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THE INTRINSIC RATE OF INCREASE AND TEMPERATURE CO-EFFICIENTS OF THE COMSTOCK MEALYBUG, *PSEUDOCOCCUS COMSTOCKI* (KUWANA) (HEMIPTERA: COCCOIDEA: PSEUDOCOCCIDAE).

ABSTRACT

The intrinsic rate of increase and temperature co-efficients of the Comstock mealybug, *Pseudococcus comstocki* (Kuwana) (Hemiptera: Coccoidea: Pseudococcidae).

Life history studies on the development of *Pseudococcus comstocki* (Kuwana) were made under laboratory conditions at four constant temperatures, namely 18, 22, 26 and 30°C. Temperature proved to have a significant effect on development, survival, reproduction and longevity, and on the sex ratio of *P. comstocki*. Reproduction, survival and longevity were greatest at 22-26°C and lowest at 30°C, which was detrimental to the nymphs. It was also found that the sex ratio became female biased at 30°C. On the basis of these data, the intrinsic rate of natural increase (r_m) was computed to be 0.05, 0.07, 0.10 and 0.08 at the above temperatures and the gross reproduction rate (GRR) was also temperature dependent and was calculated to be 153, 249, 210 and 57. The lower temperature threshold for development (TL) was estimated to be 11.0°C and the time from birth to adulthood (K) 523 degree days.

Key words: potato sprouts, fecundity, weight gain, crowding, sex ratio, mortality.

INTRODUCTION

P. comstocki (Kuwana) is a highly polyphagous, cosmopolitan pest of economic importance, and is a pest on citrus, many fruit trees and other ornamental plants, both in the field and under protected cultivation. It can cause severe damage to leaves, stems, fruits and roots (Miller & Kosztarab, 1979; Kosztarab, 1996). Plant damage can be caused directly by feeding and by the secretion of phytotoxic saliva, and indirectly through sooty moulds developing on the honeydew.

In the past, *P. comstocki* has been confused with several other mealybugs, particularly *P. cryptus* Hempel, but today these are fairly easily separated. However, because of the earlier problems with its identification, the biology of *P. comstocki* remains obscure. This study examines various life-history paramaters under four constant temperatures in the laboratory; in particular, it considers: i. the mortality of the immature stages, ii. the effect of body weight on fecundity, and iii. the intrinsic rate of increase.

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MATERIALS AND METHODS

Potato sprouts 5cm long, without a tuber, were placed in a culture of *P. comstocki* just before egg hatch at room temperature (approx. 22°C) for 5-6h to become infested with 1st-instar mealybugs. All but 10-20 crawlers were then removed from each sprout. The sprouts were then transferred to a ventilated plastic box (173 x 115 x 65mm) with two sprouting, soil-less potato tubers. Once the mealybugs had reached the 3rd or the beginning of the 4th female instar, 10 were kept on each potato and the rest were removed. Humidity in each box was kept at 60±5%. The box was then placed in a Gallenkamp compenstat incubator set at one of 4 temperatures and with continuous illumination provided by 6x8W fluorescent tubes. Five females per potato were carefully removed just after the last moult and weighed with a Sartorious electronic microbalance (0.005mg accuracy) and the other five were left in the box until oviposition was complete. As soon as the females started laying eggs, each insect was examined twice a day and all eggs were carefully removed and counted until the female died. The experiment was repeated at four experimental temperatures with 10 replications (100 female/treat.) in a completely randomised statistical design within each cabinet. The LSD technique (Clewer & Scarisbrick, 1991) was applied to contrast treatment means. The effect of crowding on egg production was also studied; uncrowded conditions were considered to be 5 adult females per sprout while crowded conditions were with 40-50 adult females per sprout.

In a second experiment, the effect of temperature on the survival of the immature stages was studied and the number of surviving individuals monitored. The experimental conditions were otherwise as above.

LIFE HISTORY STATISTICS:

The fecundity and longevity of *P. comstocki* were studied under four constant temperatures, each with 40 cohorts at the beginning of the experiment. The growth parameter was calculated from age-specific survival and fecundity schedules. For this, the following exponential model was applied: dN/dt = *r*N, where N is the number of individuals in the population at a given time *t*, *r* is the intrinsic rate of natural increase and *d* is a constant. r_m was calculated by an iterative solution of the Lutka-Euler equation:

$\sum l_x m_x e^{-r\, mx} = 1$ (van den Bosch *et al.*, 1982)

where x is the mid-point of the age intervals in days, l_x is the probability of a female surviving to age x, m_x is the mean number of female 'births' during age interval x per female aged x, and e is the base for the natural logarithms. Trial r_m values were substituted into the above expression until the left hand side was arbitrarily close to 1. l_x and m_x were calculated by tabulating age-specific fecundity and age-specific survival data obtained from cohort fecundity and survival experiments. The lower theoretical development threshold (TL) and the time-to-adult in degree days (K) were estimated by linear regression analysis of the development rate (100/Y) on temperature (Campbell *et al.*, 1974). The total amount of thermal energy required for complete development, the thermal constant (K), can be calculated from the reciprocal of the slope of the regression line (1/b), while the lower temperature threshold for development may be calculated from TL = -a/b.

Intrinsic rate of natural increase (rm)

All parameters for the intrinsic rate of natural increase were calculated. Species with the greatest values of the intrinsic rate of natural increase are among the more abundant and this could be a desirable feature from the biological control point of view. However, r_m is calculated by iteratively solving the above equation (Messenger, 1964).

RESULTS

Temperature was found to have a significant effect on the weight gained by mealybugs ($P<0.01$), with the maximum weight gain at 18±1°C (4.7mg/adult female during the preoviposition period) and the minimum at 30°C (1.6mg/adult female during the preoviposition period) (Table 1).

Temperature and density were also found to have a significant influence

Table 1. Mean weight gain (mg ± s.d.) by adult female *P. comstocki* between the last moult and the start of egg-laying (n = 50).

Temp.°C±1	Mean (± s.d.)
18	23.5 (1.76)[a]
22	17.6 (2.07)[b]
26	13.1 (1.18)[c]
30	8.0 (2.29)[d]

Note: means sharing similar letters are not significantly different at the 5% level

on the fecundity of *P. comstocki.* The most eggs/female were produced at 22±C, whilst at 30±C the mealybugs gained the least body weight and the oviposition rate was reduced to 60.5 ± 7.5 eggs/female (Table 2), clearly indicating the significant influence of temperature on population density of this pest.

Table 2. Interaction of degree of crowding and four constant temperatures on the mean number of eggs laid per female *P. comstocki* (n=50).

Temp.°C±1	crowded mean ± s.d.	uncrowded mean ± s.d.	pooled data: mean
18	305.5 (23.0)	394.4 (22.3)	349.95 B
22	425.0 (18.8)	489.0 (19.0)	475.0 A
26	203.8 (13.0)	249.5 (14.2)	226.6 C
30	60.5 (7.5)	75.0 (10.0)	58.7 D

Note: means sharing the same letter do not differ at *P*=0.05 (based on l.s.d., for temp., density and their interaction).

The results obtained from this investigation also revealed a marked effect of temperature on development, survival, longevity and the sex ratio of *P. comstocki* (Tables 3 & 4). Temperatures around 28°C+ were fatal to the immature stages. Higher mortality occurred at 30°C (49%) (Table 4).

The life-table (Table 5) parameters also show that 22°C and 26°C were the most favourable temperatures, with the greatest GRR and R^O, so that the greatest r_m was at 26°C and the least at 18°C. However, the lower temperature threshold for development was calculated to be 11°C and the thermal constant (K) was calculated to be 325 degree-days (DD).

DISCUSSION AND CONCLUSIONS

There was a direct correlation between temperature and body weight as well as between temperature and the number of eggs oviposited by each adult female, with lower body weights and reduced fecundity at higher temperatures. Similar results have been reported for *Phenacoccus manihoti* Matile-Ferrero (Iheagwam, 1981; Lema & Herren, 1985), *Planococcus citri* (Risso) (Bodenheimer, 1951; Tingle, 1985) and *Pseudococcus longispinus* (Targioni Tozzetti) (Guillani, 1999). These results explain why the winter

Table 3. Effect of temperature on rate of development (days), eggs per female per day (mean ± s.d.), and the sex ratio of *P. comstocki* at four constant temperatures.

Temp. °C±1	n	development to adult (days)	Survival (days)	Eggs/♀/day.	Sex ratio % female	Total eggs/adult
18	23	72.2 (5.3)^{a}	17.4 (5.3)^{A}	24.0 (7.5)^{a}	48	398 (153)^{a}
22	22	51.2 (4.0)^{b}	17.0 (7.6)^{A}	24.2 (5.8)^{a}	43	412 (199)^{a}
26	26	32.7 (2.6)^{c}	18.3 (6.8)^{A}	19.3 (3.1)^{a}	49	328 (135)^{a}
30	18	29.4 (3.0)^{d}	7.8 (2.5)^{B}	12.5 (5.3)^{b}	57	91 (37)^{b}

Note: means within columns sharing the same letter do not differ significantly at *P*=0.05 (based on l.s.d., separately calculated for each treatment).

Table 4. Effect of temperature on % egg hatch and crawler mortality of *P. comstocki* (n=100).

Temp.°C±1	Mean % egg hatch (s.d.)	n	Mean crawler mortality (s.d.)
18	78.5 (5.3)^{b}	74	26.0 (3.3)^{b}
22	90.0 (4.5)^{a}	75	26.2 (4.5)^{b}
26	89.4 (3.5)^{a}	71	14.5 (3.2)^{a}
30	72.0 (6.7)^{b}	62	49.0 (5.7)^{c}

Note: (a) l.s.d. analysis on the basis of arcsin transformation; (b) treatments sharing the same letter do not differ significantly at *P*=0.05

Table 5. Life-table parameters of *P. comstocki* at four temperatures.

Temp.	GRR	R_o	r_c	r_m	*Tc*	*T*	λ	*DT*
18°	153.3	42.5	0.049	0.049	76.2	76.1	1.051	14.06
22°	248.9	43.1	0.066	0.066	57.0	56.2	1.070	10.34
26°	210.0	47.9	0.099	0.102	37.9	38.0	1.107	6.80
30°	57.1	10.2	0.076	0.077	30.5	30.4	1.080	9.60

Note: where GRR = gross reproductive rate; R_o = net reproductive rate; r_c = capacity for increase; r_m = intrinsic rate of increase; *Tc* = cohort generation time *T* = generation time; λ = finite capacity for increase and *DT* = doubling time.

generations are larger and heavier than later in the year and, perhaps, why fecundity is greatest in the spring. The results also show that constant temperatures over 30°C are probably detrimental to the nymphs of *P. comstocki* but that temperatures ranging between 18-26°C were optimal.

favourable seasons for crawler development in Palestine and that juvenile mortality fluctuated between 10-32%, with temperatures above 26°C being unfavourable, particularly in combination with low humidity. Similar observations have been reported with *Planococcus ficus* (Signoret) and *P. citri* by Sayed *et al.* (1962). However, the above results were obtained with constant temperatures in the laboratory and it should be born in mind that survival etc. under oscillating temperatures and other humidities might be very different under field conditions.

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