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STUDIES ON THE BIOLOGY AND LIFE TABLE OF THE SOFT SCALE INSECT; *PULVINARIA TENUIVALVATA* ATTACKING SUGAR CANE IN EGYPT (HEMIPTERA: HOMOPTERA: COCCIDAE)

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Abstract

Biology and life table studies were conducted for sugar cane soft scale insect, *Pulvinaria tenuivalvata* (Newstead) (Hemiptera:Homoptera: Coccidae) reared on sugar cane, *Saccharum officinarum* L. under laboratory conditions of 20, 24, 28 and 32 °C and relative humidity of 72±5%.

P. tenuivalvata reproduces parthenogenetically due to absence of males in the field and in the laboratory. Duration of different stages decreased as the temperature increased. Life cycle was recorded as 60 ± 2.11, 42 ± 1.29, 34 ± 1.68 and 30 ± 1.82 days at 20, 24,28 and 32 °C, respectively. The highest reproductive rate (R_o) occurred at 28°C as 200.64 expected females /female. Intrinsic and finite rates of increase (r_m and exp r_m) were greater as temperature increased, while mean generation time decreased as temperature increased. It was 83.5, 61.0, 51.0 and 45.5 days at 20, 24, 28 and 32 °C, respectively. The population had a capacity to multiply (Dubling time) every 11.95 days at 20°C and every 6.19 days at 32°C. Zero of development for the different stages was calculated as 4.59 ºC for egg, 6.45ºC for 1st nymphal instar 9.87 ºC for 2nd instar and 5.22 ºC for 3rd instar. The calculated required thermal units were 112.75, 129.73, 212.90 and 280.16 degree-days (DD) for egg, 1st, 2nd and 3rd nymphal instars, respectively, with 1010.95 units for the whole generation.

INTRODUCTION

Sugar cane, *Saccharum officinarum* L. is the major source of sugar production in Egypt. Insect pests are limiting factors affecting its production. One of which is the soft scale insect, *Pulvinaria tenuivalvata* (Newstead) (Hemiptera: Coccidae). As a new pest, it threatens sugar cane cultivations in Egypt (Ali *et al.* 1997). High populations of this scale insect cause severe injury to sugar cane plants either by sucking the plant sap resulting in severe wilting or by sooty mould growth on the honeydew execration. Both effects impair photosynthesis and inhibit growth of infested plants. Stithanathan and Saivaraj (1974) and Washburn *et al.* (1985) found that high scale densities cause significant reduction in cane weight and juice quality, particularly sucrose content. Insect development is commonly influenced mainly by temperature.

The objectives of this study aimed at estimating: the bio-effects of different temperatures on the developmental durations, life table parameters, zero of development, thermal units required for each stage and whole generation under laboratory conditions, to be available as base for further control program.

MATERIALS AND METHODS

Laboratory technique for rearing *P. tenuivalvata*

A standard colony of the soft scale insect, *P. tenuivalvata* was established in the laboratory on the leaves of commercial sugar cane variety; Giza 54/9 (C9). Culture plants were grown in plastic pots 30 cm in diameter and height. Pots were filled with a mixture of soil and peat moss. An artificial infestation was accomplished by transferring newly full-grown females to sugar cane seedlings. Experiments were carried out to study effects of the different temperatures (i.e. 20, 24, 28 and 32°C) and relative humidity of (72 ± 5%) on the duration of the nymphal stages. Two hundred newly hatched nymphs (representing four equal replicates) were individually transferred to sugar cane seedlings and incubated at one of the tested temperatures. Nymphs at each temperature regime were monitored daily to determine moulting, developmental period and survival. Newly formed adults were monitored at 5-day intervals to record number of deposited eggs for each female until death.

Obtained data were statistically analyzed and life table parameters were calculated according to Birch (1948) using a Basic Computer Program (Abou-Setta *et al.* 1986). Zero development and degree–days (DD) of each instar were also determined according to Pruess (1983) and Pedigo (1991).

RESULTS AND DISCUSSION

Pulvinaria tenuivalvata reproduced without mating, either in the laboratory or in the field due to absence of males, similar to results have been reported for *Pulvinaria mesembryanthemi* in California (Washburn and Frankie, 1985).

Results of developmental durations indicated that as the temperature increased duration of each developmental stage decreased Table (1). The longest mean egg incubation period was 7±0.18 days at 20ºC, while the shortest one (4±0.17 days) occurred at 32 ºC .

Results in Table 1 show that increasing of used temperature negatively affected the durations of different developmental stages. The development of *P. tenuivalvata* nymphal stages showed that the three instars lasted 9, 22 and 22 days at 20ºC compared with 5, 10 and 11 days at the highest tested temperature (i.e. 32ºC), respectively. Life cycle was greatly influenced by used temperature, it showed a gradual increase as temperature decreased; (i.e. 30 ± 1.82, 34 ± 1.68, 42±1.29 and 60±2.11days at 32, 28, 24 and 20 ºC, rrrrrererrespectively. This results are in harmony with those of Erkilic and Uygun (1997) in Turkey who reported that the longevity of *Pseudaulacaspis pentagona* (Hemiptera: Diaspididae) decreased with rising the temperature. On the other hand, the adult longevity was slightly affected by the temperatures especially between 20-28ºC (40-42 days) and dropped severely to 30 ± 1.37 days at 32 ºC.

The effect of temperature on life table parameters is presented in Table 2. The multiplication rate per generation (R_O) differed according to temperature. This value increased with temperature increased till reaching 28ºC, then decreased at 32ºC. This value averaged 125.53, 175.77, 200.64 and 166.84 expected females / female at 20, 24, 28 and 32ºC, respectively. Values of mean generation time (T) were 83. 05, 61.0, 51.0 and 45.5 days at the used temperature degrees, respectively. Values of r_m as well as those of exp r_m responded positively correlated with the temperature increase. They were 0.058, 0.085, 0.104 and 0.112 indvidual / female / day for the first parameter, and 1.060, 1.088, 1.109 and 1.119 times / female / day for the second one at 20, 24, 28 and 32ºC, respectively. Life span was negatively correlated with temperature. It was (i.e. 60, 74, 84 and 100 days at 32, 28, 24 and 20 ºC, respectively).

This trend was also noticed with the survival rate. It was 0.83.0.93 and 0.96 at the first three temperature degrees, respectively, then declined to 0.86 at 32 ºC, Table 2.

These results are in agreement with those of Kapatos and Stratopoulou (1990) who constructed life tables of *Saissetia oleae* (Hemiptera : Coccidae) on olive. They indicated that mortality of young stages in summer was caused mainly by high temperatures, and mortality during spring was caused mainly by the coccinellids as predators and the parasitoid *Metaphycus helvolus*. These two factors were the predominant ones determining population fluctuations of this coccid.

The age specific female fecundity (m_x) and the rate of survival (l_x) are shown in Fig. 1. Although the rate of female survival was less at 32ºC than at 28ºC, yet the intrinsic rate of increase (r_m) was higher which was affected by the specific rate of fecundity and mean generation time.

The doubling time of the population was 11.95 days at 20ºC, 8.19 at 24ºC, 6.68 at 28ºC and 6.19 at 32 ºC, Table 2.

Using to the estimated mean duration at the four degrees of temperature, the rate of development was calculated for the different stages at each degree and the lines representing the relationship between temperature and rate of development for each developmental stage is shown in Fig. 2. It was found that zero of development for different stages was 4.59ºC for egg, 6.45ºC for 1^{st} nymphal instar, 9.87ºC for 2^{nd} instar and 5.22ºC for 3^{rd} instar, Table 3.

Calculated degree-days (DD) (thermal units) were 112.75, 129.73, 212.90 and 280.16 for egg stage, 1^{st}, 2^{nd} and 3^{rd} nymphal instars, respectively, with 1010.95 units for the whole generation. The heat units required for the developmental stages from egg to a half of oviposition period was estimated as 1252.46.

Thus, it could be concluded that 28ºC was the optimal one for the highest reproductive rate (R_O 200.64 expected females / female).

From the forementioned results, it is evident that temperature has a significant effect on the reproductive rate, intrinsic increase and finite rate of increase. These estimated parameters will eventually provide rational and predictive bases for pest control, enabling both the forecasting of climatically induced outbreaks, and also from this prediction may be made of future population trends or of the response of the population to some changes in environmental factors.

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Table 1. Effect of different temperature degrees on the durations (days) of *P. tenuivalvata.*

Temps. ºC	Incubation period	Nymphal instars			Life cycle	Adult longevity
		1st	2nd	3rd		
20	7 ± 0.18	9 ± 0.21	22± 0.78	22 ± 0.92	60 ± 2.11	40 ± 2.57
24	6 ± 0. 11	8 ± 0.30	15±0.42	13 ± 0.51	42 ± 1.29	42 ± 1.85
28	5 ± 0.12	6 ± 0 .14	11± 0.35	12 ±0.82	34 ± 1.68	40 ± 2.14
32	4 ± 0.17	5 ± 0.19	10 ± 0.28	11 ± 0.45	30 ± 1.82	30 ± 1.37

Values one mean ± stander error.

Table 2. Life tables of *P. tenuivalvata* on sugar cane seedlings at different temperatures and 72 ±5% RH.

Temp. (ºC)	Mean generation time T (days)	Total life span (days)	Survival rate of immatures	Net reproductive rate (R_0)	Intrinsic rate of increase (r_m) /day	Finite rate of increase (exp r_m) /day	Population doubling time (DT) (days)
20	83.5	100	0.83	125.33	0.0580	1.06	11.95
24	61.0	84	0.93	175.77	0.0846	1.088	8.193
28	51.0	74	0.96	200.64	0.1038	1.109	6.678
32	45.5	60	0.86	166.84	0.1120	1.119	6.189

Table 3. Zero of development and degree - days (DD) ,required for *P. tenuivalvata* different stages of development.

Temp. ºC	Stage						
	Egg	1st nymphal instar	2nd nymphal instar	3rd nymphal instar	Total nymphal stage	Generation	Total period to half oviposition
20	0.143	0.111	0.046	0.045	0.019	0.013	0.012
24	0.167	0.125	0.067	0.077	0.028	0.018	0.015
28	0.200	0.167	0.091	0.083	0.035	0.022	0.019
32	0.250	0.200	0.091	0.091	0.039	0.025	0.021
Zero of development	4.59	6.45	9.87	5.22	7.74		
Degree days	112.75	129.73	212.90	280.16	610.82	1010.95	1252.46

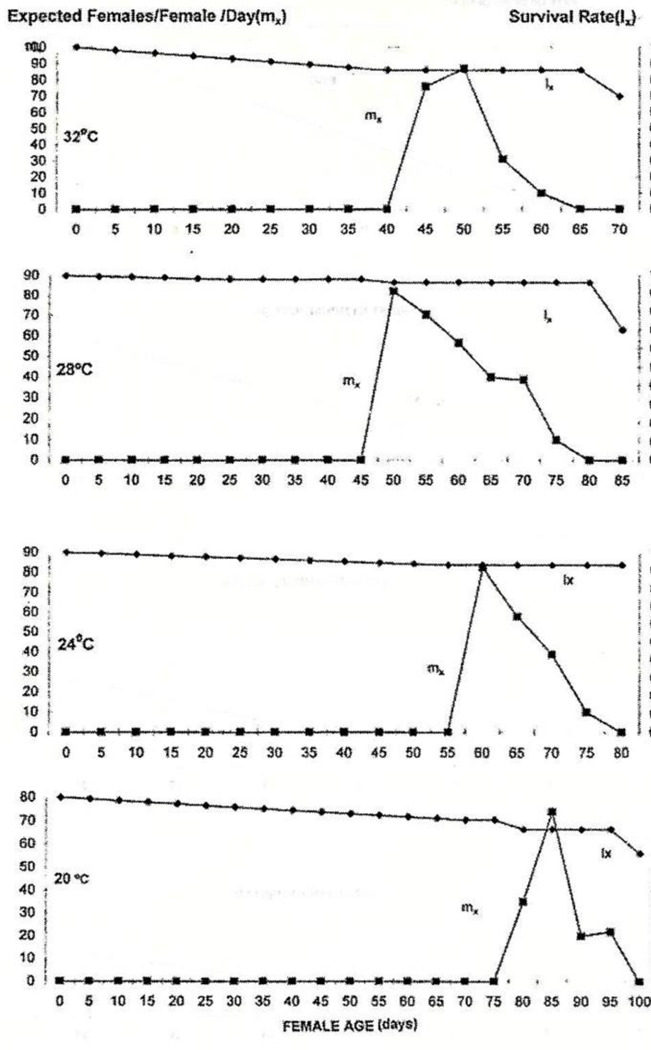

Fig. 1. Age Specific fecundity and survival rates of *P. tenuivalvata* at different temperatures.

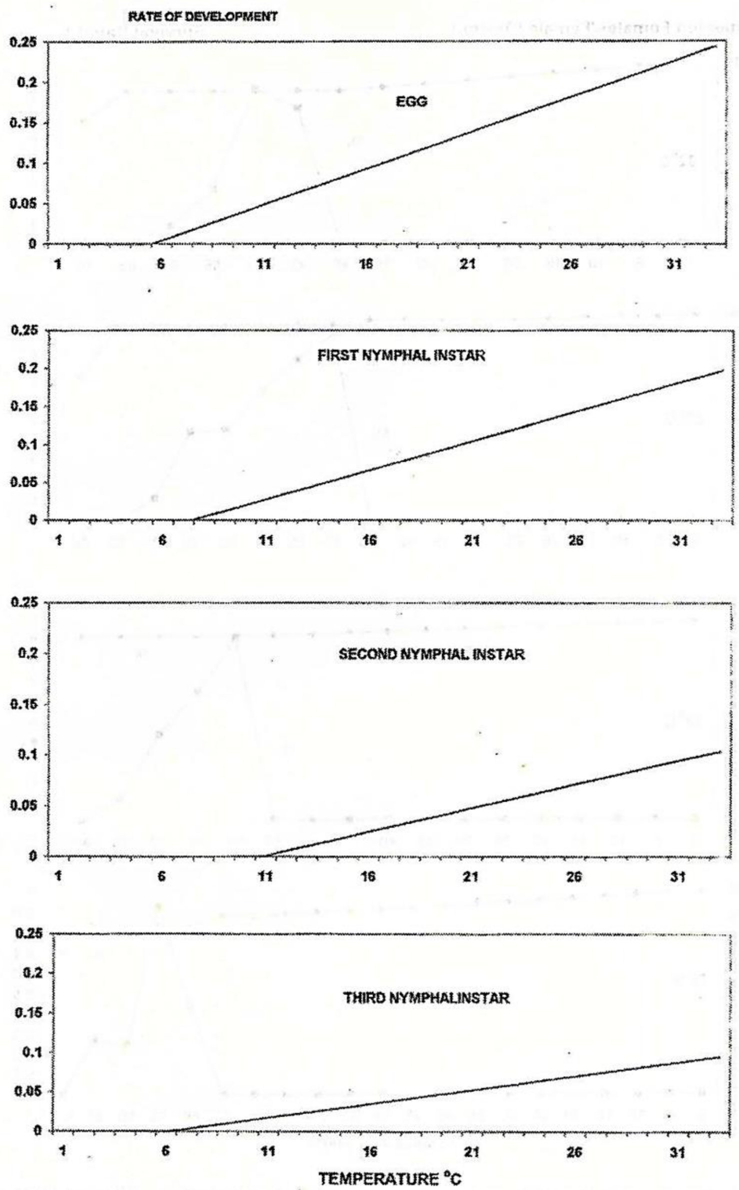

Fig. 2. Calculated zero of development for different stages of *P. tenuivalvata*.

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دراسات عن بيولوجي وجداول الحياة للحشرة القشرية الرخوة *PULVINARIA TENUIVALVATA* علي قصب السكر

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اجريت دراسات بيولوجية علي حشرة القصب القشرية الرخوة عند أربعة درجات حرارة ٢٠ ، ٢٤ ، ٢٨ ،٣٢ °م لعمل جداول الحياة وتقدير معدل الخصوبة (R_0) ومعدل الزيادة الحقيقي في تعدادها (r_m) بالاضافة الي تقدير الدرجة الحرجة للنمو والاحتياجات الحرارية لأطوار الحشرة المختلفة.

تشير الدراسة الي وجود علاقة عكسية بين درجة الحرارة وطول مدة الأطوار المختلفة حيث تراوحت مدة الجيل بين ٨٣,٥ يوم علي درجة ٢٠°م و ٤٥,٥ يوم علي درجة ٣٢ °م - علي العكس من ذلك كانت العلاقة مع قيمة الـ r_m والتي سجلت٠,٠٥٨ ، 0.112 عند درجتي الحرارة بالترتيب. ظهر من الدراسة كذلك أن قيم صفر النمو كانت ٤,٥٩، ٦,٤٥ ، ٩,٨٧، ٥,٢٢°م لأطوار البيضة والأعمار الحورية الثلاثة كما كانت احتياجاتها الحرارية (DD) ١١٢,٧٥، ١٢٩,٧٣ ، ٢١٢,٩٠ ، ٢٨٠,١٦ وحدة علي الترتيب بمعدل ١٠١٠,٩٥ وحدة حرارية للجيل الواحد . قدر معدل الخصوبة بحوالي ٢٠١ بيضة / فرد عند درجة حرارة ٢٨ °م علما بأن التكاثر في هذه الحشرة بكري. يتضح من هذه النتائج أهمية الدراسة في وضع أسس التنبؤ بتعداد تلك الآفة مما يساعد علي إمكانية وضع برنامج افضل ومتكامل لمكافحتها حقليا.