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The Effects of Temperature on the Development of Hemispherical Scale, *Saissetia Coffeae* (Walker)

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ABSTRAK

Kadar tumbesaran dan saiz teritip, Saissetia coffeae *(Walker)(Homoptera: Coccidae) telah dikaji dalam tujuh keadaan suhu: 18°C, 20°C, 22°C, 24°C, 26°C, 28°C dan 30°C. Keputusan menunjukkan bahawa peningkatan suhu yang terhad mempercepatkan tumbesaran teritip. Oleh itu jangka masa telur ke peringkat dewasa pada suhu 18°C dan 28°C ialah 95.2 hari dan 51.2 hari. Pembiakan nimfa teritip berpanjangan, pada suhu 30°C tidak dapat menghasilkan teritip dewasa. Ini menandakan bahawa suhu 30°C boleh menyebabkan kematian kepada teritip. Terdapat juga korelasi yang tinggi di antara tumbesaran dan suhu pada semua peringkat teritip apabila menggunakan regresi polinomial.*

ABSTRACT

The rate of growth and size of Saissetia coffeae *(Walker) (Homoptera: Coccidae) were studied under seven different constant temperature: 18°C, 20°C, 22°C, 24°C, 26°C, 28°C and 30°C. Results showed that an increase in temperature within limits would accelerate the rate of development for all the stages of* S. coffeae. *Thus, the development from egg to adult at 18°C and 28°C were 95.2 and 51.2 days respectively. Continuous rearing of nymphal scales at 30°C failed to produce adults indicating lethal effects at this temperature. There was a higher correlation between temperature and growth rate for all the stages of scale using polynomial regression.*

INTRODUCTION

There are many environmental factors such as temperature, relative humidity and photoperiod which affect the rate of insect development. Within the glasshouse, temperature appears to be the most important of these. In insects and other poikilothermic animals, the rate of development varies with the temperature (Andrewartha and Birch, 1954). This investigation is conducted to study the rate of development of *S. coffeae* (Walker) (Homoptera: Coccidae) under seven different constant temperatures. This finding will be used to determine the thermal requirement of the hemispherical scale.

MATERIALS AND METHODS

For biological studies of *Saissetia coffeae* eggs and crawlers were obtained from mother scales reared on green potato sprout, cv. Comet 90 in a constant room temperature of 25°C: ± 1°C (18 hours light: 6 hours dark) and 70% r.h. The constant temperature experiment was conducted in compact 130 mm × 500 mm × 500 mm Gallenkamp illuminated cooled incubators.

The eggs incubation period was determined by using one day old egg of a mother scale. Twenty eggs were spread on blotting paper in a small petri-dish (50 mm diameter). This petri dish was in turn placed within a bigger dish (85 mm diameter), containing some distilled water. The latter dish was covered with fine muslin so as to give maximum humidity to the eggs. The petri dish containing the eggs was kept in a constant temperature incubator. Five replicate petri dishes were kept at the following temperatures: 18°C, 20°C, 22°C, 24°C, 26°C, 28°C and 30°C. The procedure for determining egg viability was similar to that of egg incubation. Twenty five eggs were kept in each petri dish at the following temperatures: 18°C, 22°C, 26°C and 30°C. Four replicate petri dishes were kept at each temperature regime. The eggs were observed daily with a stereomicroscope (× 15) for the emergence of the crawlers.

For studying the development of the scale, green potato sprouts, two weeks old, were uprooted from the soil and washed with clean water. Newly emerged crawlers were transferred from the mother scale on to the leaves of potato sprouts using a fine paint brush. Each sprout was infested with 100 crawlers. The infested sprout was then kept in a ventilated polystyrene box (175 mm × 115 mm × 52 mm). Two boxes each were kept at each of the temperatures used in the study. Twenty individual scales exposed at each of the various constant temperatures were selected at random for studying their development. The development of the individual scales was observed daily using a stereomicroscope (× 15).

The data was analysed using F-tests and also regression analysis for determining the relationship of insect development and temperatures (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The eggs of *S. coffeae* are translucent or whitish, just after oviposition. As incubation advanced, the eggs became pale yellow and ultimately orange. The mean length and breadth is 0.25 mm and 0.13 mm respectively. This agrees well with those measurements recorded by El-Minshawy and Saad (1976) and Barber (1980) on different host plants, suggesting that food plant does not influence the egg size. The incubation period of eggs lengthened with a decrease in the rearing temperature (Table 1). At 18°C, the incubation period was significantly longer (P = 0.05) than at other temperatures. Temperature had an adverse effect on hatching, for there was a significant difference (P = 0.05) between

TABLE 1

Development time (in days) of *S. coffeae* at selected constant temperatres; based on 20 individuals at each respective temperature

°C	Egg			Instar I			Instar II		
	Mean ±	s.e.	LSD (1.04)	Mean ±	s.e.	LSD (0.65)	Mean +	s.e.	LSD (0.57
18	23.6	0.39	e	18.35	0.38	a	30.90	0.32	a
20	20.6	0.39	d	16.90	0.18	b	22.75	0.12	b
22	15.6	0.39	c	14.85	0.11	c	14.20	0.11	e
24	15.4	0.24	c	13.75	0.16	d	14.25	0.10	e
26	13.6	0.39	b	10.95	0.17	e	13.95	0.09	e
28	13.4	0.24	b	10.50	0.14	e	15.15	0.19	c
30	12.2	0.36	a	9.70	0.31	f	14.85	0.39	d

LSD = Least significant difference. Figures with the same letters are not significantly different at the 5% level.

TABLE 2
Egg hatching of *S. coffeae* at different constant temperatures; based on 25 eggs per replicate

Temperature	Mean/Replicate	± s.e.	LSD (4.20)
18	7.25	2.59	a
22	24.25	0.48	b
26	24.50	0.50	b
30	23.50	0.50	b

LSD = Least significant difference. Figures with the same letters are not significantly different at the 5% level.

TABLE 3
Effects of temperatures on the length of *S. coffeae;* based on 20 individuals at each regime

°C	Instar I Mean ±	s.e.	LSD (0.03)	Instar II Mean ±	s.e.	LSD (0.11)	Adult Mean ±	s.e.	LSD (0.35)
18	0.63	0.01	e	1.80	0.06	d	4.17	0.08	c
20	0.60	0.01	d	1.81	0.02	d	3.77	0.20	b
22	0.56	0.01	c	1.83	0.03	c	3.59	0.11	b
24	0.57	0.01	c	1.77	0.03	d	3.43	0.10	b
26	0.52	0.01	b	1.62	0.05	c	3.46	0.09	b
28	0.56	0.01	c	1.00	0.03	b	2.82	0.09	a
30	0.48	0.01	a	0.60	0.01	a		Died	

LSD = Least significant difference. Figures with the same letters are not significantly different at the 5% level.

hatching at 18°C and at any other temperature (Table 2). This suggests a high egg mortality at low temperatures. No significant difference was observed in egg hatching over a temperature range of 22°C to 30°C.

The newly emerged crawlers were pale amber in colour and measured no bigger than the egg. Its characters had been described by Brewer and Howell (1981). The crawlers settled on the potato sprouts within 2 – 3 days at a temperature range of 22°C to 30°C. At 18°C and 20°C, the crawlers took one week before they settled on the host plants. The settled scales began to develop in size and the colour changed from orange to light yellow. This instar was significantly greater (P = 0.05) when reared at 18°C. The shortest length was at 30°C (Table 3). Similarly, the first instar attained its greatest width at lower temperature and least at high temperatures (Table 4).

In the second instar, the scale is pale yellow and adpressed to the leaf veins. The length and breadth decreases with increases in temperature (Table 3 & 4). However, the second instar nymphs responded differently to a temperature above 26°C. For instance, at 28°C the developmental rate slowed down but a further increase in temperature to 30°C, again accelerated the development period. Possibly at a higher temperature (30°C) the scale grows quickly for a short while but then dies. The third instar nymph is characterised by the brownish marking on the dorsal part of the body. The scale is still flat and irregular in outline. The scale then undergoes

TABLE 4
Effects of temperatures on the width of *S. coffeae;* based on 20 individuals at each regime

°C	Instar I Mean ±	s.e.	LSD (0.03)	Instar II Mean ±	s.e.	LSD (0.07)	Adult Mean ±	s.e.	LSD (0.23)
18	0.30	0.009	dc	1.17	0.03	a	2.76	0.04	b
20	0.29	0.012	bc	1.19	0.02	a	2.58	0.06	b
22	0.26	0.009	b	1.24	0.03	a	2.71	0.09	b
24	0.29	0.007	bc	1.22	0.03	a	2.42	0.08	a
26	0.29	0.004	bc	1.08	0.03	b	2.42	0.08	a
28	0.27	0.009	b	0.53	0.03	c	2.42	0.09	a
30	0.23	0.012	a	0.30	0.02	d			

LSD = Least significant difference. Figures with the same letters are not significantly different at the 5% level.

rapid growth and increases in all dimensions i.e. length, breadth and depth. The adult scale attained the greatest length (significant at P = 0.05) at 18°C and the least at 28°C (Table 3). However, there was no significant difference in breadth within the temperature range of 24°C to 28°C (Table 4). None of the scales reached maturity at a constant temperature of 30°C because of mortality at early third instar. This suggests that 30°C is the temperature above the critical lethal limit for the 3rd instar nymphs. This upper threshold may vary with insect species. For instance, the second instar larvae of citrus thrips, *Scirthothrips citri* would not survive at a constant temperature of 37°C (Tanigoshi *et al.*, 1980).

The overall development period i.e. from time of infestation of crawlers until the emergence of next generation of crawlers was shortest at 28°C and longer at 18°C *(Figure 1)*. There was no significant difference in the rate of development at 26°C and 28°C but both were significantly different (P = 0.05) compared with development at other temperatures. The findings from this study show that *S. coffeae* could thrive at a temperature range of 18°C to 28°C. The optimal temperature is 26°C, for at this temperature the scales attain normal size and growth in the shortest period. Fitting quadratic regression equations to development from eggs to adult maturity gave higher coefficients of correlation (r2 value) compared to linear regression equations. In general, the regression coefficient

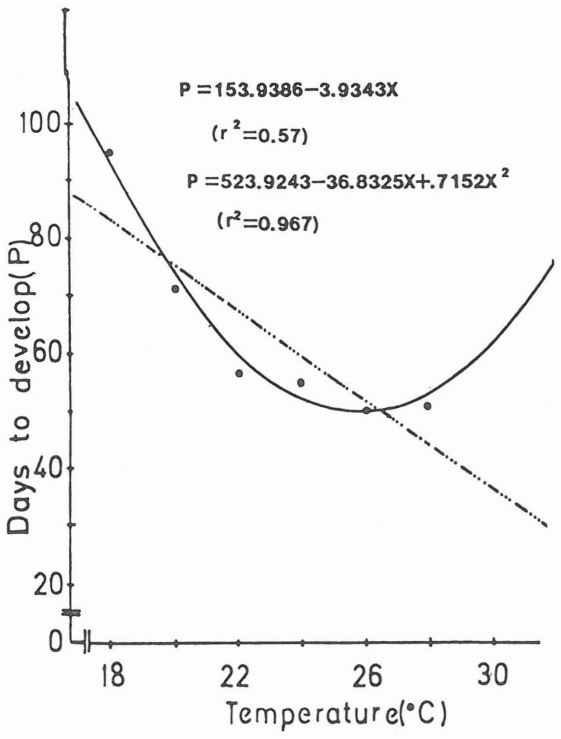

Fig. 1. Growth curve for crawlers to F. generation of crawlers of S. coffeae at different temperatures.

TABLE 5
Regression coefficients of the reciprocal of development period for each life stage of *S. cofeae*

Stage of development	Linear equation $P = B_o + B_1 T$		
	B_o	B_1	R^2
Egg	-1.42857×10^{-2}	3.2679×10^{-3}	0.893
1st instar	-2.67143×10^{-2}	4.3393×10^{-3}	0.949
2nd instar	5.7143×10^{-4}	2.43929×10^{-3}	0.225

Stage of development	Quadratic equation $P = B_o + B_1 T + B_2 T^2$			
	B_o	B_1	B_2	R^2
Egg	-9.92857×10^{-2}	1.05535×10^{-2}	-1.5179×10^{-4}	0.968
1st instar	4.95238×10^{-3}	1.6250×10^{-3}	5.6548×10^{-5}	0.977
2nd instar	-3.4209×10^{-1}	3.1810×10^{-2}	-6.1190×10^{-4}	0.834

Stage of development	Cubic equation $P = B_o + B_1 T + B_2 T^2 B_3 T^3$			
	B_o	B_1	B_2	B_3
Egg	-2.81952×10^{-1}	3.41646×10^{-2}	-1.115178×10^{-3}	1.3889×10^{-5}
1st instar	5.07285×10^{-1}	6.33055×10^{-2}	2.80655×10^{-3}	-3.8194×10^{-5}
2nd instar	-1.15952×10^{0}	1.37470×10^{-1}	-5.08690×10^{-3}	6.2153×10^{-5}
Crawler to crawler	-1.49809×10^{-1}	1.75019×10^{-2}	-6.04166×10^{-4}	6.9444×10^{-6}

of the reciprocal of growth rate for all stages of scales had a better fit with cubic regression (Table 5). However, it showed no significant differences with the quadratic regression. Therefore the quadratic regression should be useful in calculating the development of this hemispherical scale.

CONCLUSION

Temperature greatly influenced the development of *S. coffeae*. The lowering of the temperature increased the dimension of the scales and lengthened the development period. The overall development of the scale at 18°C and 28°C were 95.2 days and 51.25 days respectively. The lethal limit for scale development appeared to be 30°C. A quadratic regression was found to be a good coefficient of correlation for all stages of scales.

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