THERMAL CONSTANT AND DEGREE-DAY REQUIREMENTS FOR THE DEVELOPMENT OF THE TOMATO BUG, *NESIDIOCORIS* (*CYRTOPELTIS*) *TENUIS* (REUTER)

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Abstract

Development of the tomato bug *Nesidiocoris* (*Cyrtopeltis*) *tenuis* (Reuter) (Heteroptera: Miridae) was studied at constant temperatures (15, 20, 25 and 30 ℃ ±1 ℃). Development of immature stages was accelerated by raising of tested temperatures. Total averaged of developmental period was (76.13, 45.27, 26.73 and 20.93 days) at 15, 20, 25 and 30 ℃; respectively. Generation period ranged between 93.50 and 22.80 days depending on rearing temperature. Addionally, adult female survived slightly longer than male; also, fecundity was higher at lower temperature (15 ℃) than higher one (30 ℃). Thermal constant or threshold of development (t_o), Thermal requirements (K) and degree- days (d. d. 's) were estimated to be 12.4, 7.8 and 9.9 ℃ for egg, nymph and all immature stages, respectively. Based on 30 ℃ estimation (preferred temperature), 107.83, 325.46 and 417.30 heat units (U.T.) are required for completion the development of egg, nymph and all immature stages. Development of one generation may require 440.29 degree-days.

INTRODUCTON

The tomato bug *Nesidiocoris* (*Cyrtopeltis*) *tenuis* (Reuter) is considered as an economic ally important pest on certain plants. It causes serious qualitative and quantitative losses. By its piercing and sucking mouth parts, it sucks the juice of these plants forming brownish ringe on stems. It was recorded as a dangerous threat to tomato and tobacco by feeding on their leaves (Helal 1974).

Zoophytophagous insect *Nesidiocoris tenuis* is a special case of omnivory in which insects can feed on both plants and prey at the same developmental stages. The mirid bug is an important natural enemy of whiteflies in Mediterranean region. Omnivorous species of this family are major natural enemies of several pests; such as whiteflies in solanaceous field and greenhouse crops (Albajes and Alomar, 1999). Its population trends followed those of whiteflies, showing its role potential in biological control (Sanchez, and Lacasa 2008). The period of higher risk in tomato crops exists when *N. tenuis* reaches its high population and its prey decreases to very low numbers due to predation (Sanchez, 2009 and Sanchez *et al.*, 2009). This predator feeds solely on a plant diet seems to have little potential to complete development in the absence of prey (Urbaneja *et al.*, 2005). However, *N. tenuis* adults or nymphs, enclosed on a tomato shoot, causing the development of necrotic rings on the stem, but the harm was not significant and these rings were soon disappeared (Arno *et. al*., 2006). This work suggested to thorough light on the thermal require ments of *N. tenuis*.

MATERIALS AND METHODS

To determine the rate of development and the thermal units, the experimental work was carried out under controlled conditions (temperature and relative humidity). Eggs of *N. tenuis* deposited in the laboratory in tomato leaves, in glass vessel were taken for each temperature constant, four incubators were used to provide constant temperatures of 15, 20, 25 and 30 ℃ (each incubator contains 15 glass vessel as replicates and R.H. was ٦٥–٧٠ % under light period of ٨ hrs.). All stages from egg to adult were kept under the aforementioned conditions to determine the developmental rate and other biological parameters of each stage.

The effect of the above mentioned conditions was tested on the immature and adult stages of *N. tenuis*. 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 degrees centigrade so that the distribution of these points indicates the course of temperature time curve (Miyashita, 1971 and Nasr *et al*., 1974), (b) the points obtained when the reciprocal for time ($1/y\times100$) in days are plotted against temperature (T) in degrees centigrade, 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 temperature-velocity curve (Davidson, 1944), (c) the point which the velocity line crosses the temperature axis is the threshold of development in degrees centigrade. Thermal units required for 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

$$K= y (t- t_o) \text{ in D.D.Us.}$$

Where :

a : constant term it is the y intercept, the place the line crosses 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, the temperature data is transformed into heat units and served as a tool for studying insect population dynamics and predicting appearance of the tomato bug in the field during two successive years 2013 and 2014 at Qalubia Governorate.

The developmental threshold value that has been estimated after constant temperature experiment carried out before. Where the zero development (t_o) was 10.6 ℃ for *N. tenuis* generation. The following formula was used for computing the heat units (d. d.'s) according to Richmond *et. al.*,(1983):

$$H = \leqq HJ$$

H = Number of accumulated heat units to emergence.

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

= (max.- C)2 /2(max.-min.).if max > ℃& min.< ℃

= 0 if max. < ℃& min. < ℃

C =Threshold temperature.

RESULTS AND DISCUSSION

Data obtained in Table (1), showed that the incubation period of *N. tenuis* eggs at 30 ℃ was 6.٠٧ ± 0.2١ days; being clear shorter than those at 15, 20 and 25 ℃ (31.00 ± 0.٨٦ ; 17.67 ± 0.٢٩) and (8.73 ± 0.٣٨); respectively.

The duration of nymphal stage was also affected with the degree of temperature. Data in Table (1) showed that, the duration of the nymphal stage was 45.1٣ ± 0.٧٧; 27.60 ± 0.٣٦; 18.00 ± 0.4٢ and 14.٨٧± 0.4٠ at 15, 20, 25 and 30 ℃; respectively.

Table 1. Influence of constant temperatures on the biological aspects of *N. tenuis* reared on tomato leaves at 70 ± 5 R.H.% and estimation of the required thermal units.

Variables	Temp. (℃)	Egg Incubation Periods	Total periods of Nymphal enstars	Total periods of Immatures	Pre. Oviposition periods	Generation periods
Duration/ days	15	31.0٠ ± 0.٨٦	45.1٣±0.٧٧	76.1٣±1.1٤	17.4٠ ± 1.٤٨	93.5٣ ± 1.6٢
	20	17.٦٧ ± 0.٢٩	27.6٠±0.٣٦	45.٢٧±0.4٤	5.6٠ ± 0.4٣	50.٨٧ ± 0.6٤
	25	8.7٣ ± 0.٣٨	18.0٠±0.4٢	26.7٣±0.6٣	3.٠٧ ± 0.١٥	29.8٠ ± 0.6٥
	30	6.٠٧ ± 0.2١	14.٨٧±0.4٠	20.9٣±0.٣٧	1.٨٧ ± 0.١٦	22.8٠ ± 0.٣٩
Rate of development	15	3.23	2.22	1.31	5.75	1.07
	20	5.6٦	3.62	2.21	17.86	1.9٧
	25	11.4٥	5.56	3.74	32.٥٧	3.36
	30	16.٤٧	6.7٢	4.78	5٣.٤٨	4.39
Regression values	Intercept	-11.2901	-2.410	-2.36	-43.64	-2.4089
	Slope	0.9108	0.308	0.24	3.158	0.2268
	t_o (℃)	12.4	7.8	9.9	13.8	10.6
	K (Degree days)	107.83	325.46	417.30	30.07	440.29
	R^2	0.985	0.992	0.990	0.984	0.994

Average ± S. E.

From the aforementioned results it can be concluded that *N. tenuis* took longer developmental period at 15 ℃ than the other tested temperatures, in four-tested temperatures, however, the duration of the developmental stages of *N. tenuis* was temperature dependent. The duration of each developmental stage decreased with increasing temperature, Emara, *et al*. (1999), Ouda, (2012).

The data obtained in Table (1) represented as follows:

A- Egg stage

The incubation period of *N. tenuis* was markedly affected by temperature variations. The rate of embryo development was positively dependent on temperature where they were 3.23, 5.66, 11.45 and 16.47 % at 15, 20, 25 and 30℃**,** respectively. The estimated threshold of egg development (t_0) was 12.4 ˚C, on the other hand the average of thermal units or thermal summation was in average 107.83 d.d.'s during this stage (R^2 = 0.985).

B- The nymphal stage.

The nymphal duration was shortened with the increase in temperature. Hence, the developmental rate of nymph increased as the temperature became higher from 15 to 30 ℃, where they were 2.22, 3.62, 5.56 and 6.72 % at 15, 20, 25 and 30˚C**,** respectively. The threshold of nymphal development (t_0) was estimated as (7.٨ ℃) and the thermal units were ٣٢٥,٤٦ d.d.'s (R^2 = 0.992).

C-The Total period of immature stages:

The duration of immature stages decreased with increasing temperatures from 15 to 30°C from 76.13 to 20.93 days. For *N. tenuis* the estimated threshold of immature stages (t_0) was 9.9 ˚C. The rate of embryo development was positively dependent on temperature where they were 1.31, 2.21, 3.74 and 4.78 % at 15, 20, 25 and 30℃**,** respectively The required thermal units for the development of this stage was 417.30 d. d.'s. (R^2 = 0.990).

D- The Pre- oviposition period.

The duration of Pre- oviposition decreased with increasing temperatures from 15 to 30 ˚C from 17.40 to 1.87 days, on the other hand the developmental rates increased with increasing of tested temperatures where they were 5.75, 17.86, 32.57 and 53.48 % at 15, 20, 25 and 30 ˚C**,** respectively. The estimated threshold of Pre-oviposition (t_o) was 13.8 ˚C the required thermal units for the Pre-oviposition development of this stage was in the average 30.07 d. d.'s. (R^2 = 0.984).

E- The generation:

As other developmental stages, the duration of the Generation decreased with temperature increase from 15 to 30 ˚C from 93.53 to 22.80 days while the rate of development was retarded at lower temperature where they were 1.07, 1.97, 3.36 and 4.39 % at 15, 20, 25 and 30 ˚C, respectively. For *N. tenuis* the estimated threshold of generation (t_0) was 10.6 ˚C. The thermal units required for the development of this stage was 440.29 d. d. 's. (R^2 = 0.994).

In the present study, an explanation for variation in the number of annual generations was given here for the first time on the basis of available data and calculated degree-days required for insect development. Similarly the expected number of annual generation could be predicted by determining the date at which 440.29 d.d.'s have been accumulated at the beginning of spring. Sevacherian (1977), Johnson *et al*. (1979), Dawoud *et al*. (1999) and Marwa (2009), developed similar degree-day systems for predicting the need for and timing of insecticide application for different insect species.

REFERENCES

1. Albajes, R. and O. Alomar. 1999. Current and potential use of polyphagous predators. In Integrated pest disease management in greenhouse crops. Kluwer Academic Publishers, Dordrecht, Netherlands. pp. 265-275.
2. Arno J.; C. Castafie; J. Riudavets; J. Roig and R. Gabarra. 2006. Characterization of damage to tomato plants produced by the zoophytophagous predator *Nesidiocoris tenuis* - Bulletin I. O. B. C. / w. p. r. s., 29 (4): 249-254.
3. Blunk, M. 1923. Die Entwicklung Von Dytiscus marginalis L. von. Eibis zur Imago, Teil Die Metamorphase Zracht. Wiss. Sool. 121-171.
4. Davidson, J. 1944. On the relation between temperature and rate of development of insects at constant temperatures J. Animal Ecol. Vol. 13, No. 1 (May, 1944), pp. 26-38
5. Emara, S. A.; M. Y. Hashem; I. I. Ismail and H. F. Dahi. 1999. Impact of heat units required for the development of cotton Leafworm, *Spedoptera littoralis* (Biosd) on seasonal fluctuations and annual generations. The 2nd Int. Conf. of pest Control, Mansoura, Egypt, Sept., 6-8; 759 - 771.
6. Helal, M. A. 1974. Ecological and Biological Studies on the tomato pest *Nesidiocoris tenuis* Reut., (Miridae: Heteroptera) M. sc. Thesis, Fac. Agric. Al-Azhar University. Cairo. Egypt: 119. pp.
7. Johanson, E, F.; R. Trottier and I. E. Laing. 1979. Degree-day relationships to the development of (Lepidoptera: Gracillariidae) and its parasite Apanteles ornigis (Hymenoptera: Braconidae). Can. Entomol., 111: 1177-1184.

8. Marwa, M. A. 2009. Heat requirements as a tool for predicting the annual generations of peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) M. sc. Thesis, Fac. Agric. Cairo Univ. Egypt: 111.pp.
9. Miyashita, K. 1971. Effective of constant and alteranating temperatures on the development of *Spodoptera litura* (Lepidoptera: Noctuidae) Appl. ent. Zool. 6 (3): 105-111.
10. Nasr, E. A.; M. R Tucker and D. G. Compion. 1974. Distribution of moths of the Egyptian cotton leaf worm .*Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae). In the Nile delta interpreted from catches in a pheromone to temperature and humidity. Bull. Soc. Ent. Egypt, 28:123-131.
11. Ouda, M. 2012. Ecological and Biological Studies on *Euzophora osseatell* Treit. (Lepidoptera: Pyralidae) M. sc. Thesis, Fac. Agric. Al-Azhar University. Cairo. Egypt.. Egypt: 130.pp.
12. Richmond, J. A.; H. A. Thomas and H. B. Hattachargya. 1983. Predicting spring flight of Nantucket pint tip moth (Lipidoptera: Olethreutidae) by heat unit accumulation .J. Econ. Entomol.,(76): 260-271.
13. Sanchez, J. A. 2009. Density thresholds for *Nesidiocoris tenuis* (Heteroptera: Miridae) in tomato crops. Biol. Control, 51(3): 493-498.
14. Sanchez, J. A. and A. Lacasa. 2008. Impact of the Zoophytophagous Plant Bug *Nesidiocoris tenuis* (Heteroptera: Miridae) on tomato Yield. J. of Econ. Entomol., 101(6): 864-870.
15. Sanchez, J. A.; A. Lacasa; J. Arno; C. Castafie and O. Alomar. 2009. Life history parameters for *Nesidiocoris tenuis* (Reuter) (Het., Miridae) under different temperature regimes Journal of Applied Entomology, 133 (2): 125-132.
16. Sevacherian, V. 1977. Heat accumulation for timing Lygus control measure in a dependent growth rate simulation. Can. Ent., 106: 519-524.
17. Urbaneja A.; G. Tapia and P. Stansly. 2005. Influence of host plant and prey availability on developmental time and survivorship of *Nesidiocoris tenuis* (Het.: Miridae).Biocontrol Sci. and Technol., 15: 513-518.

الاحتياجات الحرارية ودرجات الحرارة الثابتة لنمو أطوار بقة الطماطم
Nesidiocoris* (*Cyrtopeltis*) *tenuis **(Reuter).**

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تمت دراسة تطور فترات نمو حشرة بقة الطماطم ***Nesidiocoris tenuis*** للحرارة الثابتة ١٥ ، ٢٠ ، ٢٥ و ٣٠ ± ١ °م . وأظهرت النتائج ان معدل النمو لمجموع الاطوار الغير كاملة (76,13 ، ٤٥,٢٧، 26,73 و 20,93 يوم) على درجات حرارة ١٥ ، ٢٠، ٢٥ و ٣٠ م° على التوالى. وأظهرت نتائج الدراسة أن فترة الجيل تختلف بأختلاف درجة الحرارة حيث ترواحت بين ٩٣,٥٣ و ٢٢,٨٠ يوم على درجة حرارة ١٥ و٣٠ °م على الترتيب. أوضحت نتائج دراسة الحد الحرج للنمو (صفر النمو) لمراحل النمو البيولوجى لطور البيض و الحوريات و ما قبل وضع البيض ومدة الجيل وكانت النتائج ١٢,٤ ، ٧,٨ ، ١٣,٨ و ١٠,٦° م على درجات حرارة ١٥ ، ٢٠، ٢٥ و ٣٠ °م على التوالى. أظهرت أيضآ نتائج دراسة حساب الاحتياجات الحرارية المجمعة لتطور مراحل النمو البيولوجى لطور البيض و الحوريات و ما قبل وضع البيض والجيل وكانت النتائج ١٠٧,٨٣ ، ٣٢٥,٤٦ ، ٣٠,٠٧ و ٤٤٠,٢٩ وحده حرارية على درجات حرارة ١٥ ، ٢٠، ٢٥ و ٣٠ °م على التوالى.