DEGREE - DAYS OF THE TORTOISE BEETLE *CASSIDA VITTATA* VILL. AND ITS IMPLEMENTATION FOR INSECT PREDICTION IN RELATION TO THERMAL HEAT UNITS ACCUMULATION

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Abstract

Threshold of development (t) and accumulated heat units (k) for total preimaginal development of *Cassida vittata* Vill. (Coleoptera : Chrysomelidae) were calculated to be 12 °C and 288.6 degree – days (dd's) . Development of egg stage required 79 dd's above 10.5 °C, while larval stage demanded 103 dd's above 13.8 °C and this value increased to 105 dd's above 11 °C for adult stage . Accumulation of 528 dd's were sufficient for the completion of one generation. Field observations and population dynamics of *C. vittata* showed two annual generations in 1995 & 1997 and only one generation in 1996 . Variations in insect phenology from year to year was explained and discussed. The accumulated thermal heat units (T. U.) or effective degree - days estimated through insect activity time in 1995, 1996 and 1997 were sufficient to develop two generation in 1995, 1997 and only one generation in 1996.

Assessment of thermal heat units for each development stages was successfully used for insect forecasting in sugar beet fields.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is of great significance as a source of sugar. It is considered the second source of sugar after sugarcane crop in Egypt. Sugar beet has recently introduced into the ptian agriculture rotation since 1982. The area cultivated with sugar beet in Egypt amounts 190.000 feddans produces approximately half million ton of sugar annually.

Under field conditions, sugar beet is attacked by numerous insect pests causing considerable damage and loss in sugar produced (Asmahan Yousef, 1986 , Abo Aiana , 1991 and Salama & El-Naggar ,1992).

The tortoise beetle *Cassida vittata* Vill. (Coleoptera : Chrysomelidae) is considered to be the key pest of sugar beet under Egyptian circumstances. Several biological studies on this pest were undertaken (Bibolini , 1973 , Ward & Pionkowski, 1978, Laraichi *et al.,* 1984, Bassyoni & Maareg, 1992).

Heat units are a method of quantifying a biological organism's thermal environment. Researches conducted over the past several decades has proven that proper use of heat units can provide a reliable means of predicting the growth and development of important crop species as well as many crop pests (Strong & Apple, 1958, Stinner *et al.,* 1974, Ali, 1979, Ali & Ewies, 1982, Richmond *et al.,* 1983, Pruess, 1993, Hashem *et al.,* 1997).

The goal of the present study is to estimate developmental thresholds of C. *vittata* and thermal units requirements of developing generations and possibility of it utilization for insect forecasting in sugar beet fields under Kafr El-Sheikh conditions.

MATERIALS AND METHODS

Developmental time (days) of the different stages of the tortoise beetle *C.vittata* Vill. (Coleoptera:Chrysomelidae) was determined under controlled temperatures. Three incubators were employed to provide constant temperatures of 20, 25 and 30 °C + I °C. All stages from egg to adult were kept under the constant temperatures and feeding stages were supplied with sugar beet fresh leaves serving as food to determine the developmental rates and other biological parameters of each stage.

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) so the distribution of these points indicates the course of temperature time curve (Miyashita, 1971, Nasr *et al.,* 1974), (b) the points obtained when the reciprocal for time (1/y) in days are plotted against temperature (T), each of the reciprocals is multiplied by 100 , so the values on the ordinate (100/y) represent the speed of development by the stage per day at a given temperature - the course of temperature - velocity curve, (c) theoretically, the point which the velocity time crosses the temperature axis is the threshold of development in degrees centigrade. Thermal units required for development completion of each stage were estimated according to the equation of thermal summation

$$K = y(T - a)$$

where y = developmental time of a given stage , T = temperature , a = temperature threshold of development, k = thermal units (degree - days)

RESULTS AND DISCUSSION

1. Assessment of development thresholds :

Laboratory studies revealed that developmental time as well as rate of development (1/t x 100) of the different stages of *C. vittata* were obviously affected by constant tested temperatures (Table 1). Duration of a developmental stage was shortened as ambient temperature increased and the reverse relationship was obtained concerning speed of development. Total development required 38, 22.2 and 14 days at 20,
5, and 30 °C, respectively while duration of a developed generation demanded 58, 38, and 20.5 days under the former temperature conditions.

By application the formulas described by Myshita (1971), Nasr *et al., (*1974) and Ali (1979), the lower temperature of developmental stages (= temperature threshold or zero of development) are 10.5 , 13.8 , 11 and 11.8 °C for egg , larva , pupa and generation, respectively (Table 2). Consequently, the accumulated thermal units or degree - days (dd' s) required for the development of embryo, larval and pupal stages above 10.5, 13.8 and 11 °C were 79.8 , 103 and 105 degree - days (dd's). The development of a generation required 528.2 thermal units (T. U.) above 11.8 °C.

2. Causes of varation in *C. vittata* phenology from year to year :

Field phenology of *Cassida vittata* was unstable in a single locality (El-Hamoul , Kafr El - Sheikh govemorate) and fluctuated in accordance with the climatic conditions prevailed during insect : development and activity , especially temperature. This is ascertained by the occurrence of two annual generations in 1995 & 1997 sugar beet growing seasons and only one generation in 1996.

Table 1. Development of *C. vittata* from El-Hamoul (Kafr El-Sheikh Governorate) and its corresponding reciprocals.

Stage	Developmental time (days)			Developmental rate (I/slope)		
	20±1°C	25±1°C	30±1°C	20±1°C	25±1°C	30±1°C
Egg	11.0	5.5	5.4	9.1	18.2	18.5
Larva	16.1	9.2	4.5	6.1	10.9	22.2
Pupa	10.9	7.5	4.1	9.2	13.3	24.4
Total development	38.0	22.2	14.0	2.6	4.5	7.1
Generation	58.0	38.0	20.5	1.7	2.6	4.9

Table 2. Thermal requirements for development of *C. vittata* from El-Hamoul (Kafr El Sheikh Governorate), Egypt (Temp. 25±1°C).

Stage	Developmental threshold (t)	Thermal constant (K) (days - degree)
Egg	10.5±1.5	79.8±6.80
Larva	13.8±1.2	103.0±7.20
Pupa	11.0±0.4	105.0±2.30
Total development	12.0±0.8	288.6±8.70
Generation	11.8±1.1	528.2±12.5

In the present study, an explanation for variation in the number of annual generations was given here in for the first time on the basis of available data and calculated degree - days required for insect development. Causes of variation in insect phenology at Kafr El - Sheikh region could be enumerated as follows :

1. variation in the total sum of effective temperature (degree - days) during insect activity period.
2. shifting of emergence dates of over wintering adults under the influence of temperature as a result of which stage (s) reach under field conditions to variable temperatures and photoperiods of different day -lengths (Danilevskii, 1965).

Total accumulated thermal units (degree - days) above 11.8 °C required for insect development during the entire period (February – May) in Kafr El - Sheikh region amounted 1100.4, 772 and 1185.8 degree -days (dd's) for the seasons 1995, 1996 and 1997, respectively . As development of one generation requires 528.2 dd's.

(Table 2), the calculated thermal units accumulated during the activity periods in 1995 (1100.4 dd's) and 1997 (1185.8 dd's) were sufficient for development of two generations , while that calculated for the season 1996 (772.7 dd's) enhanced the development of only one generation. These results ensure that the calculated summation of degree days agree with the actual number of generations developed under field conditions of sugar beet.

Danilevskii (1965) and Ali (1979) achieved similar explanations to clarify causes of variations in the number of annual generations in some lepidopterous and coleopterous insect species.

3. Forecasting of *C. vittata* population in relation to thermal heat units accumulation :

Thermal units or effective degree - days accumulation system has implicated for pest management as well as other areas of applied entomology. The degree - day system is a fundamental basis for temperature - dependent models which have been widely used for prediction of population events of many insect species .

The accumulated thermal heat units (= effective degree - days) estimated through 1995 , 1996 and 1997 revealed pronounce relationship between total effective degree - days and the number of developed generations per annum. Total thermal units (T.U) accumulated through the insect activity period in 1995 and 1997 and their averages compared with that calculated for 1996 accompanied with the maximum number of insect stages (peak) is given in Table (3). In 1995 and 1997 sugar beet growing seasons where two generations were developed, the first peak (P1) of over wintering adults appeared after accumulation of 274.4 and 226.8 dd's (av. 250.6 dd's), respectively. The average of the two seasons showed that peaks of 1st and 2nd generation eggs occurred after the accumulation of 268.3 and 462.4 dd's. Also/ a total of 349.7 and 675.9 dd's accumulated before the appearance of matures of 1st and 2nd generations, respectively. Adults of the first generation appeared after the accumulation of 535.5 dd's , while the maximum number of the second generation beetles occurred after the accumulation of 1142.8 dd's (Fig. 1). In 1996 - sugar beet season , the matter was quite different and only one generation could be developed . Peaks of over wintering adults , eggs , immatures and newly emerged beetles occurred in the field after the accumulation of 79.8 , 100.8 , 158.9 and 329.7 dd's , respectively (Table 3 and Fig. 1).

The aforementioned results proved that a total of 528.2 dd's was required for the development of one generation of *C. vittata.* Accordingly, it appears that accumulated thermal units calculated for each peak is greatly corresponding with the observed number of annual generations (two generations in!995 & 1997 and only one in 1996). These results seem to be of great importance, so that with the end of calculated thermal units accumulation, it is possible to forecast, to a reasonable extent, the activity or emergence of *C. vittata* adults. Once, the spring emergence pattern has been established, the successive adult peaks could be predicted depending upon the pre - calculated and accumulated degree - days for the occurrence of two or one generation.

Thus by determination the pattern of spring emergence of beetles and the date at which 274.4 dd's have been accumulated, the emergence of the subsequent adult peaks could be possibly forecasted. Similarly, the expected number of annual generations could be predicted by determining the date at which 528.2 dd's have been accumulated at the beginning of spring. Sevacherian (1977), Johnson *et al.* (1979) and Ali (1979) developed similar degree - day systems for predicting the need for and timing of insecticide application for different insect species. So, the achieved results in the present study greatly confirm within developing pest management program for the tortoise beetle *C. vittata* on sugar beet.

Table 3. Thermal units accumulated before appearance of maximum population of *C. vittata* stages in sugar beet fields at El-Hamoul, Kafr El-Sheikh Governorate.

Stage	Peak	Thermal units (dd's) accumulation above 11.8 ^{o}C			
		1995	1997	Average	1996
Egg	P1	226.8 (124.4)	345.8 (169.35)	268.3	343.6 (156.5)
	P2	357.0 (90.3)	567.7 (208.15)	462.4	-
Larva	P1	226.8 (145.2)	472.5	349.7	464.7 (384.8)
	P2	513.8 (785.7)	837.9 (155.25)	675.9	-
Adult	P1	274.4 (57.4)	226.8 (552.80)	250.6	303.1 (56.7)
	P2	714.0 (161.4)	357.0 (111.85)	535.5	777.7 (223.7)
	P3	1100.4 (200.5)	1185.2 (226.65)	1142.8	-

**Numbers between parenthesis mean the maximum number of an insect stage.*

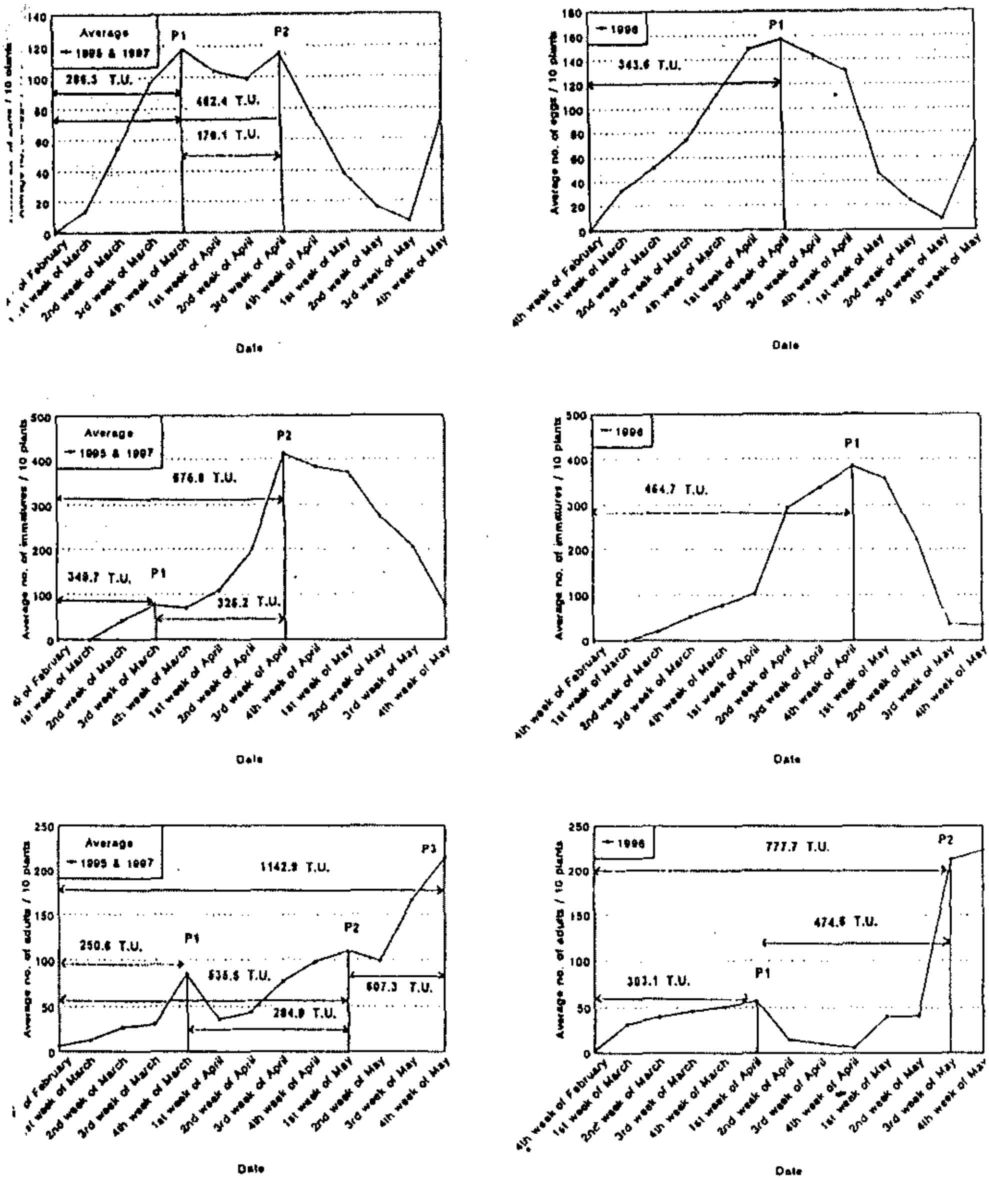

Fig. (1) : Maximum numbers of *C. vittata* different stages (peaks) estimated in sugar beet fields during sugar beet seasons 1995-1997 in relation to thermal unit (T.U.) accumulation)dd's).

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تقدير الإحتياجات الحرارية لخنفساء البنجر السلحفانية *Cassida vittata* vill وإمكانية إستخدام الوحدات الحرارية المتراكمة فى التنبؤ بجمهورها فى حقول بنجر السكر

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تم حساب الحد الحرج للنمو (T) للأطوار المختلفة لحشرة خنفساء البنجر السلحفانية (صفر النمو) حيث بلغ ١٠,٥ م٥ ، ١٣,٨ م ، ٥ ، ١١ م ٥ ١٢ م ٥ لكل من البيضة ، اليرقة ، العذراء ، الحشرة الكاملة بلغت الإحتياجات الحرارية لهذا الأطوار ٨ ، ٧٩ ، ١٠٣ ، ١٠٥ ، ٦ ، ٢٨٨ وحدة حرارية يومية متراكمة أعلى صفر النمو لكل بيضة اليرقة ، العذراء ، الحشرة البالغة كما بلغت عدد الوحدات الحرارية المتطلبة لنمو جيل بأكمله ٥٢٨,٢ وحدة حرارية يومية متراكمة أعلى صفر النمو (١٤,٨ م ٥) . تم وضع التفسير العلمى لأختلاف عدد أجيال هذه الحشرة من عام لأخر حيث سجل للحشرة جيلين فى عامى ١٩٩٥ و ١٩٩٧ وجيل واحد فقد عام ١٩٩٦ على أساس الوحدات الحرارية المتراكمة خلال فترة نشاط الحشرة فى تلك الأعوام ، ففى عامى ١٩٩٥، و ١٩٩٧ بلغت جملة الوحدات الحرارية المتراكمة خلال المواسم نمو الحشرة ١١٠,٤ وحدة حرارية يومية ، ١١٨٥,٨ وحدة رارية يومية خلال عام ١٩٩٥ و ١٩٩٧ وهى كافية لنمو جيلين للحشرة بينما بلغت الوحدات الحرارية المتراكمة خلال المواسم النمو عام ١٩٩٦ نمو٧٧٢ وحدة حرارية متراكمة وهى لا تكفى إلا لنمو جيل واحد للحشرة خلال فترة نشاطها ، كما أمكن إستخدام حساب هذه الوحدات الحرارية فى التنبؤ بأجيال الحشرة الأعوام التالية