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IMPLEMENTATION OF THRESHOLD OF DEVELOPMENT AND DAY DEGREE UNITS WHEN INTEGRATED PEST PROGRAMMES OF CITRUS LEAF MINER, *PHYLLOCNISTIS CITRELLA* STAIN ARE CONSIDERED

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Abstract

A simple method of estimating accumulated thermal units was adopted; utilizing daily mean temperature. The threshold rates of development of citrus leaf miner stages viz. egg, larva, pre-pupa, pupa and adult on 4 constant temperatures (15, 20, 25 and 30°C) were estimated. The bio feature parameters decreased with the increase in the corresponding temperature. The total life span duration varied greatly between 127.1, 53.7, 24.7 and 22.2 days at 15, 20, 25 and 30°C, respectively. The target instars reared in both laboratory temperature (26.3±2°C) and green house temperature (24.1±3°C) showed that the total life span was 25.8 and 27.1 days, respectively. The estimated zero figures of development for eggs, larvae, pre-pupae, pupae and adults were 7.5, 12.6, 10.7, 12.7, and 11.9°C, respectively with general mean 11.1°C. The accumulated thermal units needed for completing one generation was 398.29 DD units.

INTRODUCTION

During the last ten years, the citrus leaf miner (CLM), *Phyllocnistis citrella* stain plays an obvious role as "a key insect pest" affecting negatively citrus production in Egypt. CLM larvae fed on green parts destroying the new leaf flushes of citrus, in tropical and sub-tropical regions (Hill, 1974). The CLM infests a wide range of hosts belonging to Rutaceae, Oleaceae, Loranthaceae and Lauraceae. The characteristic features of larval infestation appeared as feeding sites on epidermal cells causing serpentine mines and subsequently leave curl.

Because temperature is crucial to biochemical reactions, it can be used to predict rates of insect development. Several methods have been advanced to utilize the relationship for prediction. Of the most prevalent methods of measuring and estimating physiological time is the "Degree day temperature" method. By accumulating degree-days each day and relating those to the thermal constants the expected numbers of generations are established.

The present laboratory study was conducted to estimate the most common bio-events for citrus leaf miner i.e. establishing thermal constants for egg hatching, each larval stage, nymphal molt, pupation and adult emergence. The effect of temperature threshold on the rate of development in relation to the accumulated thermal requirements was studied by Ba-Angood (1977) in Sudan, Ba-Angood (1978) in Yemen, Wilson (1991) in USA, Beattie and Smith (1993), Zhang *et al.* (1994) in China and Abd al-Aziz (1995) in Egypt.

MATERIALS AND METHOD

The colony of CLM, *P. citrella* was maintained for three years old sour orange, *citrus aurantium.* The study was carried out to verify certain biological aspects under four constant temperatures (15, 20, 25 and 30°C) as well as under green house and laboratory conditions of 24.1±3°C and 26.1± 2°C, respectively.

A hundred of sound sour orange seedlings free of any CLM infestation were artificially infested under green house condition. Each treatment was represented by five sour orange seedlings and exposed to natural infestation with CLM moths for an overnight. In the second day, the exposed seedlings were examined using steriomicroscope. Only, one egg/leaf were left and removed the excess from ten selected leaves. The exposes seedlings for each treatment were kept under an appointment temperature and protected from any newly infestation by keeping each one under perforated transparent plastic cage. The biological data were recorded for the incubation period of eggs, larvae, pre-pupae, pupae and adult longevities under laboratory and green house conditions.

Rate of development for each immature and mature stages were calculated from the equation recommended by Stinner *et al.* (1974). Threshold of temperature or zero of development for each stage was calculated accordingly to Alrouchdi (1986).

The 1st equation:

Rate of development = (1/t) 100

Where: t = period of insect development.

The 2nd equation:

$$\text{Threshold of temperature (to)} = T_1 - \frac{P_2 (T_2 - T_1)}{P_1 - P_2}$$

Where: P_1 = period of insect development at T_1 temperature.

P_2 = period of insect development at T_2 temperature

Thermal unit needed were represented as degree-days "DD°" as the fraction of time spent for each stage based on this threshold (William *et al.*, 1994).

The 3rd equation:

$$D^\circ = Dt\ (Td - Tt)$$

Where : D° = thermal unit.

Td = average temperature during development of immature and mature stages.

Tt = zero development or threshold of temperature.

Dt = development time from egg to adult

RESULTS AND DISCUSSION

The citrus leaf miner larvae, *P. citrella* is the injurious stage attacking the newly leaves of citrus and make mines to feed newly hatching larvae until pupation. So, it was not easy to determine the stadium for each larval instar, but the larval period estimated as the period of 3 stadia. As for 4th instar larva, it is so called pre-pupa.

Data in Table 1 show that the egg stage (incubation period) ranged from 9.7 days at 15°C and reduced to 3 days at both 25 & 30°C. The larval period varied according to the rearing temperatures i.e., 28.6, 11.3, 4.4 and 4.0 days for larvae reared at 15, 20, 25 and 30°C, respectively. The durations of the pre-pupal stage were 4.5 days at 15°C and one day for the other treatments at 20, 25 and 30°C. The pupal periods were 34.0, 13.8, 5.5 and 5.2 days at 15, 20, 25 and 30°C, respectively.

The female longevity demonstrated the same trend i.e. decreased with the increasing of the corresponding degree of temperatures (52.1, 23.3, 10.8 and 9.0 days at the 4 respective temperatures). Generally, the durations of total life span were 127.1, 53.7, 24.7 and 22.2 days at 15, 20, 25 and 30°C, respectively.

From data in Table 2 the mean durations of CLM stages reared in green house (20.1 - 26.7°C) and laboratory conditions (20.0 - 23.6°C) varied greatly. The incubation periods of eggs and pre-pupal period were similar for both two rearing temperatures. Larval period and pupal period, however, were shorter at green house temperatures than laboratory rearing temperatures.

On the contrary, the female longevity was quite longer in green house (11.8 days) than in laboratory (9.1 days). Generally, total life span was 27.1 days in green house compared with 25.8 days in laboratory rearing conditions.

The biological data represented in Table 1 and applying the previous mentioned equations to estimate the rate of development (equation no. 1), zero development (equation no. 2) and the thermal units or degree-days of temperature (equation no. 3). Carefully integration of data in Table (1) showed the rate of development for each developmental stage at different degrees of temperature. The rate of development value was increased gradually by the increasing of temperature. Larval, pupal duration and adult longevities values were the same at 25 and 30°C for eggs and pre-pupal stages. The incubation period and pre-pupal periods were not significantly differs at both temperatures. The total life span was 127, 53, 24 and 22days at 15, 20, 25 and 30°C, respectively, Table 1.

By applying equation 2., zero development was estimated on egg stage as the lowest degree of temperature to start the embryoes grow up (7.5°C), while the highest zero of development was recorded for pupal stage 12.7°C. Generally, zero of development for the total life span was 11.1°C, Table, 3.

The thermal units requirement (degree-days of temperature) upon applying the 3rd equation, these values were influenced by temperature degrees. The lowest thermal units requirement was recorded for survivors reared on 25°C in all developmental stages. Generally, the thermal units requirement for the total life span ranked descendingly i. e., 334.99, 400.38, 414.36 and 443.45 units at 25, 15, 30 and 20°C, respectively, Table, 3.

Like other insects, citrus leaf miner *P. citrella* is capable of survival only within certain environmental limits of the environmental factors. Temperature probably demonstrates the greatest affect on the developmental growth rates of this insect. Within certain limits, the higher (35°C), the temperature, the faster is the development. The obtained data, however, revealed that developmental rates increase with temperature to a certain limits. According to biochemical reactions between CLM and temperature one can predict the rates of development depending on "Zero of development". Several methods have been advanced to utilize the relationship for prediction; of these the most prevalent method this so-called physiological time ("the degree-day" method). To predict the stage of development from degree-days, the thermal constants for CLM were established.

Several authors estimated the thermal units, Pandy and Pandy (1964) reported that larval period 5-10 day, while pupal period was 6-22 day, Ba-Angood (1978) in Yemen, Hill 1974 in India recorded 18.5, 15.6, 12.5 and 10.4 days for larval stage and 19.5, 16.6, 16.3 and 9.2 days for pupal stage at 20, 25, 30 and 35°C, respectively., Radke and Kandalkar (1987) in India recorded 3.75 days for adult longevity; Batra *et al.*, 1988 in Punjab, Shevale and Pokhakar (1992) in India reported 10-11.6 days, Heppner (1993) in Florida; Beatie and Smith, 1993 in Australia, Zhang *et al.*, 1994 in China and Abd El-Aziz, 1995 in Egypt, also studied the temperature effects on the biology of CLM.

Table 1. Mean durations of different developmental stages of citrus leaf miner *Ph. citrella* at four degrees of constant temperatures

Temp. °C	Durations (in days)											
	Egg stage		Larval stage		Pre-pupal stage		Pupal stage		Adult female longevity		Total life-span	
	Range	Mean ±S.E.	Range	Mean ± S.E.	Range	Mean ± S.E.	Range	Mean ± S.E.	Range	Mean ± S.E.	Range	Mean ± S.E.
15°	7-9	7.9±0.22	26-31	28.6±0.6	4-5	4.5±0.17	33-35	34.0±0.26	50-55	52.1±0.72	120-131	127.1±1.23
20°	4-5	4.3±0.15	10-12	11.3±0.26	1-1	1±0.0	13-15	13.8±0.2	21-26	23.3±0.67	51-57	53.7±0.7
25°	3-3	3±0.0	4-5	4.4±0.16	1-1	1±0.0	5-6	5.5±0.17	8-13	10.8±0.5	21-27	24.7±0.6
30°	3-3	3±0.0	4-4	4±0.0	1-1	1±0.0	5-6	5.2±0.13	8-10	9.0±0.26	21-23	22.2±0.25
F-value	214.5***		1167.1***		441.0***		4801.4***		1036.9***		3876.6***	
L.S.D.	0.4		0.9		0.2		0.5		1.7		2.25	

F value 0.05 = 214.5

Table 2. Effect of prevailing temperatures on the duration of *Ph citrella* stages reared under green house and laboratory conditions (Shoubra EL- Kheima, 1997)

Range of Temperature	Durations (in days)											
	Egg stage		Larval stage		Pre-pupal stage		Pupal stage		Adult female longevity		Total life-span	
	Rang	Mean ±s.e.	Range	Mean ±s.e	Range	Mean ±s.e	Range	Mean ±s.e	Range	Mean ±s.e	Range	Mean ±s.e
Greenhouse (20.1-26.7)	3-3	3±0.0	4-4	4±0.0	1-1	1±0.0	7-8	7.3±0.5	9-14	11.8±1.5	24-30	27.1±1.4
Laboratory (20.0-23.6)	3-3	3±0.0	4-5	4.4±0.5	1-1	1±0.0	7-10	8.2±0.9	7-13	9.1±2.2	22-32	25.8±2.3

Each mean was estimated from ten replicates.

Table 3. Rate of development and the corresponding accumulated thermal units needed for citrus leaf miner, *Ph. citrella* stages at four constant temperatures.

Temp. °C	Durations (in days)											
	Egg stage		Larval stage		Pre-pupal stage		Pupal stage		Adult female		Total life-span	
	Rate of develo-pment	Thermal units	Rate of develo-pment	Thermal units	Rate of develo-pment	Thermal units	Rate of develo-pment	Thermal units	Rate of develo-pment	Thermal units	Rate of develo-pment	Thermal units
15	12.66	52.50	3.49	68.64	22.2	19.35	2.94	78.20	1.9	161.51	43.19	495.70
20	23.25	53.75	8.85	83.62	100	9.30	7.25	100.74	4.3	188.73	143.65	477.93
25	33.33	52.50	22.73	54.56	100	14.30	18.18	67.65	9.3	141.48	183.54	343.33
30	33.33	67.50	25.00	69.60	100	19.30	19.23	89.96	11.1	162.90	188.66	419.58
Mean of thermal units	58.25		69.1		15.6		84.1		163.7		539.01	
Zero of development	7.5 °C		12.6 °C		10.7 °C		12.7 °C		11.9 °C		11.1 °C	

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تطويع قراءات الحد الحرج للنمو والوحدات الحرارية المتراكمة في برامج المكافحة المتكاملة لناخرات أوراق الموالح

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بحساب الحد الحرج للنمو والوحدات الحرارية التراكمية اللازمة لاتمام نمو أطوار حشرة ناخرة أوراق الموالح باستخدام متوسط درجات الحرارة العظمى والصغرى وجد أن قيم صفر النمو لاطوار البيضة ,اليرقة، طور ما قبل العذراء، العذراء ,الطور الكامل ,الجيل الكامل على أربعة درجات حرارة ثابتة ١٥، ٢٠، ٢٥، ٣٠ °م هى ٧,٥ و١٢,٦ و١٠,٧ و١٢,٧ و١١,٩ والمتوسط العام ١١,١ °م، بينما كانت قيم الظواهر البيولوجية (العمر) مختلفة تماما تبعا لدرجة الحرارة الثابتة فكانت فترة العمر أطول ما يمكن على درجات الحرارة المنخفضة من ١٢٧,١ و٢٢,٢ و٢٤,٧ و٥٣,٦، يوم تحت درجات الحرارة ١٥ و٢٠ و٢٥ و٣٠ °م على الترتيب. ومن حساب الحرارة التراكمية بالمعايير البيولوجية كانت الحرارة اللازمة لاتمام نمو جيل كامل ٣٩٨,٤٥ درجة نوعية تراكمية، هذه النتائج هى لبنة فى امكانية التنبؤ بنشاط الافة على مدار السنة وتواريخ التواجد القصوى وهو أمر حتمى فى برامج المكافحة المتكاملة.