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Biological Aspects, Lower Developmental Threshold, and Thermal Requirements of Cotton Seed Bug, *Oxycarenus hyalinipennis* (Costa)

Asmaa Sh. El-Taher[1*]; M. S. Abdel-Wahed[2]; A. Helmi[2] and H. F. Dahi[3]

[1] Foreign Agricultural Relations, Ministry of Agriculture and Land Reclamation
[2] Plant Protection Department, Faculty of Agriculture, Ain Shams University, Egypt
[3] Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

ABSTRACT

Cotton-seed-bug (CSB), *Oxycarenus hyalinipennis* (Costa) is a serious pest of cotton and other malvaceous, the present investigation aims to determine some biological features, developmental threshold and thermal requirements (degree-days, DD's) for cotton seed-bug, *Oxycarenus hyalinipennis* in Egypt. Effect of three constant temperatures (25, 30 and 35±1°C) on developmental rates of different stages of cotton-seed-bug was detected. The incubation period, nymphal and adult durations, pre-oviposition, oviposition and post-oviposition periods, male and female longevities, sex-ratio, fecundity, fertility and generation time were estimated. Data obtained revealed that, time required for development of all stages were decreased as temperature increased. Egg incubation periods were 6.66±0.36, 5.66±0.33 and 4.33±0.66 at 25, 30 and 35°C respectively. The highest percentage of egg-hatching was 98% at 25°C, and the lowest was 88% at 35°C. The nymphal durations were 25.2±0.17, 17.11±0.27 and 13.88±1.17 days at 25, 30 and 35°C. The lowest adult longevity was 19.87±1.67 day at 35°C and the highest was 37.48 days at 25°C. The sex-ratio between males and females was nearly 1:1 at both temperatures 25 and 30°C, while it was 2:1 at 35°C. The highest female fecundity was 227.7 eggs at 25°C and the lowest one was 83 eggs at 35°C. The same trend was reported for female fertility. The lower developmental threshold for egg and nymphal stage and adult longevity were 7, 12.51, and 13.85 °C, respectively and the corresponding thermal requirements were 123.8, 285.36 and 421.36 DD's.

Keywords: Degree-days, lower developmental threshold, fecundity, fertility, longevity.

INTRODUCTION

The cotton seed bug (CSB), Oxycarenus *hyalinipennis* (Costa) is a species of plant bugs belonging to the family Lygaeidae, Subfamily Oxycareninae (Samy, 1969). It is a serious pest of cotton and other malvaceous in Egypt and other countries. It is a tropical pest that occurred in five continents with different environments (Henry, 1983). In many countries around the global, *O. hyalinipennis* also known as Dusky Cotton bug (DCB) and considers a major pest of cotton that causing potential losses to cotton crop. Both adult and nymphs of *O., hyalinipennis* feed on cotton seeds and suck oil from mature seeds. It has the ability to decrease cotton seed germination, weight and oil quality besides it being crushed during the ginning process and stained the lint of cotton to pinkish color (Henry 1983). Severe infestations of DCB damaged the seed cotton embryo which led to declining in seed viability (Kirkpatrick, 1923; Pearson, 1958; Srinivas and Patil, 2004; Amer *et al*., 2019 and Atakan *et al.*, 2021). Therefore, it is important to know more information about its development, reproduction, and physiological demands under different temperature regimes. This information could help in pest control decisions and determine favorite conditions to multiply.

MATERIALS AND METHODS

The cotton (or Dusky) seed bug, *Oxycarenus hyalinipennis (*costa) was collected from different cotton fields and other host plants in addition to the infested opened dry cotton bolls specially during autumn and winter months from different localities of Egypt as a source to establish insect culture at laboratory conditions. These bugs were maintained in glass jars at division of cotton leafworm, Plant Protection Research Institute (PPRI), Agricultural Research Center, Dokki, Giza and provided with cotton seed as a natural food. Further, this culture was supported by egg masses of *O. hyalinipennis* that obtained from the division of cotton bollworms (PPRI). Population of cotton seed bugs was reared on cotton seeds for two generations as a source for insects needed for all laboratory trails. The diet was replaced every 3-4 days to ensure and adequate supply for the insects. The effect of three temperature constant temperatures (25, 30 and 35 ±1°C) and 70-75 ±5% R.H on different biological characteristics was examined.

Development and reproduction

The newly deposited eggs of *O. hyalinipennis* were collected from the breeding cages at 12 hrs. using an electron microscope with a 10x magnification lens. The number of eggs was counted and transferred to glass jars of 300 ml capacity using a brush of camel hair with an equal number of eggs (25) was incubated at each of the three constant temperatures (25, 30 and 35±1 °C) and relative humidity of 70-75± 5%. Each treatment was replicated three times. Observations were made at 12 hr. to determine the incubation period and developmental rates at different temperatures.

The newly hatched nymphs (25 nymphs/ replicate) were isolated and reared individually in a small glass vial

* **Corresponding author.**
E-mail address: asmaashehab96@yahoo.com
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which covered with muslin cloths and provide with some cotton seeds and a small wet cotton piece. These vials were kept at the three different constant temperatures. Nymphs were monitored daily until adult eclosion. The developmental time from nymphal to adult stage and the nymphal survival rate were estimated.

The newly formed adults were sexed and immediately transferred to glass mating jars (300 ml) and kept under the same physical conditions of temperature and R.H%. These jars were provided with some cotton seeds and small pieces of wet cotton fibers. Three replicates was used for each temperature and each replicate was 15♂+15♀ Observations were made at 12 hr. intervals to record the adult survival, number of deposited eggs/ female (fecundity) and adult longevity (males and females).

Thermal requirements

The linear regression method was applied to determine the theoretical development threshold (T_0) for *O. hyalinipennis*. In which, the points obtained when the time (y) in days is plotted against temperature (ºC), so that the distribution of these point indicates the course of temperature time curve. The relationship is hyperbolic as commonly observed in many insect species (Bean 1961 and Hafez, 1961). The point when the reciprocal for time (1/y) in days plotted against temperature (ºC), each of the reciprocals is multiplied by 100, so that the values on the ordinate (100/y) represent the rate of average development made by the stage per days at the given temperature. Therefore, the distribution of the points indicates the course of temperature velocity curve (Davidsan, 1944). The values of the average percentage of development in one day which are presented within on effect are normal zone of development are fitted to straight line by method of least square (Regression line). Theoretically, the point which the velocity line crosses the temperature axis is the threshold of Development in degree centigrade.

Thermal units required for complete development of each stage was estimated according to the equation of thermal summation (Blunk, 1923).

$$K = Y (T - t_0)$$

Where Y is duration of a given developmental stage, T is temperature in degree centigrade, T_0 is lower developmental threshold, and K is Thermal units in degree- days (DD's)

RESULTS AND DISCUSSION

The present study is a high on some biological parameters of the cotton seed bug. *O. hyalinipennis* in addition to determine minimum. effective temperature (threshold of development) and thermal requirements needed for completion the development of the different stages of cotton seed bug, these values were estimated through the obtained data of laboratory work under different constant temperature, it is well known that temperature is the limiting factor which has the main effect of insects development.

Data presented in Table (1) show the required time for egg incubation period decreased as the temperature increased. The mean incubation periods were 6.66, 5.66 and 4.33 days at 25, 30 and 35 °C, respectively. Statistical analysis yielded significant differences between incubation periods at the different tested temperature. The threshold of eggs development was estimated as showed in Fig. (1) it was found to be 7 °C. These results are in harmony with those obtained by (Hammad, *et al*., 1972; Dimetry, 1973) and Kirkpatrick, (1923) found that the incubation period generally lasts from 4 to 8 days.

It is well known that the number of eggs laid by one female is the pest indicator of female fecundity while the percent of eggs hatching is the main indicator of fertility. Data presented in Table (1) and Fig. (2) revealed that temperature has a significant Effect on both of female fecundity and eggs fertility,

The highest fecundity (227.7eggs/female) and fertility (95%) were occurred at 25°C, while the least fecundity (83eggs/female) and eggs fertility (83%) were recorded at the highest tested temperature (35°C).

Table 1. Biological parameters, developmental rate, lower developmental threshold (T_0) and thermal units (DD's for *Oxycarenus hyalinipennis* at different temperature regimes (25, 3o and °C ± 1°C) and 75 % R.H.

Temp	**Egg stage**					
°C ± 1	**Incubation period (days)**	**Development rate**	**T_0 (°C)**	**Thermal Units (DD's)**		**Eggs Fertility %**
25	6.66 ± 0.36 a	15.01		119.9		95.0
30	5.66 ± 0.33 a	17.66	7.00	130.2		90.0
35	4.33 ± 0.66 b	23.09		121.2		83.0
Average				123.8		
F. Value	6.02 P=0.04					
Nymphal Stage						
Temp °C ± 1	Nymphal duration (mean ± S.e)	Development rate	T0 (°C)	Thermal Units (DD's)	Nymphal mortality%	% Nymphs Turned into adult
25	25.2 ± 0.17 a	3.96		314.7	5	95
30	17.11 ± 0.27 b	5.84	12.51	229.2	10	90
35	13.88 ± 1.17 c	7.20		312.2	22	78
Average				285.36		
F. Value	68.77 P< 0.0001					
Adult stage						
Temp °C ± 1	Pre- oviposition period (days)	Development rate	T0 (°C)	Thermal Units (DD's)	Sex ratio ♂ : ♀	
25	5.62 ± 0.2 a	17.97		18.9	1 : 1.1	
30	3.6 ± 0.16 b	27.77	21.64	30.1	1.4 : 1	
35	1.66 ± 0.24 c	60.24		21.4	1.94 : 1	
Average				23.5		
″F″ Value	90.34 P<0.0001					

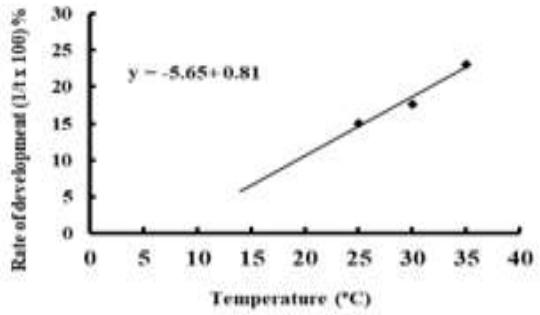

Fig. 1. Regression line between the developmental rate of O. *hyalinipennis* eggs and different temperature

Fig. 2. Percent of eggs hatching of *O. hyalinipennis* at different constant temperature.

statistical analysis enhanced the differences between the three tested temperature and indicate that temperature of 25 °C seem to be the most favorable for embryonic development, female fecundity and eggs fertility, these results are in agreement with those obtained by (Dimetry, 1973). Each female lays up to 110 eggs, either singly or in groups of 2-4 eggs, and rarely are more eggs laid according (Hammad *et al*., 1972).

Data in Table (1) revealed that temperature has a highly significant (F= 68.77 ***) effect on the development of nymphal stage, the longest nymphal duration (25.2 days) was recorded at 25 °C while the least duration (13.88 days) was at 35°C. Statistically, there are significant differences between values of the mean duration of nymphal stage at tested constant temperature, obviously the development rate of nymphs increased with the increasing of temperature. These results are in harmony with those obtained by (Dimetry 1971 and Hammad *et al*., 1972). Zero of developmental threshold for nymphal stage was estimated theoretically by extrapolation as shown in Fig. (3); this value was 12.51°C (lower developmental temperature) for nymphal stage. The lowest nymphal (5%) and highest percent of nymphs succeeded turn into adults (95%) were occurred at 25°C. Although, the shortest period of nymphal duration was recorded at 35°C, but, the highest nymphal mortality (22%) and the lowest percent of nymphs that turned to adults (78) occurred at the highest temperature of preening (35°C). These results revealed that temperature of 25°C is the most favorable temperature for *O. hyalinipennis* nymphal development.

Data in Table (2) and graphically illustrated in Fig (4) revealed that pre-oviposition period of *O. hyalinipennis* adults is highly affected by increasing temperature; it was 5.62, 3.6 and 1.66 days at 25, 30 and 35 °C, respectively.

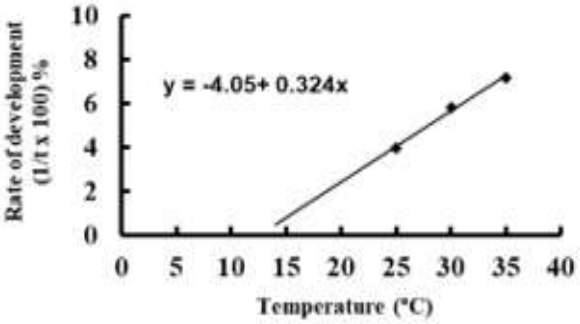

Fig. 3. Regression line between development rate of *O. hyalinipennis* nymphs and different constant temperatures.

Table 2. Female and male longevities, female fecundity, lower developmental threshold (T_0), and thermal units (DD's) at different temperature regimes.

Temp.	Female longevity				Male	Rate of development	To	Thermal units	Fecundity (No. of
(°C)	Pre	Ovi	Post	Total	longevity	(1/t×100) %	(°C)	(DD's)	Eggs/Female)
25	5.62 a	37.00 a	5.38 a	48.00 a	55.75 a	2.66		417.9	227.7±48.28
30	3.60 b	15.33 b	4.40 a	23.33 b	28.70 b	4.15		425.9	123.8 ±24.94
35	1.66 c	9.75 c	2.10 b	13.51 b	17.26 b	5.14	13.85	420.3	83.0 ± 3.05
Average								421.36	
F Value	90.34***	634.76***	15.68**	13.33**	32.18***				5.64 *

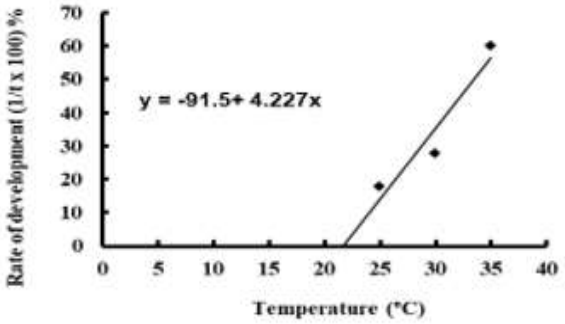

Fig. 4. Regression line of the preoviposion period of O. *hyalinipennis* at different constant temperatures.

The same trend was recorded for oviposition and post-oviposition period, whereas all periods of female longevity decreased with the increase of temperature. Analysis of variance cleared that there were significant differences between pre-oviposition, oviposition and post–oviposition periods at different temperatures (25, 30 and 35°C). Regarding, female and male longevity, there were significant differences between longevity of both sex at different temperatures. On the other hand, female longevity was found usually shorter than male longevity at all tested constant temperatures. This finding was coinciding with (Ewete and Osisanya 2011). While (Dimetry 1973) as the opposite case mentioned that adult males lived for averages of about 34.8,

28.8 and 19.9 days as compared to 42.4, 36.0 and 22.6 days for adult females at three different temperatures.

Thermal requirements or thermal units (DD's):

In Table (1) revealed that the thermal units in degree-days for egg stage required for completion embryonic development were 119.9 130.2 and 121.2 DD's at 25 ,30 and 35°C with an average of 123.8 DD's. Nymphal stage required the thermal units in degree-days for completion was determined 314.7, 229.2 and 312.2 DD's., at 25, 30 and 35°C respectively, with an average 285.36 DD's. While the adult stage required for 18.9, 30.1 and 21.4 DD's., at 25, 30 and 35°C respectively, with an average 23.5 DD's. The estimation of corresponding thermal requirements was 421.36 illustrated in Table (2).

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الخصائص البيولوجية وعتبة النمو والاحتياجات الحرارية لبق بذورالقطن *Oxycarenus hyalinipennis* (Costa)

اسماء شهاب الطاهر[1] ، محمد سالم عبدالواحد[2] ، اشرف حلمي[2] و حسن فرج ضاحي[3]

[1]العلاقات الزراعية الخارجية – وزارة الزراعة واستصلاح الاراضي

[2]قسم وقاية النبات - كلية الزراعة -جامعة عين شمس - مصر

[3]معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقي – مصر

الملخص

بق بذرة القطن (CSB) ، *Oxycarenus hyalinipennis* Costa هي آفة خطيرة على القطن والمحاصيل الاخري للعائلة الخبازية ، ويهدف الدراسة الحالية إلى تحديد بعض السمات البيولوجية ، وعتبة النمو والمتطلبات الحرارية (degree-days, DD's) لبق بذور القطن *O. hyalinipennis* في مصر. وقد تم دراسة تأثير ثلاث درجات حرارة ثابتة (25 ، 30 ، 35±1 درجة مئوية على معدلات نمو المراحل المختلفة للحشرة ، فترة حضانة البيض ، مدة طورى الحوريات والحشرات الكاملة ، وفترة ما قبل وضع البيض ، وفترة وضع البيض وما بعد وضع البيض ، وطول عمر الحشرات الكاملة ذكورا وإناثا، والنسبة الجنسية وعدد البيض لكل انثي ونسبة الخصوبة، ومدة الجيل الكامل. وقد أظهرت النتائج المتحصل عليها أن الوقت اللازم لتطور جميع المراحل قد انخفض مع زيادة درجة الحرارة ، وكانت فترات حضانة البيض 6.66±0.36 و 5.66±0.33 و 4.33±0.66 عند 25 و 30 و 35 درجة مئوية على التوالي. وكانت أعلى نسبة لفقس البيض 98٪ عند 25 درجة مئوية ، وأقل نسبة 88٪ عند 35 درجة مئوية ، وكانت فترات الحوريات 0.17±25.2 و 17.11±0.27 و 13.88±1.17 يومًا عند 25 و 30 و 35 درجة مئوية على التوالي. وكان أقل عمر للحشرات الكاملة 19.87±1.67 يومًا عند 35 درجة مئوية ، وأعلى عمر للحشرات الكاملة 37.48 يومًا عند 25 درجة مئوية. النسبة الجنسية بين الذكور والإناث 1: 1 تقريبًا في درجات حرارة 25 و 30 درجة مئوية ، بينما كانت 2: 1 عند 35 درجة مئوية. وكانت أعلى نسبة خصوبة للإناث 227.7 بيضة عند 25 درجة مئوية ، وأقلها 83 بيضة عند 35 درجة مئوية. وفى نفس الاتجاه لخصوبة الإناث كانت عتبة النمو الأدنى لمرحلة البيض والحوريات وطول عمر الحشرات الكاملة 7 و 12.51 و 13.85 درجة مئوية على التوالي ، وكانت المتطلبات الحرارية المقابلة لمرحلة البيض والحوريات وطول عمر الحشرات الكاملة 123.8 و 285.36 و 421.36 وحدة/يوم على التوالى.