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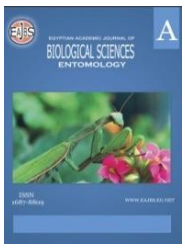

Biological Study of Cucurbit Fruit Fly, *Dacus ciliatus* (Loew) on Constant Temperatures

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Tephritidae, *Dacus ciliates*, Cucurbit fruit fly, Threshold Temperature.

ABSTRACT

Development of the cucurbit fruit fly *Dacus ciliates* (Loew) (Diptera: Tephitidae) was studied at constant temperatures (15, 20, 25 and 30 ± 1℃). The development of immature stages was accelerated by rising of tested temperatures. Development stages average of eggs, larvae, pupal and pre-oviposition period ranged between (31.13 and 3.47), (37.07 and 5.80), (30.27 and 7.20) & (33.13and 5.73) days on 15 and 30℃, respectively. Also, total immature stages ranged between 98.47 and 16.47 days on 15 and 30℃, respectively. Whereas, Generation period ranged between 131.60 and 22.20 days on 15 and 30℃, respectively. Additionally, adult females survived slightly longer than males, also life span, and sex ratio. While the estimated (t_o) threshold temperatures stages eggs, larval, pupal and pre-oviposition period were 15.05, 13.39, 10.64 and 13.11 heat units (U.T.) at 15, 20, 25 and 30℃ ±1℃, respectively. Based on 30℃ estimations are required to complete the development of all immature stages. Also, Thermal requirements (K) D.D.'s were estimated to be 58.35, 97.07, 133.58 & 103.81 for eggs, larval, pupal and pre-oviposition periods at 15, 20, 25 and 30℃ ±1℃, respectively. And development for one generation required 386.17 D.D′s, The study showed that with the identification of threshold temperatures (t_o) and thermal units (K) for generation calculated nine expected generations in the field they: two generations in spring, four generations in summer, two generations in autumn, one generation in winter.

INTRODUCTION

Dacus ciliatus is widespread in Africa and Asia. Details on its distribution are available in the EPPO Global Database (EPPO, 2018). Larvae of *D. ciliatus* develop in the fruits of a wide range of cucurbit crops and wild Cucurbitaceae but are also reported from several other plant families. cucumbers and melons are considered the main potential hosts, the USDA Compendium (Peck & McQuate, 2000). Also, cucurbit fly classification preferred Scientific Name**:** *Dacus ciliatus* Loew, Preferred Common Name**:** lesser pumpkin fly Taxonomic position: Class**:** Insecta**:** -Order: Diptera-Family: Tephritidae, International Common Names (English)**:** cucurbit fly; Ethiopian fruit fly; lesser melon fly. The genus *Dacus* belongs to the family Tephritidae. *Dacus ciliatus* have patterned wings, and the female has a long telescopic and pointed ovipositor (CABI, 2016). EPPO lists *D. ciliatus* as an A1 quarantine pest, within the category "non-European Tephritidae" (EPPO, 2018); it is also of quarantine significance to many other countries. In 2018, a problem that emerged in cucumber cultivation areas of the southeastern Anatolia Region (Diyarbakır, Mardin, Siirt and Şırnak) was identified. *D. ciliatus* Loew 1862 (Diptera: Tephritidae) was found in the region causing damage to melons and watermelons. *Dacus ciliatus* is a polyphagous species,

included in the European quarantine list by the European and Mediterranean Plant Protection Organization, that causes economic losses on plants, especially in the Cucurbitaceae. This report on *D. ciliatus* is the first for agriculture and the fauna Tephritidae in Turkey, (Filiz Çalişkan K., *et. al.*, 2019).

In Egypt, recently and with changing climatic factors the outbreak of this pest appeared on the fruits of the cucurbit plants and it became a big problem for farmers, and this problem requires studying and determining the cause of its population increase. The study is based on the biological changes of cucurbit flies at different temperatures under laboratory conditions, and the results used to predict the expected prediction of *D. ciliates*, it is useful in determining the early dates of infestation in the field and preparing for the control.

MATERIALS AND METHODS

The experiment was carried out in the laboratory of the Department of Research Vegetable Pests at the Plant Protection Research Institute, Giza Governorate, during the years 2021 and 2022. Infested squash fruits were collected from the field in Qaha City, Qalyoubia Governorate. These fruits were kept at room temperature in a glass vessel followed until adult emergence. Obtained adults were used to deposit their eggs on new fruits (uninfestation) to start the experiments, adult flies were fed on sugar with water and yeast protein hydrolysate at a ratio of 3:1(Jean-François, 2008), respectively. All stages egg to adult were kept under the aforementioned conditions to determine the developmental rate and other biological parameters of each stage in a glass tube were taken for each constant temperature, during the pre-oviposition, oviposition, post-oviposition periods add uninfested squash fruits for the adult, replicates of the glass tube for infestation squash fruits changed daily. Four incubators were used to provide constant temperatures at 15, 20, 25 and 30℃ (each incubator contained 15 glass tubes as replicates and relative humidity ranged between 55 - 70±5 R.H % (Use a hygrometer to measure R.H%) under a light period of 12:12 L:D).

The effect of the above-mentioned conditions was tested on the immature and adult stages of *D. ciliatus*. The theoretical development thresholds were determined according to the following : (a) the points obtained when the time (y) in days is plotted against temperature (T) in centigrade degrees so that the distribution of these points indicates the course of the temperature-time curve, (b) the points obtained when the reciprocal for time (1/y) in days are plotted against temperature (T) in centigrade degrees, each of the reciprocal is multiplied by 100 so that the values on the ordinate (100/y) represent the average percentage of development made by the stage per day at the given temperature. Therefore, the distribution of the points indicates the course of the temperature curve (Davidson, 1944), (c) the point at which the velocity line crosses the temperature axis is the threshold of development in degrees centigrade. Thermal units required for the complete development of each stage were determined according to the equation of thermal summation (Blunk.1923): Also, from the straight-line equation y= a+bx we can determine the two constants:

t_o = -a/b (℃) and K=1/b also K= y (t- t_o) in D.D′s.

Where: a: constant term it is the y-intercept, the place the line crosses the y-axis.
b: the developmental rate line slope. X: constant temperature (℃).
t_o: temperature threshold of development in degrees centigrade.
K: The developmental heat constant in degree-days (D. D.'s).
y: developmental duration of a given stage. t: temperature in degrees centigrade.

To study the prediction possibility in relation to heat unit accumulations (K), the temperature data is transformed into heat units and served as a tool for studying insect population dynamics and predicting the appearance of the squash fruits in the field. The developmental threshold value has been estimated after the constant temperature experiment carried out before. Where the zero development (t_o) was 13.37℃ for *D. ciliatus* generation. The following formula was used for computing the heat units (D. D's) according to Richmond *et. al*. (1983):

$$H = \Sigma HJ$$

HJ = (Max. + Min.)/ 2-C, if max.>C & min.>C.
= (max.- C)2 /2(max.- min.) if max >C & min.<C
= 0 if max. <C & min.<C.

H = Number of accumulated heat units to emergence.
C = Threshold temperature.

RESULTS

Data obtained in Table (1), showed the results of rearing the cucurbit fruit fly at different temperatures, and they were as follows:

A) Eggs Stage:

In this stage, the incubation period of *D. ciliatus* was markedly affected by the tested temperature. Showed the infestation in squash fruit formed a circle in the infestation part of the fruits by egg laying machine of female, where layed eggs at the mid-fruit, as shown in Fig. (1). Data in Table (1), showed that the Mean of Incubation Periods of eggs were 31.12±1.05,19.60±0.55, 7.20±0.22 and 3.47±0.13 days at 15, 20, 25 and 30°C, respectively. While the rate of development was retarded at lower temperatures recorded at 0.03, 0.05, 0.14 and 0.29 at 15, 20, 25 and 30℃**,** respectively. On the other hand, the estimated threshold of egg development (t_0) was 15.05°C, but the thermal units were (K) 58.35 D.D.'s, gave R^2= 0.896.

b) Larval Duration:

Obtained results in Table (1) & Fig. (2), showed that larval duration differs in its development which is affected by the tested temperatures, where increased development with increased temperature and was active, the larvae live in more than one tunnel numbers in the place of infestation inside the fruit. Add sawdust for larval pupation (by curling them into a ∩-shape and then quickly straightening) and jump out of the fruit onto the sawdust for pupation. The obtained data in Table (1) show that the average larval duration were 37.07±1.12, 26.67±0.98, 8.60±0.27 and 5.80±0.22 days at 15, 20, 25 and 30°C, respectively. Also, the rate of development was 0.03, 0.04, 0.12 and 0.17 at 15, 20, 25 and 30℃**,** respectively. While, the estimated threshold of larval development (t_0) was 13.93°C, whereas the thermal units were (K) 97.07 D.D.'s, gave R^2= 0.934.

c) The Pupal Duration:

The pupa of *D. ciliatus* is a coarctate type as shown in Fig. (3) it's jumping into sawdust the duration varies according to the tested temperature until the emergence of adult fly, as shown in Fig. (4). Data in Table (1), indicated that the average of pupal duration were 30.27±0.90, 15.80±0.49, 8.33±0.25 and 7.20±0.24 days at 15, 20, 25 and 30°C, respectively. Whereas, the rate of development recorded 0.03, 0.06, 0.12 and 0.14 at15, 20, 25and 30℃, respectively. The estimated threshold of pupal development (t_0) was 10.64°C, where the thermal units were (K) 133.58 D.D.'s, gave R^2= 0.967.

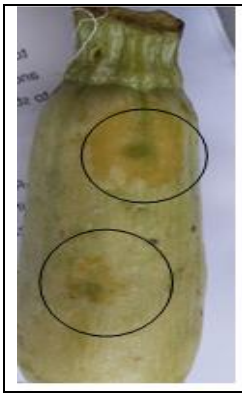

Fig. 1: Infestation on fruits

Fig. 2: Larval stage

Fig.3: Pupal stage

Fig.4: Adult stage

Table 1: Influence of four constant temperatures on the biological aspects and estimation of the required thermal units of *D. ciliatus* reared on squash fruits.

Variable	Temp (°C)	Mean of Incubation Periods of eggs	Mean of Larval duration	Mean of Pupal duration	Total immature stages.	Pre-oviposition Period	Generation
Duration/ day	15	31.13 ± 1.05	37.07 ± 1.12	30.27 ± 0.90	98.47 ± 1.85	33.13 ± 1.24	131.60 ± 2.33
	20	19.60 ± 0.55	26.67 ± 0.98	15.80 ± 0.49	62.07 ± 1.17	18.47 ± 0.59	80.54 ± 1.43
	25	7.20 ± 0.22	8.60 ± 0.27	8.33 ± 0.25	24.13 ± 0.24	9.73 ± 0.34	33.86 ± 0.46
	30	3.47 ± 0.13	5.80 ± 0.22	7.20 ±0.24	16.47 ± 0.35	5.73 ± 0.21	22.20 ± 0.24
Rate of development	15	0.03	0.03	0.03	0.01	0.03	0.01
	20	0.05	0.04	0.06	0.02	0.05	0.01
	25	0.14	0.12	0.12	0.04	0.10	0.03
	30	0.29	0.17	0.14	0.06	0.17	0.05
Regression values	Intercept	-0.258	-0.144	-0.080	-0.048	-0.13	-0.03
	Slope	0.017	0.010	0.007	0.004	0.01	0.00
	t_o (°C)	15.05	13.93	10.64	13.43	13.11	13.37
	K (D. D.s)	58.35	97.07	133.58	282.40	103.81	386.17
	R^2	0.896	0.934	0.967	0.953	0.953	0.956

Average ± S. E.

D) The Total Immature Stages:

The immature stages decreased with increasing temperatures recorded at 98.47±1.85 &16.47±0.35 days at 15 to 30˚C, respectively. Also, the estimated threshold of immature stages (t_0) was 13.43˚C. While, the rate of embryo development was positively dependent on the temperature they were 0.01, 0.02, 0.04 and 0.06 at 15, 20, 25 and 30℃, respectively. The required thermal units (K) was 282.40 D.D.'s, gave $R^2 = 0.953$.

E) Pre-oviposition Period:

The Pre- oviposition period decreased with increasing temperatures and developmental rates increased with increasing tested temperatures, with the estimated threshold of Pre- oviposition (t_0) at 13.11˚C. Whereas, the average of the pre-oviposition period were 33.13±1.24, 18.47±0.59, 9.73±0.34 and 5.73±0.21 days at 15, 20, 25 and 30˚C, respectively. While, the rate of development there was 0.03, 0.05, 0.10 and 0.17 at 15, 20, 25 and 30℃, respectively. Recording the thermal units lasted to (K) 103.81 D.D.'s, gave R^2=0.953, shown Table (1).

e) The Generations Duration:

Data in Table (1) indicated that the generation decreased with temperature increase and the average generation was from 131.60±2.33 to 22.20±0.24 days from 15 to 30℃, respectively. While, the rate of development they were 0.01, 0.01, 0.03 and 0.05 at 15, 20, 25 and 30℃, respectively. The estimated threshold of generation

(t_0) was 13.37℃. Recorded thermal units (K) 386.17 D.D.'s, gave R^2= 0.956. From the previous results, we calculate the number of expected generations in the field according to Richmond *et. al*. (1983) with the identification of threshold temperatures (t_o) and thermal units (K) for generation calculated nine expected generations in the field they: two generations in spring, four generations in summer, two generations in autumn, one generation in winter.

E) Oviposition and Post-Oviposition Period:

The results in Table (2) showed that the oviposition period decreased with increasing temperatures of tested temperatures, where the average oviposition period were 39.53±1.52, 33.53±0.90, 26.20±1.01 and 14.40±0.47 days at 15, 20, 25 and 30°C, respectively. Also, the rate of development there were 0.03, 0.03, 0.04 and 0.07 at 15, 20, 25 and 30℃**,** respectively. The estimated threshold (t_0) was 8.05 °C. whereas, the average of thermal units was (K) 355.15 D.D.'s, giving R^2= 0.834. While, the average of the post-oviposition period were31.40±0.40, 15.27±0.56, 13.60±0.52 & 8.67±0.25 days at 15, 20, 25 and 30°C, respectively. Also, the rate of development was (0.03, 0.07, 0.07 and 0.12) at 15, 20, 25 and 30℃, respectively. additionally, the estimated threshold recorded (t_0) is 8.66 °C. The thermal units (K) 193.41 D.D.'s, gave R^2= 0.945.

F) The longevity Adult:

Data in Table (2) indicate that the average of *D. ciliatus* longevity for female duration recorded at 98.27±6.23, 67.27±1.13, 49.53±1.03 and 28.80±0.58 days, and for the male period were 73.40±1.82, 60.20±1.37, 35.07±1.20 and 21.87±0.88 days at 15, 20, 25 and 30°C, respectively. The rate of development of longevity in females reached (0.01, 0.01, 0.02 and 0.03) & (0.01, 0.02, 0.03 and 0.05) at 15, 20, 25 and 30℃ for males**,** respectively. Additionally, the estimated threshold for both females and males where (t_0) 9.84 & 10.43°C, respectively. The average of thermal units for both females and males was (K) 633.21 &462.08 D.D., respectively. showed the (R^2) for both females and males recording 0.918 & 0.920, respectively.

g) The Life Span and Sex Ratio:

The results in Table (2) indicated that the average life span was 196.73±6.84, 129.33±1.65, 73.67±1.00 & 45.27±0.57 days, and 171.87±2.55, 123.27±1.39, 60.07±1.03 & 38.33±1.03 days at 15, 20, 25 and 30 °C for females & males, respectively. reached the rate development of Life span was (0.01, 0.01, 0.01 and 0.02) for females (0.01, 0.01, 0.02 and 0.03) at 15, 20, 25 and 30℃ for mal, respectively.

Table 2: Influence of four constant temperatures on the biological aspects and estimation of the required thermal of *D. ciliatus* reared on squash fruits**.**

Variable	Temp. (°C)	Oviposition	Post-oviposition	Longevity		Life span		Sex ratio %	
				Female duration	Male Period	Female duration	Male Period	Female	Male
Duration	15	39.53 ± 1.52	31.40 ± 0.40	98.27 ± 6.23	73.40 ± 1.82	196.73 ± 6.84	171.87 ± 2.55	49.65	50.35
	20	33.53 ± 0.90	15.27 ± 0.56	67.27 ± 1.13	60.20 ± 1.37	129.33 ± 1.65	123.27 ± 1.39	50.41	49.59
	25	26.20 ± 1.01	13.60 ± 0.52	49.53 ± 1.03	35.07 ± 1.20	73.67 ± 1.00	60.07 ± 1.03	54.90	45.10
	30	14.40 ± 0.47	8.67 ± 0.25	28.80 ± 0.58	21.87 ± 0.88	45.27 ± 0.57	38.33 ± 1.03	53.29	46.71
Rate	15	0.03	0.03	0.01	0.01	0.01	0.01		
	20	0.03	0.07	0.01	0.02	0.01	0.01		
	25	0.04	0.07	0.02	0.03	0.01	0.02		
	30	0.07	0.12	0.03	0.05	0.02	0.03		
Regression values	Intercept	-0.023	-0.045	-0.016	-0.023	-0.013	-0.017		
	Slope	0.003	0.005	0.002	0.002	0.001	0.001		
	t_0 (°C)	8.05	8.66	9.84	10.43	11.84	12.29		
	K (D. D.s)	355.15	193.41	633.21	462.08	879.33	721.01		
	R^2	0.834	0.945	0.918	0.920	0.949	0.944		

Average ± S. E.

Additionally, the estimated threshold of the Life span for both females and males where (t_0) 11.84 & 12.29°C, respectively. The average of thermal units for both females and males was (K) 879.33 & 721.01 D.D.'s, respectively. Gave (R^2) for both females and males recording 0.949&0.944, respectively.

While, the sex ratio percentage recorded 49.65, 50.41, 54.90 & 53.29% and 50.35, 49.59, 45.10 & 46.71% for females & males at 15, 20, 25 and 30°C, respectively.

the shortest life span of *D. ciliatus* under constant temperature (30°C) while the longest period occurred at 15°C. This explains the decrease in infestation in the cold months and the increase in the infestation of squash fruits in the hot months, shown in Table (2). The shortest life span of *D. ciliatus* was under constant temperature (30°C) while the longest period occurred at 15°C and sexual ratio also.

DISCUSSION

The obtained Data indicated that the immature stages of *D. ciliatus* developed successfully within a temperature ranging between 15 to 30°C. Whereas, temperature thresholds of eggs, larvae and pupae were 15.05, 13.93 and 10.64°C, respectively. Meanwhile, the thermal units for eggs, larvae and pupae recorded 58.35, 97.07 and 133.58 D.D.'s, respectively. These findings are in general agreement with those obtained by many authors such as Jean-François *et. al.* (2008) and Dhillon *et. al.* (2005) who found similar results for the incubation period. On the other hand, Mahmoud (2016) showed agreement with similar results of the larval duration reaching 27, 13, 8 & 4.50 days at 15, 20, 25 and 30 °C, respectively, the results of the other stages are similar to this study. Also agree with many authors, who showed that the hatching period decreased with an increase in temperature from (15°C to 30°C) Younes and Akel (2010). Also, the data on *D. ciliatus* morphology in immature and adult agree with EPPO Datasheet (2021) and the morphology of adult also agree with Badr (2009).

Conclusion

The Cucurbit Fly, *D. ciliatus* (Loew) (Diptera: Tephritidae) was reared on squash fruits to study the effect of four constant temperatures (15, 20, 25, and 30°C) on certain biological aspects. The incubation period, larval duration and pupal duration were estimated. The time required for development was decreased as the temperature increased from 15 to 30°C. The differences between the four tested temperatures in incubation periods and adult longevity were significant. Larvae raised at 30°C transformed into pupae in a much shorter time than those raised below 15°C. The calculated number of expected generations was nine in the field: two generations in spring, four generations in summer, two generations in autumn generation, and one generation in winter.

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ARABIC SUMMARY

دراسة بيولوجية لذبابة ثمار القرعيات على درجات حرارة ثابتة
Dacus ciliatus (Loew)

محمد إبراهيم عوده، عصام على محمد موسى و فتينة بيومي
معهد بحوث وقاية النبات – مركز البحوث الزراعية – الدقى – جيزة - جمهورية مصر العربية.

تمت دراسة بيولوجية لحشرة ذبابة ثمار القرعيات *D. ciliates* على اربعة درجات حرارة ثابتة 15 , 20 ، 25 و 30 ± 1 مْ ، وأظهرت النتائج ان معدل النمو لمجموع الاطوار غير الكاملة (98.47 ، 62.07 ، 24.13 ، و 16.47 يوم) على درجات حرارة 15 ، 20، 25 و 30 مْ على التوالى. وأظهرت نتائج الدراســة أن فترة الجيل تختلف بأختلاف درجة الحرارة حيث تراوحت بين 131,60 و 22,20 يوم على درجة حرارة 15 و30 مْ على الترتيب. أوضــحت نتائج دراســة الحد الحرج للنمو (صفر النمو) لمراحل النمو لطور البيض و اليرقة والعذراء وما قبل وضع البيض و الجيل وكانت النتائج 15,05 ، 13,93 ، 10,64 ، 13,11و13.37 مْ على درجات حرارة 15 ، 20، 25 و 30 مْ على التوالى. أظهرت أيضاً نتائج دراســة حســاب الاحتياجات الحرارية المجمعة لتطور معدل النمو لطور البيض و اليرقة والعذراء وما قبل وضــع البيض و الجيل وكانت النتائج 58,35، 97,07 ، 133,58 ، 103,18 و 386,17 وحده حرارية على التوالى.
ومن النتائج الســابقة ومعلومة صــفر النمو والوحدات الحرارية للجيل أمكن حســاب تســعة أجيال متوقعة لذبابة ثمار القرعيات فى الحقل هم:
جيلان فى الربيع ، اربعة أجيال فى الصيف ، جيلان فى الخريف ، واحد جيل فى الشتاء .