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STUDIES ON THE LIFE TABLE OF COTTON LEAFWORM, *SPODOPTERA LITTORALIS* (BOISD.) AT CERTAIN CONSTANT TEMPERATURE REGIMES

Hamouda, S. H.H.
Plant Protection Department, Faculty of Agriculture, Minia Univ.

ABSTRACT

Age-specific survival, age-specific fecundity and population growth statistics of the cotton leafworm, *Spodoptera littoralis* (Boisd.) were studied in relation to five different constant temperature regimes over the range of 15-35°C with progressive increments of 5°C. The gross reproductive rate (GRR), net reproductive rate (R_o), intrinsic rate of increase (r_m), finite rate of increase (λ), mean generation time (T) and population doubling time (DT) were the basic population parameters calculated to assess the influence of constant temperature regimes on the insect.

The maximum proportion of individuals still alive (l_x) and mean daily age-specific fecundity (m_x) (0.481 and 201.450) were estimated for the insects reared at 25°C.

The highest values of (r_m) and (λ) with the shortest times of (DT) were recorded at 25 and 30°C, indicating a good adaptability of *S. littoralis* to increase and survive in a moderately high temperatures of (25-30°C).

INTRODUCTION

One of the ultimate objects in studying the biology of the insect pests, is to be able to estimate the rate at which they will increase (Howe, 1953). The accepted criterion for this is the intrinsic rate of increase (r_m), which is the actual rate of increase of a population under specified constant environmental conditions, in which space and food supply are unlimited and other animals of different species are excluded (Birch, 1948 and Andrewartha and Birch, 1954). This rate may be calculated from the age-specific fecundity and survival rates observed under defined environmental conditions. Many authors have obtained these parameters for several pests (Birch, 1948; Harcourt, 1969; Frazer, 1972; Deloach, 1974; Karaman, 1975; Wyatt and Brown, 1977; Hogg, 1985; Gergis, 1987; Pinkham and Oseto, 1988; Caceres and Childers, 1991; Gergis and Younis, 1991 and Hamouda, 1993.

Despite the economic importance of the cotton leafworm, *Spodoptera littoralis* (Boisd.), few studies have examined the effect of temperature on different stages of this pest (Nasr and Ibrahim, 1965; Abul-Nasr *et al.*, 1973; Moftah, 1976; El-Shafei *et al.*, 1981; Younis, 1992; Gergis *et al.*, 1994 and Yaseen, 2000.

Critical success of the integrated pest management programs of the cotton leafworm is the understanding of the population size and dynamics of this pest and its interactions with temperature. Quantification of these interactions provide useful information for development of models using either the variable life table or intrinsic rate of increase approach. These modeling approaches proved to be useful in the study of an insect population dynamics. Thus, in the study reported here, the effect of five different constant temperature regimes on age-specific life tables and population growth statistics of *S. littoralis* was determined.

MATERIALS AND METHODS

The insects needed for the study were obtained from a rearing culture maintained in the Department of Plant Protection, Faculty of Agriculture, Minia University.

Duration and survival of immature stages, fecundity and longevity of adults were recorded under five constant temperature regimes (15, 20, 25, 30 and 35°C) using Heareus incubators (Model BK 500) with relative humidity about 65±5% and photoperiods of (12/12 L/D).

To study the incubation period, 1500 newly deposited eggs were distributed in five petri dishes (9 cm diameter) placed without lids in larger glass containers covered with fine-mesh gauze lids and tightly secured with rubber bands. The eggs were examined twice daily under each tested constant temperature. The number of hatched eggs were recorded and the incubation period was calculated.

In order to study the larval durations under each tested constant temperature, 50 newly hatched larvae were placed separately in glass tubes (3.5 X 7 cm) ,then fresh castor- oil leaves were introduced to each tube to maintain adequate food ,and the leaves were replaced twice daily. When larvae stopped feeding activity, they were kept into the same glass tubes to complete their pupation until moth emergence. Observations were taken daily to record the larval and pupal durations and mortality. To study the fecundity and longevity of adults, pairs of newly emerged adults were confined separately in chimney glass (10.5 X 12.5 cm), lined with waxed paper as oviposition site. The moths were fed with 10% sucrose solution and kept at each tested constant temperature. Eggs laid during the previous twenty four hours were counted and removed. The procedure continued until adults died.

The basic requirements were used to calculate the life table parameters according to the method of Birch (1948) were :

1. The developmental cycle and adult life is divided into convenient units which are tabulated in the 1st column of age-specific survival and fecundity rate tables. Egg laying and death are assumed to occur at the mid-point in each day which is represent the pivotal age in the above mentioned tables.
2. The probability of an egg emerging as alive adult is the product from percent of hatchability multiplied by the percent of larvae emerged as adults. In other words, the age-specific survival rate (l_x) when l_0 is taken as unity.
3. The mean number of female offspring produced per unit of time by a female which represent the age-specific fecundity rate (m_x).
4. The total of the (m_x) column is the average daughter eggs might be expected by a female which lived throughout the entire span of the reproductive ages. This figure is analogous to the gross reproduction rate (G.R.R).

5. The sum of ($l_x m_x$) figure represent the net reproduction rate (R_o), or the ratio of the total female births in two successive generations.
6. Generation time (T) which is the mean time elapsing between birth of parents and the birth of offspring $T = \sum x l_x m_x / \sum l_x m_x$
7. Finite rate of increase (λ) that the self-multiplicative rate of the species, is calculated according to Howe (1953), who provided a means of representing a long oviposition cycle by a single figure. So that the final calculation resembles the primitive single period method. The oviposition period is divided into a number of convenient unit periods and using a table of weighting factors provided, the number of eggs laid in each of these unit periods is converted into the number of eggs required to be laid in the first of these unit periods of oviposition to make an equivalent contribution to the rate of increase.
8. The intrinsic rate of increase (r_m) is calculated as the natural logarithm of the self-multiplicative rate of increase λ : $r_m = \log_e \lambda$.
9. The doubling time (DT) which is the time required for a given population to double its numbers and it can be computed from: $DT = Log_e^{2/rm}$

RESULTS AND DISCUSSION

Age-specific survival and fecundity rates of *S. littoralis* reared at five different constant temperature regimes are recorded in Tables (1-5) and graphically illustrated in Figs. (1-5). Data revealed that the highest proportion of individuals still alive from the beginning of the oviposition period was 0.481 for the insects reared at 25°C, whereas the lowest proportion of 0.161 was recorded for those reared at 35°C. Also, the same trend was observed for the age-specific fecundity rates. Average daily fecundity (m_x) per female per day was 13.15, 70.24, 122.15, 93.67 and 6.86 ♀/♀/day at 15, 20, 25, 30°C and 35°C, respectively. These results indicate the adverse effect of the lower and higher temperatures (15 and 35°C) on the adult fecundity. Similar effects of temperature on survival and fecundity rates of potato tuberworm, *Phthorimaea operculella* (Zell.) and spiny bollworm, *Earias insulana* (Boisd.) have been demonstrated by Gergis (1987) and Makadey (1990), respectively.

Table (1): Age-specific survival and fecundity rates of the cotton leafworm, *S. littoralis* reared at 15°C

Age group in days	Pivotal age in days (x)	Age-specific survival rate (l_x)	Age-specific fecundity rate (m_x)	$l_x m_x$
123-124	123.5	0.259	3.85	0.997
124-125	124.5	0.259	8.25	2.137
125-126	125.5	0.243	8.80	2.138
126-127	126.5	0.243	22.0	5.346
127-128	127.5	0.243	28.05	6.816
128-129	128.5	0.213	20.35	4.335
129-130	129.5	0.213	14.30	3.046
130-131	130.5	0.183	27.50	5.033
131-132	131.5	0.183	4.95	0.906
132-133	132.5	0.153	4.95	0.757
133-134	133.5	0.107	1.65	0.177
			Mean = 13.15	

			G.R.R= 144.650	R_o= 31.688

Table (2): Age-specific survival and fecundity rates of the cotton leafworm, *S. littoralis* reared at 20°C

Age group in days	Pivotal age in days (x)	Age-specific survival rate (l_x)	Age-specific fecundity rate (m_x)	l_xm_x
48-49	48.5	0.412	24.440	10.069
49-50	49.5	0.412	74.730	30.789
50-51	50.5	0.412	71.910	29.627
51-52	51.5	0.412	104.810	43.182
52-53	52.5	0.357	117.030	41.780
53-54	53.5	0.357	70.500	25.169
54-55	54.5	0.302	84.600	25.549
55-56	55.5	0.275	87.420	24.041
56-57	56.5	0.220	71.910	15.820
57-58	57.5	0.165	52.640	8.686
58-59	58.5	0.165	12.690	2.094
			Mean = 70.24	
			G.R.R= 772.680	R_o= 256.806

Table (3): Age-specific survival and fecundity rates of the cotton leafworm, *S. littoralis* reared at 25°C

Age group in days	Pivotal age in days (x)	Age-specific survival rate (l_x)	Age-specific fecundity rate (m_x)	l_xm_x
28-29	28.5	0.481	32.640	15.670
29-30	29.5	0.481	39.270	18.759
30-31	30.5	0.481	86.190	41.457
31-32	31.5	0.481	190.740	91.746
32-33	32.5	0.481	201.450	96.898
33-34	33.5	0.444	164.220	72.914
34-35	34.5	0.444	139.230	61.818
35-36	35.5	0.407	175.440	71.404
36-37	36.5	0.296	126.990	37.589
37-38	37.5	0.296	65.280	19.323
			Mean = 122.15	
			G.R.R= 1221.450	R_o= 527.578

Table (4): Age-specific survival and fecundity rates of the cotton leafworm, *S. littoralis* reared at 30°C

Age group in days	Pivotal age in days (x)	Age-specific survival rate (l_x)	Age-specific fecundity rate (m_x)	l_xm_x
21-22	21.5	0.291	43.240	12.583
22-23	22.5	0.291	51.980	15.126
23-24	23.5	0.291	154.100	44.843
24-25	24.5	0.291	110.860	32.260
25-26	25.5	0.269	112.240	30.193
26-27	26.5	0.269	143.980	38.731
27-28	27.5	0.269	70.840	19.056
28-29	28.5	0.269	62.100	16.705
			Mean = 93.67	
			G.R.R= 749.340	R_o= 209.497

Table (5): Age-specific survival and fecundity rates of the cotton leafworm, *S. littoralis* reared at 35°C

Age group in days	Pivotal age in days (x)	Age-specific survival rate (l_x)	Age-specific fecundity rate (m_x)	l_xm_x
18-19	18.5	0.161	1.560	0.251
19-20	19.5	0.161	11.960	1.926
20-21	20.5	0.161	5.720	0.921
21-22	21.5	0.161	10.400	1.674
22-23	22.5	0.143	4.680	0.669
			Mean = 6.86	
			G.R.R= 34.320	R_{o}= 5.441

Data presented in Table (6) show that the pattern of both gross reproductive rate (G.R.R) and the net reproductive rate (R_o) were approximately similar. It is clear that the G.R.R. and R_o values for *S. littoralis* were greater when it reared at 25°C (1221.45 and 527.578 female/female, respectively), while at 35°C were lowest (34.32 and 5.441 female/female, respectively). The overall response of the cotton leafworm to temperature is summarized in the different values of intrinsic rate of natural increase (r_m). It increased gradually from a low value of 0.026 at 15°C to a high value of 0.213 at 30°C, then decreased at 35°C. Higher reproductive capacities do not necessarily translate into higher potentials for increase. Thus, the value of (r_m) reached a maximum at 30°C at temperature of which production of total progeny and female progeny were lower than that of 25°C. This was due to the lower developmental time required at 25°C which more effective than reducing the reproduction. However, the values of (r_m) were converted to finite rate of increase (λ) by using the procedure outlined by Howe (1953). It is obvious from the results in Table (6), that the population of *S. littoralis* will multiply 1.026, 1.115, 1.229, 1.237 and 1.078 times per female per day when it reared at 15, 20, 25, 30 and 35°C, respectively. Generally, the highest values of (r_m) and (λ) were recorded at 30°C. This trend agrees with the findings of Wu *et al.*(1980), who found, at 30°C the innate capacity for increase (r_m) of *Heliothis armigera* (Hb.) was 0.1902 and the finite rate of increase (λ) was 1.210/day. Also, Gergis (1987) recorded that the intrinsic rate of increase for *P. operculella* at 30°C was 0.212.

Table (6): Population growth statistics for the cotton leafworm, *S. littoralis* under five constant temperature regimes.

Temp. °C	G.R.R.	R_o	r_m	λ	T	DT
15	144.650	31.688	0.026	1.026	129.313	26.66
20	772.680	256.806	0.109	1.115	50.902	6.36
25	1221.450	527.578	0.206	1.229	30.429	3.37
30	749.340	209.497	0.213	1.237	25.093	3.25
35	34.320	5.441	0.075	1.078	22.586	9.24

The calculated data in Table (6) indicate also that the cotton leafworm *S. littoralis* had the potentiality to double every 26.66, 6.36, 3.37, 3.25 and 9.24 days when it reared at 15, 20, 25, 30 and 35°C, respectively. Also, the longest mean generation time (129.313 days) was recorded for ***S. littoralis*** reared at 15°C, meanwhile, the shortest (22.586 days) was detected at 35°C. The generation time (T) followed the same pattern of inverse relationship with temperature as did the developmental time, decreasing as temperature increased.

In conclusion, the population growth parameters proved that temperature range of 25-30°C was the favourable range for cotton leafworm *S. littoralis* to reproduce, persist and increase with higher capacity.

These results are in agreement with those obtained by El-Saadany and Abd El-Fattah (1974) on *S. littoralis*; El-Refai (1982) on the black cutworm, *Agrotis ipsilon*(Hufn.); Makadey (1990) on spiny bollworm, *Earias insulana* (Boisd.) and Shengchih and Ouyang (1994) on *S. litura* (Fabricious).

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دراسات عن جدول الحياة لحشرة دودة ورق القطن الكبرى تحت بعض درجات الحرارة الثابتة

سيد حسن حسين حمودة
قسم وقاية النبات-كلية الزراعة-جامعة المنيا

تم دراسة علاقة معدلات الحياة والخصوبة وإحصائيات نمو المجموع لحشرة دودة ورق القطن بخمسة درجات حرارة ثابتة مختلفة تبدأ من 15°م الى 35°م بزيادة 5°م . كما تم حساب معدل الخصوبة المتناهى ومعدل الخصوبة الصافى والمعدل الحقيقى للزيادة والمعدل النهائى للزيادة ومتوسط مدة الجيل والوقت اللازم لتضاعف الجيل وذلك لتقدير تأثير مستويات درجات الحرارة الثابتة على الحشرة .

أظهرت النتائج أن أعلى نسبة من الأفراد التى ظلت حية وأيضا أعلى متوسط يومى للخصوبة قد تم تسجيلهما على درجة حرارة 25°م كما تبين أن أعلى قيم لمعدلات الزيادة الحقيقى والنهائى وأقصر فترة لتضاعف الجيل سجلت على درجات الحرارة 25°م و 30°م مما يدل على أن حشرة دودة ورق القطن كان لها القدرة العالية للزيادة والبقاء على درجات الحرارة المتوسطة الإرتقاع (من 25-30°م) .