view of the wide distribution of this species in the Caribbean area, its occurrence in Hispaniola is not surprising, and only emphasizes how little collecting has been done there.

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DEVELOPMENT AND FECUNDITY OF THE WHITE PEACH SCALE[1] AT TWO CONSTANT TEMPERATURES[2]

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Abstract

White peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), required a minimum of 110.8 days to complete a generation at 13.3±2°C and 40.4 days at 26.4±0.3°C. Adult maturation and oviposition encompassed the longest intervals. Females began laying eggs 50 days after molting to the

[1] *Pseudaulacaspis pentagona*, Homoptera: Diaspididae.

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adult at 13.3°C and 16 days at 26.4°C. The period of oviposition by the cohort spanned 54 and 20 days, respectively, at 13.3 and 26.4°C.

The white peach scale (WPS), *Pseudaulacaspis pentagona* (Targioni-Tozzetti), is a major pest of peach trees and numerous ornamental plants in the southeastern United States. Although WPS is attacked by several natural enemies (Collins and Whitcomb 1975), chemical control is needed in managed peach orchards to prevent damage. To be most effective, insecticides have to be applied against the crawler stage (Kuitert 1967). To determine when crawlers are emerging requires monitoring the population at close intervals after harvest (Ball and Brogdon 1978). In practice, scouting by the growers has been erratic and the crawler stages or low populations are often missed. Since the appearance and time interval when a particular stage occurs in each generation is temperature related, a thermal model offers a way to predict or follow development that would require minimal input from field sampling.

The seasonal phenology of WPS has been studied in detail in many regions (Bennett and Brown 1958, Bobb et al. 1973, Kuitert 1967, Monti 1955, Van Duyn and Murphey 1971, Yonce and Jacklin 1974), but less is known about this insect's response to discrete temperatures. Van Duyn (1967) reported a generation time of 50 days for scale reared in the laboratory at ca 21°C. Bennett and Brown (1958) did not provide details for the developmental intervals they reported for WPS reared at 25°C.

This paper reports on the developmental times for the stages of WPS when held at 13.3°C and 26.4°C.

MATERIALS AND METHODS

The WPS came from insectary stock reared on Irish potato tubers since 1975. For study, tubers were infested with 50-100 eggs aspirated from underneath mature females and placed in separate temperature control cabinets: 5 potatoes at 13.3±2.0°C and 3 potatoes at 26.4±0.3°C. Since WPS had to be maintained longer at 13.3°C, more potatoes were used to minimize loss to the cohort should a tuber degrade prior to completion of the life cycle. Photoperiod was 14L:10D and RH ranged between 72 and 90% at 13.3°C and 80 and 95% at 26.4°C. All unhatched eggs were recoved from the potatoes after 48 h and 72 h in 26.4 and 13.3°C environments, respectively. The start of cohort development was taken as the midpoint of the hatch interval.

With a few exceptions, scale insects were checked daily to determine the stage of development. During the adult stage, the female test had to be removed to establish the occurrence and amount of oviposition. This handling would either maim the females or force them to produce more wax to refasten the armor. In either case, the normal process of oviposition would be interrupted and therefore, once examined, those females were removed. In order to span the egg-laying interval with the limited number of females available, the interval between samples was expanded and, towards the end of the period, the number of females that were sampled was reduced. Although the number of eggs and empty chorions were recorded, an accurate determination of hatch was not possible because chorions became matted together or were carried off by crawlers from underneath the females' test.

Because the armor and old cuticle are retained over the body after each molt, the exact time of ecdysis cannot be established without dissection, which was precluded in this study. After molting, the body of the 2nd instar pulls away from the old cuticle, which with proper illumination can be seen as a transparent crescent bordering the opaque body. This was used to designate the 1st molt. Protrusion of the tip of the female's pygidium beyond the armor, which occurs early in the 3rd instar prior to mating, was used to establish 2nd instar ecdysis. Both criteria occur at an unknown but presumably short time after ecdysis and, therefore, will lead to some overestimation of the 2 molt periods. Prepupal and pupal stages in the males were not observed and were included in the overall development of the 2nd instar to adult emergence. In the 2nd instar, males form white, sheath-like cases that distinguish them from females.

The average developmental time for 1st and 2nd instars is the weighted mean of the time interval required for all individuals to molt to the next stage. Molt is assumed to have occurred midway between counts. Destructive sampling of the adult female prevented measuring the entire range of female longevity because some were still alive when the last sample was taken.

Results and Discussion

Males appeared to develop to adults sooner than females (Table 1), but there were too few males to provide a good estimate of the mean emergence time; thus, discussion will center on the female.

The minimum generation time at 26.4°C was 40.4 days. A mean of 9.4 days was spent in the 1st instar and 12.0 days in the 2nd. Oviposition started 16.1 days after the 2nd instar molt. The first hatch was recorded 2.9 days later; oviposition (including incubation) by the cohort spanned 20.5 days.

It took 2.7 times longer to complete a generation at 13.3°C. The mean developmental time was 24.3 days for the 1st instar and 22.6 days for the 2nd. Oviposition was first recorded 49.6 days after molt of the 2nd instar. Eggs were still present when the last female was examined 54.5 days after oviposition commenced.

The mean duration of the 1st instar was 1.8 days longer than the 2nd instar at 13.3°C and 2.6 days shorter at 26.4°C. This apparent effect may be due to the lack of precision in recognizing ecdysis.

Female survival was high in the first 2 instars at both temperatures, but was considerably less in the 3rd instar at 26.4°C (Table 1). Host condition is probably responsible for the mortality as it seems unlikely that 26.4°C is marginally lethal to WPS. This does point up the problems associated with maintaining sessile organisms on hosts whose own state may degrade in a particular environment.

The histogram (Fig. 1) shows the distribution of eggs per female through time at the 2 temperatures. At 26.4°C, peak numbers occurred ca. 5 days after oviposition had begun; 2 days later ca. 50% of the eggs laid until then had hatched. The 2.9-day incubation period is a minimum value, since it represented only 2.7% of the eggs laid until that time and 10% of the eggs laid in the first 24 h (Table 2). Oviposition by the cohort was rapid and synchronous. All females were laying within the first 48 h and, con-

TABLE 1. SURVIVAL AND DEVELOPMENT OF WHITE PEACH SCALE AT 13.3 AND 26.4°C.

	Female				Male		
			Developmental Time (days)			Developmental Time (days)	
Instar	N	Percent survival	$\bar{X}$	Min.-Max.	N	$\bar{X}$	Min-Max.
			13.3°C				
1st (crawler)	155	93.4	24.3±0.24*	21.9-28.4	7	24.4	20.4-28.4
2nd	147	94.8	22.6±0.42	19.6-27.2	6	21.7§	18.5-23.2
3rd (adult)	125	85.0	49.6**	—	—	—	—
egg	—	—	14.2†	—	—	—	—
Generation time: 110.8‡							
			26.4°C				
1st	220	90.2	9.4±0.09*	8.5-10.5	8	9.2	8.5-10.5
2nd	204	92.7	12.0±0.12	10.1-13.1	7	9.7§	8.3-11.3
3rd	120	58.8	16.1**	—	—	—	—
egg	—	—	2.9†	—	—	—	—
Generation time: 40.4‡							

*95% confidence interval.
**Minimum female maturation calculated to start of oviposition.
†Interval from first oviposition to first hatch.
‡Minimum generation time calculated to time of first hatch.
§Includes prepupal and pupal development.

sidering the incubation period and decline of the curve, most recruitment was completed in the first 7 days. Bennett and Brown (1958) stated that the entire complement of eggs were laid in 8 to 9 days at 25°C.

Adult female maturation was considerably affected at 13.3°C (Fig. 1). Only 10 to 20% of the females sampled had started ovipositing 22 days after the first eggs were found and 20 to 40% had not started to oviposit when the final samples were dissected (Table 2). This is not thought to be due to unmated females in the cohort because none formed the loose tangle of wax which was characteristic of older females that had not mated (see Bennett and Brown 1958). When eclosion was first observed only 1 of the 9 females sampled was ovipositing and 47% of her eggs had hatched (crawlers were found on the potatoes at the prior count, but the hatch had not occurred in the sample dissected). It is apparent that a much larger sample is necessary to adequately represent the oviposition phase at the lower temperature. Some of the females in the later samples may have been moribund, but this could not be definitely established.

As explained earlier, mean fecundity could not be established because an accurate count of the number hatching was not possible. However, at 26.4°C, 1 female had a clutch of 115 unhatched eggs at the time of dissection, and 98 eggs were found under a female developing at 13.3°C. Van Duyn and Murphey (1971) reported an average of 125 eggs per female reared on potatoes.

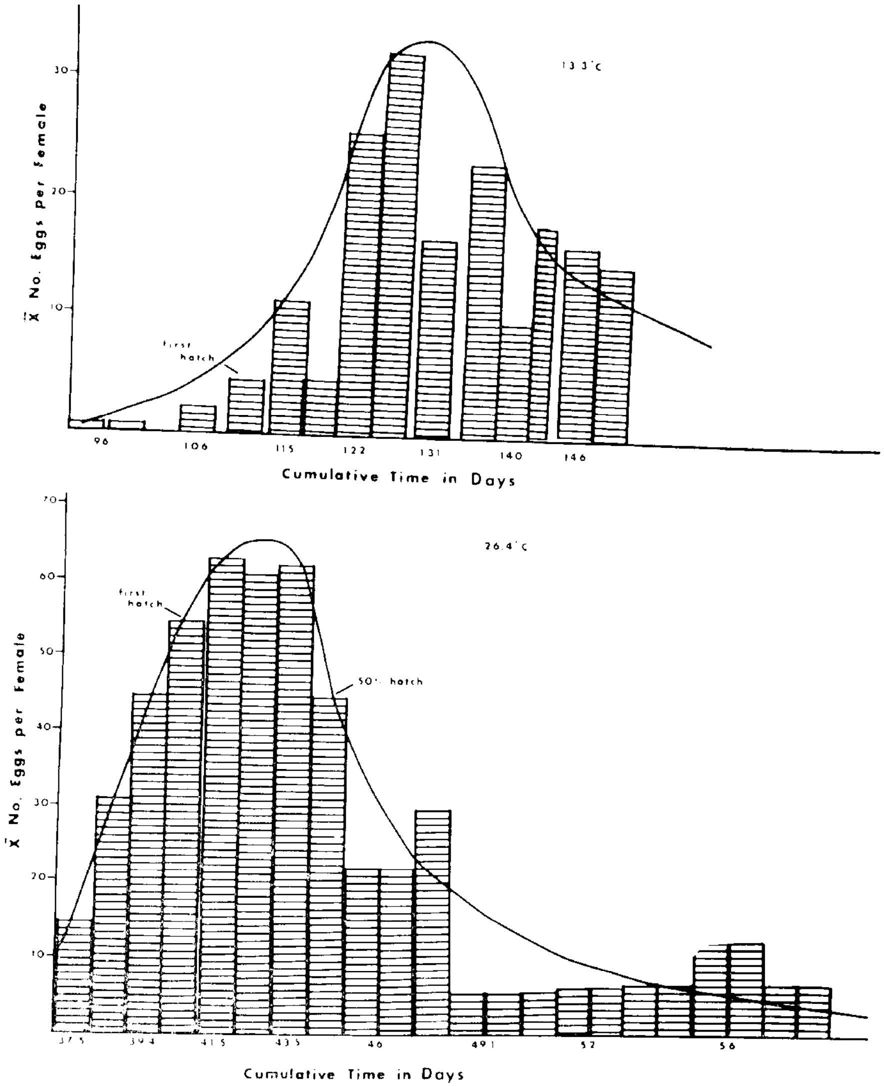

Fig. 1. Distribution through time of the mean number of eggs per female *Pseudaulacaspis pentagona* reared at 13.3°C (top) and 26.4°C (bottom).

Kuitert (1967) reported 4 generations of WPS a year for central Florida. Van Duyn (1967) stated that there should be 3.5 to 4 generations in north Florida in a normal year. I have observed egg laying by overwintering females as early as mid-February in north Florida which, coupled with the developmental rates found in this study, would allow for 4 generations a year. In Virginia there are 3 generations a year with the 1st generation beginning in mid-April (Bobb et al. 1973).

In order to model the development of WPS, the response to additional temperatures are required to provide thresholds and thermal constants. Before this can be done, however, it will be necessary to obtain a more accurate estimate of oviposition and incubation.

TABLE 2. SAMPLE SIZE AND OVIPOSITION RECORD OF WHITE PEACH SCALE AT 26.4 AND 13.3°C.

26.4°C					13.3°C				
Time in days	Females sampled	No. females ovipositing	Unhatched eggs/female	Percent hatch	Time in days	Females sampled	No. females ovipositing	Unhatched eggs/female	Percent hatch
37.5	10	8	15	0	96.5	9	1	0.67	0
38.5	10	10	31.8	0	102.1	9	0	0	0
39.4	10	10	44.9	0	106	9	1	2.33	0
40.4	10	10	55	2.7	110.8	9	1	4.22	47.2
41.5	10	10	63.1	13.4	115.4	9	2	11.4	1.9
42.5	10	10	60.5	16.8	119	9	1	4.3	0
43.5	10	10	62.3	26.3	122.5	9	6	25.7	5.7
44.5	10	10	44.9	48.6	126.4	9	6	32.9	3.0
46	7	7	22	72.9	130.9	10	5	16.7	43.6
47.5	6	6	28.3	64.3	136	9	8	23.3	36.6
49.1	4	4	5	93.2	140	9	5	9.8	27.3
50.6	6	6	5.2	—	142.6	9	4	18.2	46.6
52	7	7	5.7	—	146.5	9	7	16.4	59.5
54	6	6	6.5	—	151	7	4	14.7	44.3
56	3	3	14	—					
58	1	1	7	—					

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