# MONITORING THE CHANGES IN THE DEVELOPMENTAL RATE OF THE EUROPEAN CORN BORER *OSTRINIA NUBILALIS* (HUBN.) AS INDICATED BY LIFE TABLE PARAMETERS

**SAADIA A. ABD EL SAMEA**

*Plant Protection Research Institute, Agricultural Research Centre, Dokki, Giza, Egypt*

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***Abstract***

Life table parameters were estimated for *Ostrinia nubilalis* (Hubn.) fed on an artificial diet at serial constant temperatures viz: 18, 22, 26 and 30°C. The optimum temperature was estimated as 26°C characteristic, with the highest net reproductive rate (236) expected females/ female. Mean generation duration was 76.6 days at 18°C, while it was 28.7 days at 30°C. The average thresholds of development was 11.75 °C, while the degree- days required for completion of one *O. nubilalis* generation was 475.47 DDU.

## INTRODUCTION

European corn borer, *Ostrinia nubilalis* (Hubn.) is one of the most destructive insect pests. Maize fields planted after June are heavily infested by *O. nubilalis* which cause reliable losses in corn yields in Egypt. According to Sherif and Lutfallah (1992) 33.6% as general mean reduction in maize yield for plants grown on July, 25$^{th}$ .For this reason maize fields planted before the beginning of May or after end of June may be treated with insecticides to insure grain yield (Isa and Awadallah ,1975).

Temperature is considered as the main environmental factor governing the changes in the developmental rate of insect pests. Lasack *et al.* (1987) indicated that temperature and other factors played a reliable role in regulating the changes in the population developmental rates and consequently the population density of stalk borer insects. Forecasting, however, is essential for the accurate scheduling when integrated control tactics are considered. Such predictions strategy required an understanding of the simultaneous relationship between insect developmental rates and the prevailing corresponding temperatures. This relationship often

described based on temperature driven phenology. The most widely used models are based on accumulated degree-day (DDU) and developmental rates (Gregg, 1981). From the practical point of view, the value of this parameter was particularly interesting for key insects to obtain a useful and good model for forecasting and predicting system of insect populations. This work was pointed on the relationship between temperature and certain biological aspects of which gives a quantitative expression for this relationship, as indicated by life table, zero of development and thermal accumulation parameters.

## MATERIALS AND METHODS

Four hundreds of newly laid eggs (representing four groups each of 100 eggs) were incubated under serial constant temperature degrees viz; 18, 22, 26 and 30 °C. Newly hatched larvae were fed individually in glass vials (2.5 x 7.5 cm) filled to one third with an artificial diet consisted of 213.3 gm kidney beans, 20.0 gm dry yeast, 3.2 gm ascorbic acid, 2.0 gm methyl parahydroxy benzoate, 1.0 gm sorbic acid, 2.0 ml formaldehyde (40%), 12.8 gm agar and 640.0 ml water (Abd EL-Samea 1990). The vials were covered tightly with absorbent cotton plugs and held under the tested constant temperatures. All vials were examined daily and the newly formed pupae were transferred individually to clean vials contained pieces of wetted cotton and incubated until moth emergence. Pairs of newly emerged moths (one female and one male) were introduced into a glass mating cage lined internally with wax paper, as oviposition site, and provided with a piece of cotton soaked in a 20% sugar solution. All cages were also covered with wax paper. Cages were inspection daily to collect laid egg clusters which were kept in Petri-dishes until hatching. Records of durations of the serial stages in addition to total number of eggs/female at each temperature were recorded. Data obtained in the present study was subjected to statistical analysis by F-test.

Specific Life table parameters for cohorts on each of the tested temperatures were thus obtained. The net reproductive rate ($R_0$), instantaneous population growth rate and mean generation duration were estimated according to

Birch (1948) using a Basic Computer Program" Life 48" (Abou-Setta *et al.* 1986). Zero development and degree–days (DDU) of each instar were also determined according to Pruess (1983) and Pedigo (1991).

## RESULTS AND DISCUSSION

Certain biological features of the European corn borer, *O. nubilalis reared* on artificial diet were studied in the laboratory at constant temperature degrees 18, 22, 26 and 30 °C, Table 1. Results obtained indicate the presence of negative relationship between the generation durations of each stage and the corresponding temperatures. The egg incubation periods recorded were 9.0, 6.0, 4.0 and 3.0 days at 18, 22, 26 and 30 °C, respectively. Abd EL-Samea *et al.* (1998) reported that, three days old *O. nubilalis* eggs were successfully kept for 9 days at 15°C with a complete viability. The larval stage lasted about 43, 32, 21 and 16 days at the same respective temperatures, while the pupal duration averaged 16, 9, 7 and 6 days at these serial constant temperatures, respectively. The emerged adult moths lived for 16 days at 18 °C and 8 days at 30 °C. Data in the same Table revealed the presence of significant differences between the mean durations for each stage and the corresponding constant temperatures. El-Kifl *et al.* (1972) mentioned that the life cycle of *Agrotis ipsilon* was affected by temperature which is an important determinant for development. The whole life cycle lasted for 125.6 days at 15°C, 79.6 days at 25°C and 45.4 days at 30°C.

As a matter of life table parameters are fundamental based on biological aspects to emphasize development, survival rates of longevity of adult and fecundity of females, which is representative's basic data for life table analysis. Thus, life tables considered a powerful tool for clarifying and understanding the impact of an external factor upon the growth, survival, reproduction and rate of increase of an insect population (El-Saadany and Hamed (1990) and Wittmeyer and Coudron (2001).

Data in Table 2 showed that, duration required for the completion of one generation was greatly influenced by temperature, i.e. decreases in temperature with the increasing in duration i.e. lasting 78.6, 55.8, 36.5 and 28.7 days at 18, 22, 26 and 30°C, respectively. The same trend was found with total life span; 84.0, 59.7, 43.0 and 33.0 days, respectively. Data in the same Table indicate that, the constant temperature regime of 26°C seems to be the optimum degree for insect survivors and net reproductive rates of the corn borer. The highest net reproductive rate ($R_0$) was 236.03 expected females/female at this degree, while the lowest rate demonstrates 89.19 expected females / female at 30°C. These results are in agreement with the findings obtained by Ali and Darwish (1984) who mentioned that the reduction in the fecundity o f the cotton leaf worm at high temperature could be attributed to various factors.

On the other hand, the highest intrinsic rate of increase *O. nubilalis* was 0.1564 individual/ female/day at 30°C. The population doubling time needed for 11.5 days at 18 °C, decreased to 4.4 days at 30 °C. The highest survival rate (0.92) was obtained at 26°C while the lowest one (0.75) was at 18°C. El-Saadany and Hamed (1990) mentioned that, the cohort generation time of *Spodoptera littoralis* (Boisd.) life table fed on cotton, barseem and castor-oil was 32.51, 32.309 and 33.264, while the finite capacity for increase was 1.164, 1.193 and 1.190, respectively.

Data in Table 2 reveal that, the sex ratio of *O. nubilalis* was approximately 1:1 with a slight bias toward females; 68 and 63% at 18 and 22 °C, respectively. This sex ratio was 50 and 49% females at 26 and 30°C, respectively. This result is in harmony with the finding of Chen and Hasiad (1984) who recorded $R_0$ as 405.91 with 1:1 sex ratio of *S. litura* .

The method of day-degrees was adopted in the assessment of the threshold (zero) of development of the different stages of *O.nubilalis* at four constant temperature degrees namely 18, 22, 26 and 30°C, Table 3. The rate of development calculated for each developmental stage at the different temperatures was illustrated in Fig 1.

The threshold of development was estimated as 12.26, 11.72 and 9.97°C for egg, larva and pupa, respectively. Day-degrees represent the accumulation of heat units of minimum temperatures for 24 hours. The minimal thermal degrees on development took place, but for maximal thermal, heat units are accumulated towards development, Table 3. Data in this table indicated that, the accumulated thermal units (DDU) required for completing the same stages duration were 54.57, 297.84 and 117.29 day-degrees, respectively. Caffrey and Worthley (1927) and Apple (1952) reported threshold temperatures as 44.3, 36.5 and 41.2°F for development of egg, larva and pupa, respectively. However, they stated that the straight-line thresholds (the temperature at which development becomes significant) for egg, larva and pupa were 58.7, 49.7 and 55.4 °F, respectively.

Thermal summation method, represents the hyperbolic relationship between temperature and developmental times given by equation Y (T-11.75) = 475.47, which derived from the linear regression equation Y= -0.0252+0.0021x. The lower threshold of development could be estimated graphically by extrapolation from the Fig 1 was 11.75 for generation of *O. nubilalis*.

The complete development of one generation required 446.43, 512.50, 475.46 and 467.95 degree-days at 18, 22, 26 and 30 °C, respectively, Table 3. The average of total thermal units required for generation of *O. nubilalis* development was 475.47 degree days when estimated using the equation K= Y (T-11.75).

The results obtained from this study can be used as a guide parameter index for prediction purposes and consequently used in integrated control program for managing this pest population in Egypt, to evaluate the proper time needed to make an evaluation of the corn borer infestation especially for late maize plantation (Nili plantation), which suffered greatly from severe infestation with *O. nubilalis* larvae. The accumulative thermal units and low effective temperatures were used by several researchers to predict the seasonal development and emergence of different insects (Eckenrode *et al.*, (1975) and El-Saadany *et al.*, (2003).

Table 1. The changes in the effect of constant temperatures on certain biological features of *O. nubilalis*.

| Temp. °C | Longevity of insect stages (day ) | | | | Life cycle in day |
|---|---|---|---|---|---|
| | Egg | larva | Pupa | Adult | |
| 18 | 9 ±0.05 a | 43±0.80 a | 16±0.12 a | 16±0.21 a | 68± 1.20 a |
| 22 | 6±0.07 b | 32±0.50 b | 9±0.07 b | 13±0.19 b | 47±0.75 b |
| 26 | 4±0.08 c | 21±0.33 c | 7±0.04 c | 11±0.30 c | 32±0.24 c |
| 30 | 3±0.06 c | 16±0.14 d | 6±0.11 d | 08±0.16 d | 25±0.20 d |

Means in the same columns not followed by the same letter is not significantly different ($P< 0.05$)

Table 2. Specific life table parameters of *O. nubilalis* at four constant temperatures.

| Temp. °C | Mean gener . time (day) | Total life span (day) | Survival rate to adult stage | Females/ total | Net reprod-uctive rate ($R_o$) | Intrinsic rate of increase ( $r_m$ ) | Finite rate of increase (exp $r_m$) | Population doubling time DT ( day ) |
|---|---|---|---|---|---|---|---|---|
| 18 | 78.59 | 84.0 | 0.75 | 0.68 | 113.17 | 0.0602 | 1.06 | 11.51 |
| 22 | 55.80 | 59.7 | 0.83 | 0.63 | 150.28 | 0.0898 | 1.09 | 7.72 |
| 26 | 36.54 | 43.0 | 0.92 | 0.50 | 236.03 | 0.1496 | 1.16 | 4.63 |
| 30 | 28.72 | 33.0 | 0.84 | 0.49 | 89.19 | 0.1564 | 1.16 | 4.43 |

Table 3. Threshold temperatures and accumulated thermal requirements for development of *O. nubilalis*.

| Stages | Zero of developme | Accumulated thermal units (DDU) | | | | Average thermal units (DDU) |
|---|---|---|---|---|---|---|
| | | 18 | 22 | 26 | 30 °C | |
| Egg | 12.26 | 51.66 | 58.44 | 54.96 | 53.22 | 54.57 |
| Larva | 11.72 | 270.04 | 328.96 | 299.88 | 292.48 | 297.84 |
| Pupa | 09.97 | 128.48 | 108.27 | 112.21 | 120.18 | 117.29 |
| Generation | 11.75 | 446.43 | 512.50 | 475.0 | 467.95 | 475.47 |

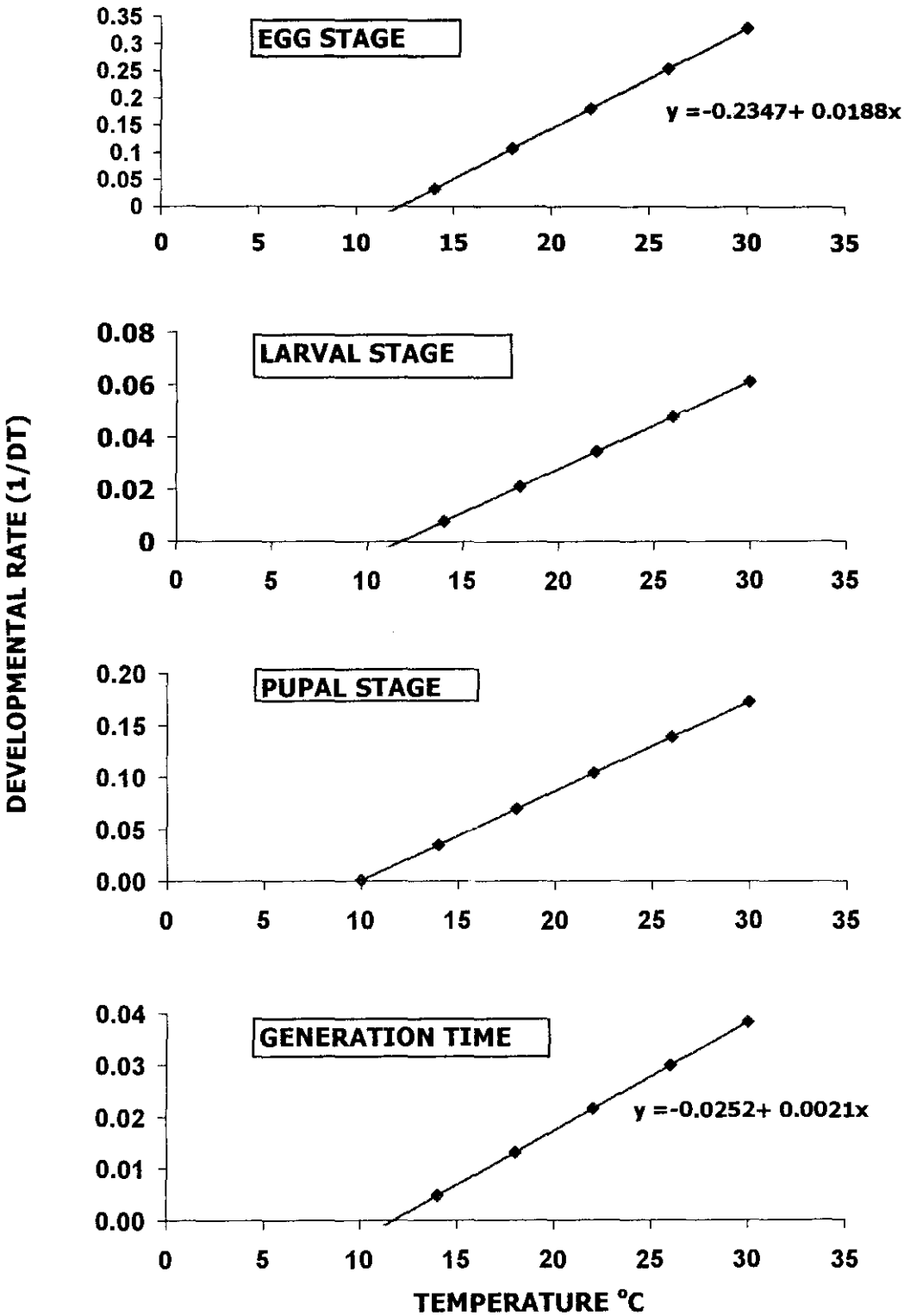


**Fig 1. Calculated developmental threshold for *O. nubilalis***

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# رصد التغيرات فى معدل نمو ثاقبة الذرة الأوروبية *Ostrinia nubilalis* (Hubn.) باستخدام جداول الحياة

**سعدية عبد البصير عبد السميع**

*معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقي – جيزة – مصر*

تـم تربـية دودة الذرة الأوروبية *Ostrinia nubilalis* علي بيئـــة صناعية عند أربعـــة درجـات حـــرارة ثابـتة : ١٨و ٢٢و ٢٦و ٣٠ م وذلـك لدراســة جداول الحياة ، الاحتياجات الحرارية و تقدير حد النمو الحرج لأطوار النمو المختلفة للحشرة. أشارت النتائج إلـــى أن اعلي معدل خصوبة ( ٢٣٦ بيضة/ فرد) كان عند درجة حرارة ٢٦ م – اختلفت مدة الجـيل تـبعا لدرجة الحرارة حيث بلغت أقصاها ( ٧٦,٦ يوما) عند درجة ١٨ م بينما كانت ٢٨,٧ يومـــا فقط عند درجة ٣٠ م. ظهر من الدراسة أن صفر النمو البيولوجي للجيل الكامل لهذه الحشرة ١١,٧٥ م ويحتاج الجيل الى ٤٧٥,٤٧ وحدة حرارية لكي يكتمل.