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Development Rate, Mortality and Growth Rate of Immature *Chrysomya albiceps* (Wiedemann) (Diptera: Calliphoridae) at Constant Laboratory Temperatures

Fahad A.M. Al-Misned, Mikky A.Amoudi and Salah. S.M. Abou-Fannah

Department of Zoology, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia

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Abstract. Total developmental time of *Chrysomya albiceps* (Wiedemann) from egg to adult was 18.5, 14.1, 9.8 and 9.2 days when reared at 20, 25, 30 and 35 °C, respectively, at 15 °C all pupae did not develop to adult stage, and there were no significant differences between sexes ($p>0.05$). Estimates of the lower developmental threshold temperatures (t_L) were 10.5, 7.7, - 11.0, 5.0, 6.7, and 5.9°C and the thermal constant (K) were 9.8, 99.8, 78.2, 159.8, 88.6 and 258.5 degree - days (DD) for eggs, feeding larvae, wandering larvae, larvae (feeding+ wandering), pupae, and total developmental time, respectively. The lowest proportion of mortality was recorded at 25 and 30°C. Flies reached their maximum weight in pupal and adult stages at 25°C, whereas minimal weights were recorded at 35°C. Regardless of temperature, the mean weight of pupa and adult was smaller ($p<0.001$) in males than in females. The developmental rate, low mortality and greatest weight reached their optimal condition between 25 and 30°C.

Introduction

Chrysomya albiceps is an important insect in the tropical and subtropical areas [1]. It has been reported to be potentially important vector of enteric pathogens [2-3]. It is also responsible for cutaneous myiasis both in man and animals [4] and is widespread in Saudi Arabia and Oman [5]. There is also report of being involved in calf myiasis [6]. *C albiceps* is considered to be myiasis producers in Egypt [7]. In South Africa, *C. albiceps* is classified as a major problem in sheep; so it is known as sheep blow fly [7]. There are two reports, one on human cases in India [8] and the other on the effects of cadmium on life cycle parameters [9]. As no previous work on the effect of temperature on the biology of immature stages of this fly has been reported from Saudi Arabia; however, several works have been published on other species [10 to13]. Temperature as we know is a key factor in determine insect behaviour and insect life, several adaptive mechanisms such as tolerance that have evolved in response to the change in

environmental temperature. The fact that flies have been exposed to high a temperature have shown less potential to survive suggesting that such fl susceptible to high and low temperature. We identified the developmental sta sensitive to temperature regulation, larvae were most likely to be affected temperature and pupae failed to develop to adult; such information we conclu developmental rates and temperature threshold could be very useful in predic emergence and periods of risk for myiasis in the field which allow to imp chemical and biological control more effectively.

Materials and Methods

Stock colony

During November 1991, *C. albiceps* adults were collected using aerial n Riyadh city, Saudi Arabia. The colony was maintained in the laboratory on cow an environmental chamber at 25°C, 60-65% RH, and a 15:9 (L:D) h photope described by Amoudi *et al.* [14].

Developmental time

Egg, larval and pupal stages of *C. albiceps* were reared at the constant tempe of 15,20,25,30 and 35±1°C, 60-65% RH, and a 15:9 (L:D)h photoperiod. Egg were removed from the stock colony within an hour of oviposition and pla moistened filter paper in a covered petri dish at constant temperatures until hatchi completed. Eggs were observed with a binocular microscope every hour incubation period was recorded for individual eggs. Eggs were measured (leng width), measurements of the width were of the widest portion of the eggs.

Ffty newly hatched larvae (o to 6h old) were placed in rearing jars (5 cm 10cm. diameter) lined with aluminum foil and containing 100g cow liver. Reari were placed in larger jars (18cm deep X 14cm. diameter) 4cm. filled with sawdu space between the jars sides also was filled with sawdust. The large jars had cover with holes (5cm diameter) covered with cloth to permit ventilation. All jar subjected to treatment temperatures for 48h before use. Two replicate jars were determine developmental time and four replicates were used for measureme feeding larvae at each temperature.

Developmental time for feeding larvae was determined after larval grow completed and the larvae began to crawl out of the media. Larvae then were trans daily to new jars (14 cm deep X 21cm diameter) containing 4cm deep of sawdu were checked at 12-h intervals until pupation to determine wandering developmental time. Daily ten larvae were isolated from the medium, killed in b water, weighed, removed to filter paper and measured (length and width), measure of the width were of the widest part of body.

Fresh pupae were weighed and then placed separately into vials (5cm d 2.5cm diameter) with 10mm of sawdust, vials were covered by cloths held by band until adults emergence to determine the pupal developmental time. Upon emergence, flies were etherized lightly, weighed, and their sex was determined.

All weights were measured on an electronic balance (Ac-100 balance; Mettler Instrument, Zurich, Switzerland; accuracy, 0.1mg). Length and width were measured using a binocular microscope with a micrometer.

Data analysis

Lower thresholds (t_L) for development were estimated from the linear regression of the developmental rate (y =1/developmental time) on constant temperature (X) [13,15]. The thermal constant (K) was calculated from the equation K=y (d - t), were y is the developmental time (days), d is the temperature (°C), and t is the theoretical developmental threshold temperature (°C) [16]. The thermal constant was calculated for each temperature to obtain the overall K (Mean ± SD) for each life stage. Values of K represent the number of degree- days (DD) above the threshold needed for development. Pupal and adult weights were compared among temperatures by analysis of variance (ANOVA). Student's t test was used to compare males and females.

Results and Discussion

Developmental time

Developmental time of *C. albiceps* immature stages at five constant temperatures is presented in Tables 1, 2, 3. Sexes were combined since an initial analysis indicated no significant differences ($P>0.05$) between males and females. Developmental time generally decreased with increasing temperatures, while it was slow at 15 °C and all pupae did not develop to adult stage. Developmental time is several days shorter in *C. albiceps* than in some other Sarcophagid flies such as *Wohlfahrtia nuba* Wiedemann [11], *Parasarcophaga ruficornis* (F.) [12] and *Bercaea cruentata* (Meigen) [10]. The overall mean of the developmental times (Mean ± SD) for eggs, feeding larvae, wandering larvae, combined feeding and wandering larvae, pupae, and egg to adult were: males: 0.7 ± 0.3, 5.5 ± 2.1, 1.9 ± 0.6, 7.4 ± 2.5, 4.7 ± 1.6, and 12.8 ± 4.3 days, respectively; females: 0.7 ± 0.3, 5.6 ± 2.1, 2.2 ± 0.5, 7.8 ± 2.5, 4.6 ± 1.7, and 13.0± 4.3 days, respectively. The developmental rate within the range of 20 - 35 °C was linear (Fig. 1). In contrast, the developmental rate was linear within the range of 21-33 °C for *W. nuba* [11], 16-34 °C for *P. ruficornis* [12] and 17-29 °C for *B. cruentata* [10].

Regardless of the rearing temperatures used in this study, the percentage duration for egg, feeding larvae, wandering larvae, combined feeding and wandering larvae and pupae required 5.0 ± 0.5, 42.5 ± 1.7, 16.6 ± 3.4, 59.1 ± 2.2 and 35.8 ± 2.1 (Mean ± SD%) of total developmental time, respectively.

The regression equations (20-35°C, n=4) for the mean developmental rate (1/days), lower developmental thresholds (t_L) and degree - days (K) for each stage are presented in Table 4. The linear regression models were constructed using pooled developmental time for males and females because duration of *C.albiceps* life stages was not consistently different between sexes. The lower developmental threshold temperatures (t_L) and the degree - days (K) were calculated to be 5.9 °C and 258.5 ± 15.4 DD for total developmental times (egg to adult), respectively. Coefficients of determination (R^2) were 99.7, 88.5, 99.4, and 95.1% for eggs, larvae (feeding + wandering), pupae, and total

developmental time (egg to adult), respectively, indicating a good linear model fit in all cases (Fig. 1). Degree- days required by *C. albiceps* to complete total developmental time was less than by other species; *W. nuba* required 268 DD above 13.6°C [11] and *P. ruficornis* required 388 DD above 7.7°C [12] but it was higher than in *B. cruentata* required 229 DD above 12.9 °C [10].

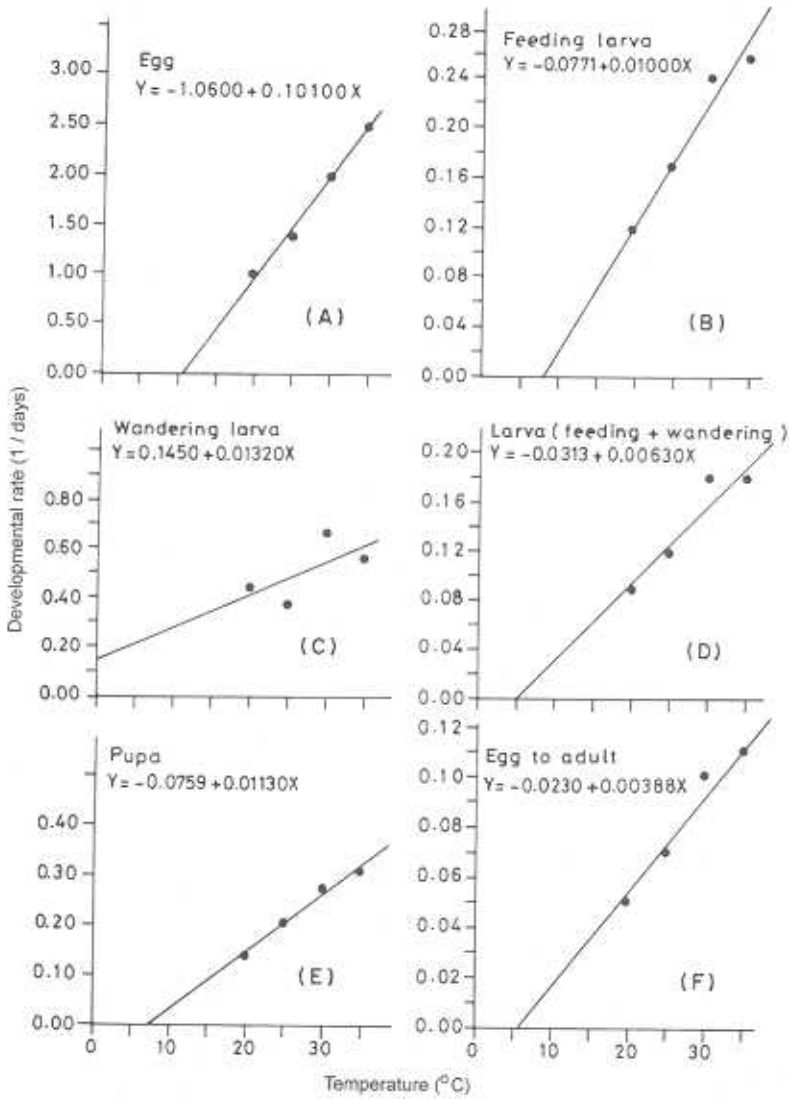

Fig. 1. Developmental rates for immatures of *C. albiceps* under different constant temperatures. (A) egg, (B) feeding larva, (C) wandering larva, (D) feeding + wandering larva, (E) pupa, (F) egg to adult.

Mortality

Mortality of the immature stages is summarized in Table 5. The highest proportion of mortality was recorded at 15, 20 and 35°C, and at 15°C all pupae failed to develop to the adult. The lower proportion of total mortality was calculated to be 1 and 5% at 25 and 30°C, respectively. In contrast, Amoudi *et al.* [12] found that the lower proportion of total mortality of *P. ruficornis* were 10% at 28°C and Al- Misned and Abou- Fannah [10] found that it is 13% at 25°C for *B. cruentata*, whereas Amoudi [11] found that the pupal mortality for *W. nuba* was low at all temperatures used. In general, the larval stage was affected more by low temperatures than high temperatures, whereas the pupal stage was more affected at both low and high temperatures. In contrast, Amoudi *et al.* [12] and Al- Misned and Abou- Fannah [10] found that the larval stage was affected more by low temperatures than the pupal stage, whereas the pupal stage was more affected at high temperaturrs for *P. ruficornis* and *B. cruentata*, respectively. A large proportion of the immature stages did not survive at 35°C (Table 5), indicating that the upper developmental threshold was between 30 and 35°C. This result is typical of these for *P. ruficornis* (31-34°C) [12] and for *B. cruentata* (33°C) [10].

Growth rate

Eggs collected following oviposition at 25°C range in length from 1.44 to 1.61 mm (Mean ± SD = 1.46 ± 0.09 mm); the width range from 0.24 to 0.32 mm (Mean ± SD = 0.26 ± 0.04 mm). The growth rates curves of the feeding larvae under different constant temperatures are shown in Fig. 2. Maximum weight, length, and width of the final feeding larval stages were attained at 25°C. Larvae reared at 15°C had a very slow rate of growth until 17 days approximately.

The mean weight of pupae and adults (combined sexes) varied significantly among temperatures for pupae ($F = 188.5$; $df = 4, 313$; $p<0.001$) and for adults ($F = 189.9$; $df = 3, 290$; $p<0.001$) (Table 6). Maximum pupal and adult weights were attained when reared at 25 °C, pupal and adult weights at 25 °C were larger than at 20 and 30 °C ($P<0.001$). In comparison, the maximum pupal and adult weights for *W. nuba* were recorded at 21°C [11], for *P. ruficornis* at 25 and 28 °C [12] and for *B. cruentata* at 21 and 25°C [10]. There were significant differences ($P<0.05$) between sexes in pupal and adult weights at 20, 25 and 35 °C. Regardless of the rearing temperatures, there were significant differences between sexes in pupal weights ($t= -7.05$; $df = 292$; $P<0.001$) and adult weights ($t = -9.3$; $df = 292$; $P< 0.001$), pupal weights and adult weights were smaller in males than in females.

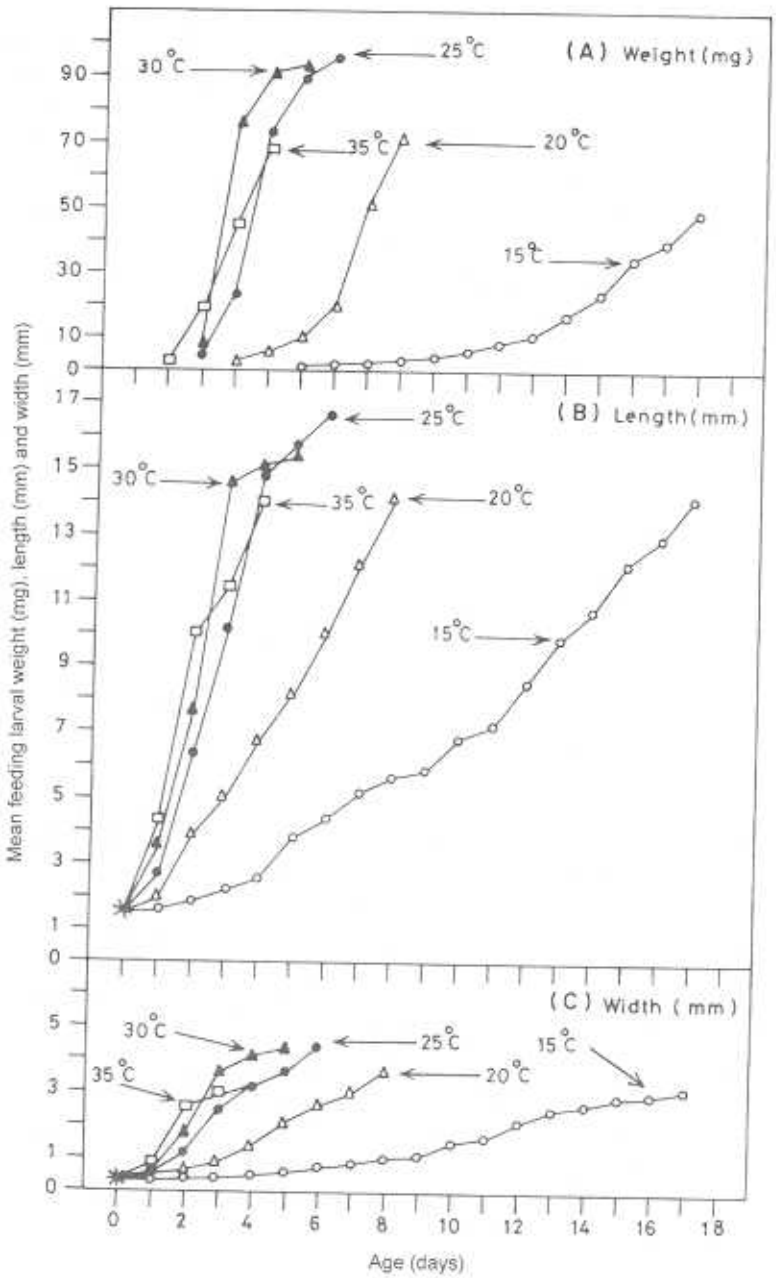

Fig. 2. Comparison of growth rates of *C. albiceps* feeding larvae under different constant temperatures. (A) weight, (B) length, (C) width.

In terms of rapid developmental rate, low mortality, and weight, the optimal developmental temperature ranged between 25 and 30°C for all stages (Tables 1-6). This result is similar of these for *W. nuba* (21-33°C) [11], for *P. ruficornis* (22-28°C) [12] and for *B. cruentata* (21-29°C) [10].

The data reported here are in consistent with other data reported before on other species of medical importance such as *W. nuba* [11], *P. ruficornis* [12] and *B. cruentata* [10]. Such data would be very useful for predicting the insect outbreak in time that the control masure would be implemented efficiently.

Table 1. Egg incubation periods (h) of *C. albiceps* at five constant temperatures

Temp.°C	n	Mean ± SD	Range
15	286	51.4 ± 2.41	48 - 56
20	230	24.1 ± 1.58	22 - 27
25	194	16.9 ± 1.42	15 - 19
30	160	12.2 ± 0.82	11 - 13
35	205	9.6 ± 0.76	9 - 11

Table 2. Larval developmental times (days) of *C. albiceps* at five constant temperatures

		Larval stages, Mean ± SD (range)		
Temp.°C	n	Feeding	Wandering	Feeding + Wandering
15	24	18.1 ± 0.93 (17-19)	4.9 ± 0.65 (4-6)	23.0 ± 0.89 (21 - 24)
20	79	8.3 ± 0.54 (8 - 11)	2.3 ± 0.47 (2-3)	10.6 ± 0.62 (10 - 14)
25	99	5.9 ± 0.30 (5 - 6)	2.7 ± 0.47 (2-3)	8.6 ± 0.50 (8 - 9)
30	95	4.1 ± 0.33 (4 - 5)	1.5 ± 0.50 (1-2)	5.6 ± 0.65 (5 - 7)
35	21	3.8 ± 0.40 (3 - 4)	1.8 ± 0.40 (1-2)	5.6 ± 0.50 (5 - 6)

Table 3. Pupal and total developmental time (days) of C. *albiceps* at five constant temperatures

		Stages, Mean ± SD (range)	
Temp.°C	n	Pupa	Egg to adult
15	24	*	
20	79	6.9 ± 0.42 (6 - 8)	18.5 ± 1.01 (18 - 23)
25	99	4.7 ± 0.57 (4-6)	14.1 ± 0.49 (13.7 - 14.7)
30	95	3.7 ± 0.48 (3 - 5)	9.8 ± 0.63 (8.5 - 11.5)
35	21	3.2 ± 0.40 (3 - 4)	9.2 ± 0.40 (8.4 - 9.4)

* All pupae failed to develop to adult

Table 4. Regression of developmental rate (Y) on rearing temperature (X)* for immature stages of *C. albiceps*.

Life stage	Regression equation	t_L (°C)	R^2 (%)	K (DD ± SD)
Egg	Y = -1.0600 ± 0.10100X	10.5	99.7	9.8 ± 0.3
Feeding larva	Y = -0.0771 ± 0.01000X	7.7	95.9	99.8 ± 5.7
Wandering larva	Y = 0.1450 ± 0.01320X	-11.0	41.9	78.2 ± 15.3
Larva (feeding+ wandering)	Y = -0.0313 ± 0.00630X	5.0	88.5	159.8 ± 14.2
Pupa	Y = -0.0759 ± 0.01130X	6.7	99.4	88.6 ± 2.9
Egg To adult	Y = -0.0230 ± 0.00388X	5.9	95.1	258.5 ± 15.4

* No points (°C) = 4 (20-35)

Table 5. Mortality of the immature stages of *C. albiceps* at five constant temperatures

Temp. °C	% Mortality (n)				
	Larva				
	Feeding	Wandering	Feeding + Wandering	Pupa	Total
15	22 (100)	69.2 (78)	76.0 (100)	100.0 (24)	100 (0)[a]
20	19 (100)	0.0 (81)	19.0 (100)	2.5 (81)	21 (79)[b]
25	0 (100)	1.0 (100)	1.0 (100)	0.0 (99)	1 (99)
30	0 (100)	5.0 (100)	5.0 (100)	0.0 (95)	5 (95)
35	0 (100)	4.0 (100)	4.0 (100)	78.1 (96)	79 (21)

[a] All pupae failed to develop to the adult.
[b] Numbers of flies reaching the adult stage.

Table 6. Pupal and adult weights of *C. albiceps* reared at five constant temperatures

Temp.°C	Sex	n	Fresh pupal weight (mg)	Adult weight (mg)
			Mean ± SD (range)	Mean ± SD (range)
15	> ++	24	22.7 ± 4.5 (16.3 - 32.2)	
20	>	38	*47.8 ± 5.6 (35.7 - 59.6)	*30.1 ± 4.1 (22.3 - 37.7)
	+	41	54.4 ± 4.1 (45.1 - 62.5)	36.5 ± 2.8 (31.7 - 42.9)
	> ++	79	51.2 ± 5.9 (35.7 - 62.5)	33.4 ± 4.7 (22.3 - 42.9)
25	>	10	*56.1 ± 5.5 (47.8 - 64.3)	*36.0 ± 1.7 (33.4 - 38.7)
	+	89	60.9 ± 5.9 (49.5 - 73.6)	41.8 ± 3.1 (33.9 - 47.6)
	> ++	99	60.3 ± 5.9 (47.8 - 73.6)	41.2 ± 3.4 (33.4 - 47.6)
30	>	44	39.7 ± 7.7 (22.3 - 55.3)	25.0 ± 5.3 (11.9 - 37.5)
	+	51	40.9 ±12.0 (20.7 - 80.9)	27.2 ± 7.4 (12.0 - 43.7)
	> ++	95	40.4 ±10.2 (20.7 - 80.9)	26.2 ± 6.6 (11.9 -73.7)
35	>	8	*31.6 ± 4.1 (27.2 - 38.9)	*17.3 ± 3.9 (12.9 - 24.7)
	+	13	36.0 ± 4.4 (29.7 - 44.4)	22.1 ± 4.2 (16.2 - 31.2)
	> ++	21	34.3 ± 4.7 (27.2 - 44.4)	20.3 ± 4.6 (12.9 - 31.2)

* Means between sexes in a particular temperature are significantly different ($P < 0.05$; t test).

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معدل النمو ونسب الموت للأطوار غير اليافعة لذبابة كريزومايا ألبيسيس التابعة لعائلة *Chrysomya albiceps* (Wiedemann) الذباب الملون من رتبة ثنائية الجناح عند درجات حرارة ثابتة في المختبر

فهد عبد المحسن المسند ، مكي عبد الله العمودي ، وصلاح سالم أبو فنه

قسم علم الحيوان ، كلية العلوم ، جامعة الملك سعود ، ص.ب ٢٤٥٥ ،

الرياض ١١٤٥١ ، المملكة العربية السعودية

(قدم للنشر في ١٤٢٢/٢/١٤هـ ؛ وقبل للنشر في ١٤٢٢/١١/٩هـ)

ملخص البحث . أجريت هذه الدراسة على ذبابة *Chrysomya albiceps* في المختبر لمعرفة تأثير بعض درجات الحرارة الثابتة على مدى نمو ونسب موت الأطوار غير اليافعة . وأثبتت الدراسة أن فترة النمو الكلية من طور البيضة إلى الطور اليافع كانت تقل كلما زادت درجة حرارة التربية فقد كانت ١٨,٥ ، ١٤,١ ، ٩,٨ ، ٩,٢ يوم عند درجات الحرارة ٢٠ ، ٢٥ ، ٣٠ ، ٣٥°م على التوالي . وأن جميع العذارى لم يكتمل نموها إلى أفراد يافعة عند درجة حرارة ١٥°م . كما أثبتت الدراسة أنه لا توجد فروق معنوية بين متوسطات فترات النمو لكل من الذكور والإناث . واستخدمت البيانات لإيجاد نموذج يربط درجات الحرارة بالأيام (حرارة/ أيام) اللازمة لإتمام النمو (DD) للتنبؤ بكثافة هذه الذبابة في الحقل وقد قدرت بـ ٩،٨ ، ٩٩،٨ ، ٧٨،٢ ، ١٥٩،٨ ، ٨٨،٦ ، ٢٥٨،٥ (DD) وكانت درجات الحرارة الدنيا التي يمكن أن يتم عندها النمو هي ١٠،٥ ، ٧،٧ ، -١١ ، ٥ ، ٦،٧ ، ٥،٩°م للأطوار البيض والطور اليرقي المتغذي والطور اليرقي المتجول والطور اليرقي (المتغذي + المتجول) والعذارى وفترة النمو الكلية (البيضة إلى الطور اليافع) على التوالي . كما أظهرت الدراسة أن أقل نسبة موت سجلت عند درجات الحرارة ٢٥ و٣٠°م . وقد أظهرت النتائج الإحصائية أن أكبر وزن للعذارى والذباب البالغ كان عند درجة حرارة ٢٥°م وأن أقل وزن سجل عند درجة حرارة ٣٥°م . وكانت أوزان ذكور العذارى والذباب اليافع أقل من أوزانها في الإناث . كما استخلص من البحث أن درجة الحرارة المثلى لتربية هذه الذبابة تقع بين درجتي حرارة ٢٥ و ٣٠°م .