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# CERTAIN BIOLOGICAL ASPECTS, THRESHOLD OF DEVELOPMENT AND THERMAL UNITS FOR *HYMENIA recurvalis* (FAB.), (LEPIDOPTERA: PYRALLIDAE)

**[30]**

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## ABSTRACT

Biological studies on the Hawaiian beet webworm, *Hymenia recurvalis* were carried out under laboratory conditions of 18.6 ± 2°C and 70 ± 5% R. H. The incubation period ranged between 5 and 7 days with a mean of 6.0 ± 0.3 days. The mean durations of larval, prepupal and pupal stages were 26.29 ± 0.3, 5.04 ± 0.08 and 16.86 ± 0.18 days, respectively. Mean adult longevities were 28.42 ± 1.80 and 26.08 ± 1.83 days, ranging between 19-41 and 15-37 days for female and male, respectively. The sex ratio was about 1 : 1.3 (♀ : ♂ ). Accumulative thermal units needed for certain biological features of *H. recuurvalis* were calculated and the estimated thermal thresholds were 10.97, 12.14, 10.49 and 13.55°C for egg, larval, pre – pupal and pupal stages, respectively. The corresponding values for the thermal units needed for development of these stages were 51.49, 168.47, 47.88 and 102.59 day degree at 25°C for the respective stages.

**Keywords:** Biology, Hawaiian beet webworm, Threshold of development, Thermal units

## INTRODUCTION

Sugarbeet, *Beta vulgaris* L. is an international crop for producing sugar. Hawaiian beet webworm *Hymenia recurvalis* (Fab.) is considered the most dangerous defoliators of this crop in the fields. **(Cooke and Scott, 1993).**

Few studies were carried out on this insect. In Japan, **Yamada *et al* (1979)**, recorded *H. recurvalis* (Fab.) as an important pest of spinach, sugarbeet and other crops in central and southern Japan. In Egypt this insect pest was recorded for the first time in 2001 year on sugarbeet plants **(El-Gendi *et al* 2003)**.

The aim of the present work is to study certain biological aspects of this insect under laboratory conditions and the accumulative thermal units of the different stages for the purpose of finding out the threshold of development, for eggs and immature stages of *H. recurvalis.*

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## MATERIAL AND METHODS

### 1. Stock culture

Sugarbeet leaves infested with *H. reurvalis* larvae were collected from the field at El-Fayoum and kept in glass jars (20 cm diameter x 15 cm height). Covered with muslin and held in position by rubber bands. Jars were daily cleaned and supplied with fresh and clean leaves as food until pupation. Pupae were collected and placed in glass chimneys until moths emergence. The emerged adults were separated into females and males.

### 2. Biological studies

The annual generation and life history of *H. recurvalis* were studied under laboratory conditions of 18.6 ± 2°C and 70 ± 5% RH. Seventeen couples of newly emerged moths were taken and each pair was kept in chimney glass, provided with pieces of cotton soaked in 10% sugar solution as well as leaves of sugarbeet as oviposition site. Each leaf was placed in small glass vial filled with water under a chimney glass and changed daily. The pre-oviposition and oviposition periods, number of eggs/female/ day as well as the total number of deposited eggs during the whole life span of the female and the postoviposition period were recorded for female moths. The longevity of male moth was also recorded.

Newly hatched larvae were transferred individually in sterilized Petri dishes and supplied daily with fresh sugarbeet leaves. Observations were made daily and the durations of different larval instars, pre-pupal, and pupal stages were recorded.

### 3. Threshold of development and thermal units for *H. recurvalis* immature stages

*H. recurvalis* were reared in three electric incubators, adjusting on 20, 25 and 30ºC under a daily photo – periodic regime of L: D (12 : 12) and relative humidity of 75 ± 5% RH. to study the effect of temperatures on the egg, larval, prepupal and pupal stages of the experimental insect. The theoretical developmental thresholds were determined as follows: the periods obtained were expressed as "Y" in days at the corresponding temperature (T) in centigrade degrees. The distribution of these two points demonstrates the course of temperature–time curve. The relationship is hyperbolic as commonly observed in many insects **(Bean, 1961 and Miyashita, 1971)**. The point obtained when reciprocal for period (1/y) in days was plotted against temperature (T) in centigrade degrees each of reciprocals multiplied by 100. Values on the ordinate 100/y represent the average percentage development made by the stage/day , at the given temperature.

Therefore, the distribution of the points indicate the course of temperature velocity curve (Davidson, 1944). The values of average percentage normal zone of development were fitted to a straight line by method of least squire equation (Regression line). Theoretically, the point at which the velocity line crosses the temperature axis is considered as the threshold of development ($\underline{+}$°C).

The linear regression equation, $\hat{Y} = \bar{Y} \pm \mathbf{b}\,(\mathbf{x} - \bar{X})$ was adopted where:

$\hat{\boldsymbol{Y}}$ and $\overline{\boldsymbol{Y}}$ = the estimated and average durations (in days), respectively; b= the simple regression coefficient (value unit

effect); $\bar{X}$ = the assumed degree of temperature (corresponding y); X = the average degrees of temperature.

The equation for estimatation the threshold of determined development by applying the following equation was adopted by **Alrouechdi, (1986)** was used as followes;

$$a = ti(1) - \frac{di\,(2)\,[ti(2) - ti(1)]}{di(1) - di(2)}$$

where

ti (1) and ti (2) = The minimum and maximum temperatures of 20 and 30°C, respectively; di (1) and ti (2) = the mean number of days for incubation at 20°C and at 30 °C, respectively; and a = the development threshold figure.

The thermal units required for development of each stage was determined according to the following equation **(Line *et al* 1954)**.

$$K = di\,(ti - a)$$

where

K = thermal units; di = the mean number of days in an incubator at the experimental temperature; ti = the temperature of incubator; and a = the development threshold degree.

The data obtained were statistically analyzed by using F-test and L.S.D. values **(Snedecor and Cochran, 1980)**.

Results and Discussion

**1. Certain morphological biological aspects of *H. recurvalis***

The egg of *H. recurvalis* is white in colour, oral in shape and like the scales. The incubation period lasted an average of 6.0 $\pm$ 0.3 days, ranging between 5-7 days (Table, 1).

The larva is creamy – white in colour but grayish – green and black marks subsequently appear on the body with yellow head capsules. The newly hatched of larva is characterized by a distinct dark line down the middle of the back and measures a mean of 1.12 ± 0.04 mm in length and 0.11 ± 0.02 mm in width. The larval stage passed through four moults with five instars. Means of 3.9 ± 0.12, 6.2 ± 0.62, 10.4 ± 0.33 , 12.8 ± 0.27 and 18.3 ± 0.56 mm. for larval length and 1.3 ± 0.04 , 2.3 ± 0.04 , 3.5 ± 0.11 , 4.3 ± 0.09 and 4.6 ± 0.15 mm. for larval width were recorded for the successive five instars, respectively. The larval stage durated 26.29 $\pm$ 0.3 days ranging between 24-30 days (Table, 1).

The pre-pupa is pink in colour then quiescence at the end of this stage and spin a silken cocoon to pupate. This cocoon appear a white in colour. The prepupal stage lasted 5.04 $\pm$ 0.08 days ranging between 4-7 days.

The pupa is obtect in type and appear in white brownish colour through the first two days then becomes dark brown. The male pupa measures from 10 to 11 mm with an average of 10.4 mm ± 0.16 in length and 3.3 – 4.0 mm in width with an average of 3.7±0.11 mm. The female pupa measures from 7.9 to 9.1 mm, with an average of 8.7 ± 0.16 mm in length and from 3.5 – 5.5mm with a mean of 4.4 ± 0.26 mm in width. Generally, the pupal duration was 16.86 $\pm$ 0.18 days, ranging between 15-18 days.

The mean length of adult is 11.0 ± 0.12 mm for male and 8.5 ± 0.13 mm for female. The adult is dark brown with two incomplete white stripes on each forewing and a complete one across each hind

Table 1. Durations (in days) of the immature stages of the Hawaiian beet webworm, *H. recurvalis* (Fab.) and egg hatchability under laboratory conditions of 18.6 ± 2ºC and 70 ± 5 % RH.

| Stages | Biological aspects | Mean ± S.E. | Range |
|---|---|---|---|
| Egg | Incubation period (days) | 6.0±0.3 | (5-7) |
| | Hatchability (%) | 78.86 | |
| Larval | Duration of: | | |
| | 1st instar (days) | 7.14±0.28 | (5-12) |
| | 2nd instar (days) | 4.5±0.33 | (2-8) |
| | 3rd instar (days) | 4.36±0.25 | (1-7) |
| | 4th instar (days) | 5.0±0.16 | (4-7) |
| | 5th instar (days) | 5.79±0.31 | (2-10) |
| | Total | 26.29±0.3 | (24-30) |
| Pre-pupal | Duration (day) | 5.04±0.08 | (4-7) |
| Pupal | Duration (days) | 16.86±0.18 | (15-18) |
| Femal longevity | Preoviposition (days) | 5.21±0.51 | (4-10) |
| | Oviposition (days) | 19.75±1.17 | (13-27) |
| | Postoviposition (days) | 3.50±0.78 | (1-8) |
| | Total | 28.46±1.88 | (18-45) |
| Male longevity | (days) | 26.08±1.83 | (15-37) |
| Fecundity | Mean No. of eggs/♀/day | 14.15±1.82 | (3-27) |
| | Total No. of eggs/♀ | 263.25±30.38 | (71-509) |
| Generation | Duration (days) | 82.42±1.88 | (71-93) |

wing. It has a wingspan of about 2 cm and filiform antennae. Female longevity was 28.42 ± 1.88 days, ranging between 19-41 days which longevity could be divided into pre-oviposition period (5.21 ± 0.51 days ranging between 4-10 days, the oviposition period (19.75 ± 1.17 days ranging between 13-27 days and the post-oviposition period (3.5 ± 0.78 days ranging between 1-8 days). During the oviposition period, female moth laid a total of 263.25 ± 30.38 eggs ranging between 71-509 eggs at the rate of 14.15 ± 1.82 eggs/female/day. The mean hatchability percentage was (78.86 %) Adult longevity of male moth was 26.08 ± 1.83 days, ranging between 15-37 days.

The period from egg-laying until the beginning of egg deposition of the resulted mated female (generation) lasted 82 ± 1.88 days, ranging between 71 - 93 days. Sex ratio (♀- ♂) was about normal, being 1 : 1.3 (Table 1).

Relatively similar results were recorded by **Yamada *et al* (1979)**, who stated that the incubation parid of *H. recurvalis* eggs took 4 to 5 days, the larval stage lasted about three weeks and the pupal stage took about one week.

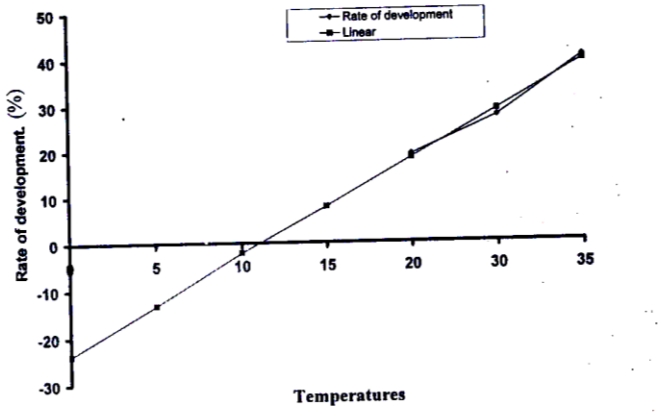


**Fig. 1. Zero and rate of embryonic development in eggs of *H. recurvalis* at constant temperatures**

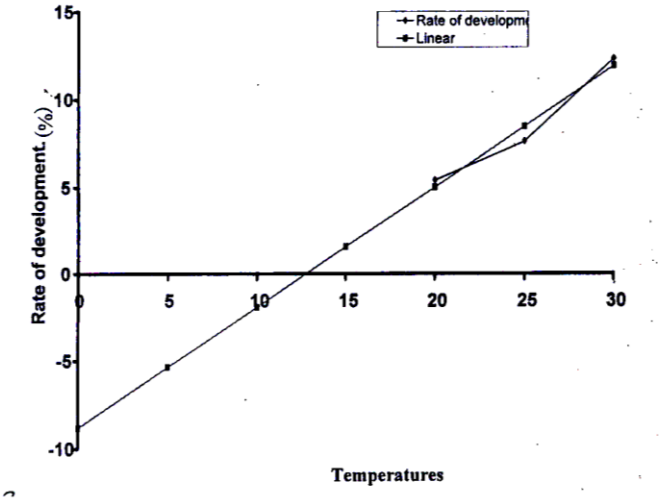


**Fig. 2. Zero and rate of development for larval stage of *H. recurvalis* at constant temperatures**

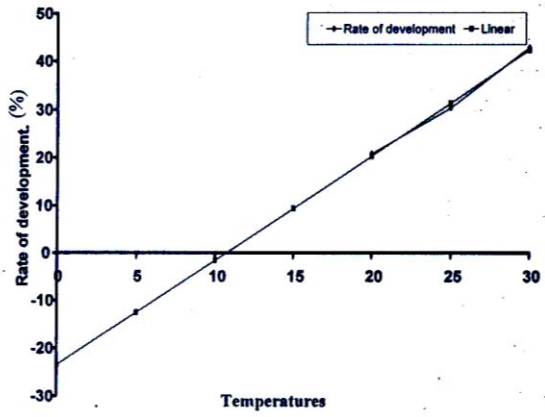


**Fig. 3. Zero and rate of development for pre-pupal stage of *H. recurvalis* at constant temperatures**

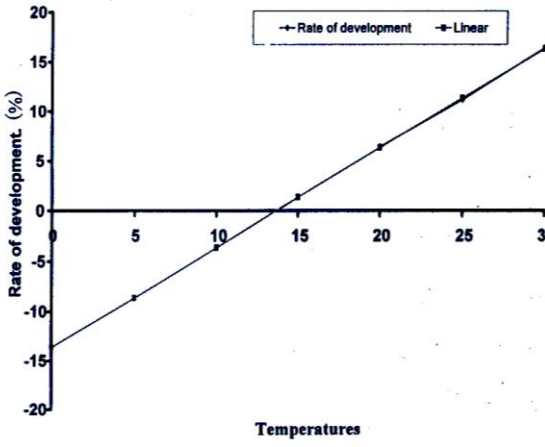


**Fig. 4. Zero and rate of development for pupal stage of *H. recurvalis* at constant temperatures**

**2. Estimation of the threshold of development for the different immature stages of *H. recurvalis***

**2.1. Egg stage**

The relation between temperature and rates of egg development was calculated by the equation; y = -23.807 ± 2.102 x. As shown in (Table, 2), hypothetical threshold of development used in the present experiment was out of the tested temperatures. The estimated threshold of egg development was found to be 10.97°C, which was calculated according to **Alrouechdi, (1986)** method. As shown in Fig. (2), the threshold temperature for development of *H. recurvalis* eggs was 11.09°C **(Davidoson, 1944)**.

The thermal units required for egg development were 47.59, 51.49 and 47.58 day – degree at 20, 25 and 30°C, respectively (Table 2).

**2.2. Larval stage**

The threshold of development for larval stage was estimated as 12.91°C (Fig. 2), and calculated as 12- 14 °C according to **Alrouechdi, (1986)** which was quite comparable. The thermal units required for larval stage development were 144.62, 168.47 and 144.67 day – degree at 20, 25 and 30°C, respectively (Table, 2).

**2.3. Pre-pupal stage**

The zero for pre-pupal stage development was estimated as 10.80°C (Fig 3). Also, the threshold of pre-pupal development was found to be 10.49°C which was calculated according to **Alrouechdi, (1986)** and the thermal units required for complete development of this stage were 45.65, 47.88 and 45.65 day – degree at 20, 25 and 30°C, respectively.

**4. Pupal stage**

The calculated threshold of development for pupal stage was 13.58°C (Fig. 4). And it was 13.58°C (Fig. 4). The threshold of pupal stage development was 13.55°C, calculated according to **Alrouechdi, (1986)** method. The thermal units required to pupal stage development as shown in (Table, 2) were 99.98, 102.59 and 100.02 day – degree at 20, 35 and 30°C, respectively.

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مجلة اتحاد الجامعات العربية للدراسات والبحوث الزراعية ، جامعة عين شمس ، القاهرة ،١٤(١) ، ٤٤٧-٤٥٦ ، ٢٠٠٦

# بعض النواحي البيولوجية ، والحد الحرج للنمو، والوحدات الحرارية لحشرة *Hymenia recurivalus*

**[٣٠]**

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تناولت هذه الدراسة وصف لأطوار حشرة *H. recurvalis* عند التربية المعملية تحت ظروف درجة حرارة ١٨,٦ ± ٢° م ورطوبة نسبية ٧٠ ± ٥ % و١٢ ساعة إضاءة يومية بالنسبة لفترة حضانة البيض ونسبة الفقس وطول العمر اليرقى وطورى ما قبل العذراء والعذراء فقد بلغوا فى المتوسط ٦ ، ٧٨,٨٦% ، ٢٦,٢٩ ، ٥,٠٤، ١٦,٨٦ يوما . وبلغ عدد البيض الذى تضعه الأنثى ٢٦٣,٢٥ فى المتوسط والنسبة الجنسية حوالى واحد صحيح حيث كانت نسبة الذكور أعلى من نسبة الإناث بمقدار بسيط (١- ١,٣) وكان طول فترة الجيل ٨٢,٤٢ يوما فى المتوسط .

كذلك تم حساب صفر النمو البيولوجى اللازم لنمو طور البيضة وهو ١٠,٩٧°م حسابيا، ١١,٠٩°م بيانيا ومتوسط الوحدات الحرارية المتراكمة اللازمة للنمو هى ٤٧,٥٩، ٥١,٤٩، ٤٧,٥٨ درجة/ يوم عند درجات الحرارة ٢٠، ٢٥، ٣٠°م، على

التوالـى أما صفـر النمو البيولوجى اللازم لنمو طور اليرقـة فهـو ١٢,١٤°م حسابيا، ١٢,٩١°م بيانيـا وأن متـوسط الوحدات الحراريـة اللازمـة للنمو على درجة ٢٠، ٢٥، ٣٠°م هـى ١٤٤,٦٢، ١٦٨,٤٧، ١٤٤,٦٧ درجـة / يوم ، على التوالى. أما بالنسبة لطـور ما قبل العذراء فقد وجد أن صفر النمو البيولوجى اللازم لنموه وتطوره هو ١٠,٤٩°م حسابيا، ١٠,٨°م بيانيا وأن متوسط الوحدات الفعالة اللازمة لنمو طور ما قبل العذراء داخل درجات الحرارة ٢٠، ٢٥، ٣٠°م هى حوالى ٤٥,٦٥، ٤٧,٨٨، ٤٥,٦٥ درجة/ يوم، على التوالى وقد وجد أن صفر النمو البيولوجى لطور العذراء هو ١٣,٥٥، ١٣,٥٨°م عند حسابه حسابيا وبيانيا، على التوالى وأن متوسط الوحدات الحرارية اللازمة لنمو العذراء على درجات ٢٠، ٢٥، ٣٠°م هو حـوالى ٩٩,٩٨ ، ١٠٢,٥٩ ، ١٠٠,٠٢ درجـة/يـوم ، على التوالى.

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**تحكيم:** أ.د أحمـد علـى جمعـه
أ.د رمضان عبد القادر على