LIFE TABLE AND INTRINSIC RATE OF INCREASE IN LEPIDOPTERAN PEST *Hypsa producta*

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Abstract:
Hipsa producta is the Lepidopteran insect pest is forest pest which acts as defoliator of *A. excelsa*. Therefore life table and intrinsic rate increase have been studied. The first adult mortality was noted on 5th day. Average period of immature stages was 30 days. Maximum mean progeny production per day, mx was 26 on the 3rd day. The immate capacity for increase was found to be 0.141 per female per day and population of *H. producta* multiplied 76.76 times in generation 'T' of 30.78 days.
Keywords: *Alianthus excelsa, H. producta,* life table, intrinsic rate of increase.

Introduction:
The estimate of rate of growth of the pest have tremendous importance in pest management. The estimates of the rate of growth of the pests have tremandous importance in pest management (Howe, 1953). In a given environment an individual living animal shows its own characteristics qualitatively and quantitatively at longevity and fecundity. The value of development, are determined in part by the environment and in part by inherent characteristics of the living animal itself. According to Thompson (1924) the inherent characteristics of the animals are collectively called the 'innate capacity for increase". He visualised the first mathematical method for population dynamics. Later, Lotka (1925) derived the function for "the intrinsic rate of natural increase' and then Birch (1948) used the same for animal ecology and for the insect populations. In the present study the life tables were constructed according to Birch (1948) as elaborated by Howe (1952) and Watson (1964) .

Review of literature indicates that life table studies have been attempted in different orders of insects by several workers, noteworthy amongst them refers to Morris & Miller (1954) on Choristoneura fumiferana (Lepidoptera), Stark (1959) on Recurvaia starki (Lepidoptera), Richards & Waloff (1961) on Phytodecta olivacea (Coleoptera), Le Roux et al.,(1963) on Spilonota ocellana (Lepidoptera); Waloff (1968) on Sitona recansteinansis Herbst (Coleoptera) and on Arytacina cenistae (Homoptera), Mcleod (1972) on Neodiprion swainei Midd. (Hymenoptera), Tamaki et al.,(1972) on Zebra caterpillar (Lepidoptera), Bains & Shukla (1976) on Chilo partellus (Swinh.) (Lepidoptera), Bilapate & Pawar (1980) and Reddy & Bhattacharya (1988) on Helicoverpa armigera.

Material and methods:
Intrinsic rates of increase-

Birch (1948) visualized the following equation to study intrinsic rate of natural increase.

$$\sum e^{-r} m^{x} l_x \, m_x = 1$$

Where
'e' is the base of the natural logarithms,
'x' the age of the individual in days,
*l*x the number of individual alive at age, 'x' as a portion of one, and m_x the number of female offsprings produced per female in the age interval 'x'.
The sum of the products 1x mx is the net reproductive rate,
'R_0' which is the rate of multiplication of the population in each generation measured in terms of females produced per generation.

The approximate value of cohort generation time 'Tc' was calculated as follows:

$$T_c = \frac{l_x m_x X}{l_x m_x}$$

The formula: $r_c = \frac{\log_e R_o}{T_c}$

provides the arbitrary value of innate capacity for increase 'r_c'.

This was an arbitrary value for rm and value of r_m Upton two decimal places was substituted in the formula until the two values of the equation were

found which lies immediately above or below 1096.6. The two values of

$$\sum e^{7-r} m^x l_x m_x = 1$$

were then plotted on the horizontal axis against their respective arbitrary r_m s on the vertical axis. The point of intersection gives the value of r_m accurate to 3 decimal places. The precise generation time 'T' was calculated as

$$T = \frac{\log_e R_0}{r_m}$$ and

the finite rate of increase (λ) was calculated as-

$$\lambda = e^r m.$$

Adults moths of *H. producta* reared under laboratory conditions (25 ± 2^{0}c, 65 ± 5 % R.H., 12 hrs. photoperiod). The laboratory culture was used for determining intrinsic rate of increase.

The life tables were prepared with the help of fecundity data and later the intrinsic rates of natural increase of population of moths were calculated. All the experiments were carried out at laboratory conditions (25 ± 2^{0}c, 65 ± 5 % R.H., 12 hrs. photoperiod) and replicated for ten times.

Result:

Intrinsic rates of increase in *H. product-*

The first adult mortality was noted on the 5th day. Average period of immature stages was 30 days, Maximum mean progeny production per day, m x was 26 on the 3rd day. The innate capacity to increase was found to be 0.141 per female per day and population of *H. producta* multiplied 76.76 times in generation time 'T' of 30.78 days. Results are shown in tables 1-5.

$$T_c = \frac{1_x m_x X}{1_x m_x} = \frac{2506.34}{76.76} = 32.65$$

Where T_c is arbitrary T.

$$\frac{= \log_e R_0}{= T_c} = \frac{76.76}{32.65} = 0.132$$

Where r_c is arbitrary r_m

T_c = 32.65

r_c = 0.132

Now arbitrary 'rm's are 0.11 and 0.15 where λ is the finite rate of natural increase.

r_m = 0.141 (figure)

$$T = \frac{\log_e 76.76}{0.141} = 30.78$$

$$T = 30.78 \quad days.$$

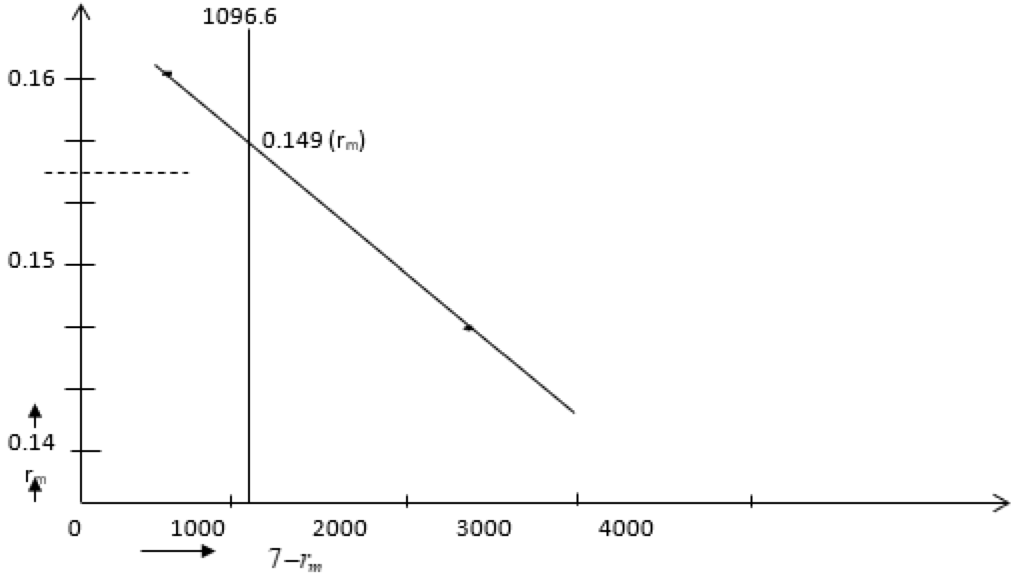

Fig.: 1 Determination of intrinsic rate of increase in *H. producta.*

Table 1: Developmental period required for females of *H. product.*

Sr. No	Egg (days)	Larva (days)	Pupa (das)	Adult formation (Total days)
1	3	20	7	30
2	3	21	7	31
3	3	21	8	32
4	3	18	8	29
5	3	21	8	32
6	3	18	7	28
7	3	21	7	31
8	3	18	7	28
9	3	18	7	28
10	3	20	8	31
Mean				30

Table 2: Daily production of progeny by mated females of *H. producta*

Replicates	**Number of progeny produced /day**																
Female number	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**Males**	**Females**	**Total**
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**			
1	7	12	8	18	17	28	5	14	2	-	D	7	-	D	39	79	118
2	9	14	10	16	12	19	5	17	2	10	D	D	-	-	38	76	114
3	8	17	9	21	15	25	5	17	3	D	D		-	-	40	80	120
4	6	12	10	20	15	24	5	10	5	11	D	5	-	D	41	82	123
5	9	14	11	17	14	23	4	15	D	6	-	D	-	D	38	75	113
6	8	11	10	18	12	27	4	13	3	4	-	D	-	-	37	73	110
7	7	15	12	27	16	28	7	15	D	D	-		-	-	42	85	127
8	8	13	12	19	12	29	6	14	3	8	D	D	-	D	41	83	124
9	9	12	11	27	12	30	6	9	D	D	-		-	-	38	78	116
10	10	16	11	19	12	27	6	11	D	7	-	D	-	-	39	80	119
Mean	8.1	13.6	10.4	20.2	13.7	26.0	5.3	13.5	1.8	4.6		1.2	-	-	39.3	79.1	118.4

Table 3: Life table statistics of *H. producta*

Pivotal age (days) x	Proportional live age × Lx	Number of female progeny per female mx	Lx mx	Lx m_xx
1-30 days immature stages				

31	1.0	13.6	13.60	421.60
32	1.0	20.2	20.20	646.40
33	1.0	26.0	26.00	858.00
34	1.0	13.5	13.50	459.00
35	0.7	4.6	3.22	112.70
36	0.2	1.2	0.24	8.64
37	0.0	0.0	0.00	0.00
			∑ 76.76	∑ 2506.34

Table 4: Provisional r_m (0.11) for *H. producta* and related values of $e^{7-r}mxl_xm_x$

x	r_{mx}	$e^{7-r}mx$	e^{7-r} mx	e^{7-r} mxl_xm_x
31	3.41	3.59	36.23	492.72
32	3.52	3.48	32.45	655.49
33	3.63	3.37	29.07	755.82
34	3.74	3.26	26.04	351.54
35	3.85	3.15	23.33	75.12
36	3.96	3.04	20.90	5.01
37	4.07	2.93	18.72	0.0
				∑ 2335.7

Table 5: Provisional r_m (0.5) for *H. producta* and related values of $e^{7-r}mxl_xm_x$

x	r_{mx}	$e^{7-r}mx$	e^{7-r} mx	e^{7-r} mxl_xm_x
31	4.65	2.33	10.48	142.52
32	4.8	2.20	9.02	182.20
33	4.95	2.05	7.76	201.76
34	5.1	1.90	6.68	90.18
35	5.25	1.75	5.75	18.51
36	5.4	1.60	4.95	1.18
37	5.55	1.45	4.26	0.0
				∑ 636.35

Discussion:

Bains and Shukla (1976) studied the life tables and intrinsic rate of increase in *Chilo partellus* (Swin.) (lepidoptera), the intrinsic rate of increase (r_m) at different temperatures were in ascending order 0.0002 (35^{0}C), 0.165 (32.5 ^{0}C), 0.223 (25^{0}C), 0.383 (27.5^{0}C) and 0.435 (30^{0}C). These conclusions showed that the rate of increase was maximum at 30^{0}C which should be considered to be the optimum temperature for the multiplication of this lepidopterous pest. However, the present study was not carried out at different temperature. Further observations of Bains and Shukla (1976) on the finite rate of increase per week were 4.67, 15.59, 21, 3.177 and 1.002 at 25^{0}C , 27.5^{0}C, 30^{0}C , 32.5^{0}C and 35^{0}C respectively, In the present study λ was calculated for each lepidopterous pests (*H. producta,*) in respect of daily increase at laboratory temperature (25 ± 2^{0}C, 65 ± 5 % R.H and 12 hrs. photoperiod.).

In *H. armigera,* the value of R_0 indicated that 285.06 females were produced per female during one generation. The innate capacity and finite rate for increase in numbers were 0.1210 and 1.1260 respectively. The mean duration of a generaton was 46.71 days. Under conditions of abundant space, the daily finite rate of increase of *H. armigera* was 1.1286 which enabled the insect to multiply 2.3322 times every week (Bilapate and Pawar, 1980).

According to Reddy & Bhattacharya (1988) the life expectancy (e_x) of *H. armigera* declined up to first 6 days due to egg mortality and increased upto 10th day due to larval mortality. Later, with the advancement of development e_x decreased steadily till it reached 46th day. This type of enhancement in e_x due to heavy mortality at any age group was also reported for *Naranga diffua* Walker, *Phyllonistis citrella* Stainton, *Creatonotus gangis* Linneaus, *S. obliqua* and *S. litura* (Singh, 1984). There was indication of the survival fraction (lx) of each cohort. Females started laying eggs after 31.5th day and stopped it after 39.5th day with lx values being 0.42 and 0.17 respectively. The lx decreased gradually after 4.5th day due to adult mortilty.

Fecundity rate (mx) and reproductive rate (*l*x mx) of each age group showed an undulating pattern during the entire egg laying period. Such pattern was also reported for several other insects (Evans & Smith, 1952; Choudhary and Bhattacharya, 1986). Reddy and Bhattacharya (1988) studied various life parameters computed to get an overall picture of different vital statistics of *H. armigera* on maize based diet. Mean length of generation (T) indicated that this insect completed first generation in 35.5 days. Similarly, net reproductive rate (R_0), accurate estimate of intrinsic rate (r_m), finite rate of increase or the population multiplication in on unit time (λ) , time required for the population become double (DT), potential fecundity (PT) and annual ratio of increase

(AR) were 46.98, 0.1090, 1.1152, 3.36, 134.40, 1.898×10^{17} respectively.

Conclusion:

In the present study 'r_m' and 'T' of *H. producta*, were 0.141 and 30.78 days respectively. The present studies will be helpful for population dynamics of above forest pests and in deciding control strategies for them.

References:

1. Bains, S. B. and K. K. Shukla, 1976. Effect of temperature on the development and survival of maize borer Chilo pertellus (Swinhoe). Indian J. Ecol., 3(2), 149 – 155.
2. Birch, L. C. 1948. The intrinsic rate of natural increase in an insect population. J. Anim. Ecol., 17, 15-26 (W.L. 25559).
3. Bilapate, G. G., and V.M. Pawar, 1980. Life fecundity tables for Heliothis armigera Hubner (Lepidoptera : Noctuidae) on sorghum earhead. Proc. Indian Acad. Sci. (Ani. Sci.), 89 (1), 69-73. (W. L. 2555).
4. Howe, R. W. 1953. The rapid determination of intrinsic rate of increase of an insect population. Appl. Biol., 40, 134-155.
5. Le Roux, E. J. 1963. Population dynamics of agricultural and forest insect pests. Mem. Ent. Soc. Can., 32, 1-103.
6. Lotka, A. J. 1925. Elements of Physical Biology. Williams and Wilkins, Baltmore Md – pp. 462.
7. Morris, R. F. and C. S. Miller, 1954. The developments of life tables for the spruce budworm. Can. J. Zool., 32, 382-301.
8. Reddy, C.G. and Bhattacharya, 1988. Life tables of Heliothis armigera (Hubner) on semisynthetic diets. Indian J. Ent., 50 (3), 357-370.
9. Stark, R.W. 1959. Population dynamics of the lodgepole needle miner, Nicrophorus spp and the mite Poecilochirus necrophori. J. Animi. Ecol., 37, 417-474. (W.L. 25559).
10. Thompson, W.R. 1924. La theorie mathematique deiaction des parasites entomophages et. le. facteur du hasar du hasar d. Annls Fal. Sci. Morseilla, 2, 69-89.
11. Watson, T. F. 1964. Influence of host plant conditions on population increase of Tetranychus tetarius (Linnaeus). Hilgardia, 35, 275-322.