0.1425	0.1097	1.5913	
15	0.77	16	-2.0784	0.1251	0.0964	1.5730	
16	0.77	17	-2.2083	0.1099	0.0846	1.3814	
17	0.77	18	-2.3382	0.0965	0.0743	1.1031	
18	0.77	19	-2.4681	0.0847	0.0653	1.0653	
19	0.76	20	-2.598	0.0744	0.0566	0.9234	
20	0.76	21	-2.7279	0.0654	0.0497	0.8009	
21	0.76	22	-2.8578	0.0574	0.0436	0.7121	
22	0.76	23	-2.9877	0.0504	0.0383	0.6054	
23	0.76	24	-3.1176	0.0443	0.0336	0.5492	
24	0.76	25	-3.2475	0.0389	0.0295	0.4823	3.09
25	0.76	26	-3.3774	0.0341	0.0259	0.4236	
26	0.75	27	-3.5073	0.0300	0.0225	0.3671	
27	0.75	28	-3.6372	0.0263	0.0197	0.3224	
28	0.75	29	-3.7671	0.0231	0.0173	0.2831	
29	0.75	30	-3.8970	0.0203	0.0152	0.2486	
30	0.75	31	-4.0269	0.0178	0.0134	0.2183	
31	0.75	32	-4.1568	0.0157	0.0117	0.1917	
32	0.75	33	-4.2867	0.0138	0.0103	0.1684	
33	0.75	34	-4.4166	0.0121	0.0091	0.1479	
34	0.75	35	-4.5465	0.0106	0.0080	0.1299	
35	0.75	36	-4.6764	0.0093	0.0070	0.1140	
36	0.75	37	-4.8063	0.0082	0.0061	0.1001	0.62
37	0.75	38	-4.9362	0.0072	0.0054	0.0879	
38	0.75	39	-5.0661	0.0063	0.0047	0.0772	
39	0.75	40	-5.196	0.0055	0.0042	0.0678	
40	0.75	41	-5.3259	0.0049	0.0036	0.0596	
41	0.75	42	-5.4558	0.0043	0.0032	0.0523	
42	0.75	43	-5.5857	0.0038	0.0028	0.0459	
43	0.75	44	-5.7156	0.0033	0.0025	0.0403	
44	0.75	45	-5.8455	0.0029	0.0022	0.0354	
45	0.75	46	-5.9754	0.0025	0.0019	0.0311	
46	0.6	47	-6.1053	0.0022	0.0013	0.0219	
47	0.44	48	-6.2352	0.0020	0.0009	0.0141	
48	0.34	49	-6.3651	0.0017	0.0006	0.0096	
49	0.24	50	-6.4950	0.0015	0.0004	0.0059	
				Total	6.1250	100.00	100.00

5. Conclusion

There are many key mortality factors influencing on growth, longevity, reproduction and mortality of an insect under natural condition. The cohort life table was constructed under a controlled environment indicated that the survival of different life stages of *H. armigera* on sunflower was found to be 3, 20 and 10 days in egg, larval and pupal stages, respectively. The maximum mean progeny production by female (mx) per day was 89.17 females per female in the life cycle on the 43rd day of pivotal age that declined to 9.15 females per female (mx) per day on 48th day. The net reproductive rate (R_o) was 281.011 with mean length of generation (T) was 41.40 days. The innate capacity (r_m) and finite rate (λ) of increase in number was 0.13 and 1.14 females per female per day, respectively. The stable age distribution of *H. armigera* clearly indicated that immature stages contributed the maximum towards the stable age distribution.

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