Development Time and Fecundity of the White Peach Scale, *Pseudaulacaspis pentagona*, in Turkey

L.B. Erkiliç[1] and N. Uygun[2]

The white peach scale (WPS), *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera: Diaspididae), is a worldwide polyphagous scale insect. It is widely distributed in Turkey, where it is the main pest of peach trees. The development and fecundity of *P. pentagona* were examined at different temperatures and on different hosts in the laboratory; from these data, life tables were constructed and intrinsic rates of increase were calculated. The longevity of WPS decreased with a rise in temperature. At 25°C the largest number of crawlers (76.1 crawlers/female) was observed. The development time of WPS was generally longer on peach than on squash or potato; fecundity was higher on potato than on the other hosts, potato tubers and peach trees.

KEY WORDS: *Pseudaulacaspis pentagona*; white peach scale; Diaspididae; biology; life tables; temperature effects; host effects.

INTRODUCTION

The white peach scale (WPS), *Pseudaulacaspis pentagona* (Targioni-Tozzetti), is a highly destructive and polyphagous scale insect all over the world, and is considered the main pest of peach trees in the east Mediterranean region of Turkey. Several studies have been conducted on the biology of *P. pentagona* under both field and laboratory conditions in different countries (3,4,7,8,10,11,12,16,17,20). In the east Mediterranean region of Turkey, the infestation rate varied significantly among different geographical areas from 58% in the coastal area to only 21% in the mountain area. *P. pentagona* completed two generations in the mountain area (June/July and September/October) and three generations per year in the coastal area (April, June/July and October/November) (6).

In this study, the development and fecundity of *P. pentagona* were examined under laboratory conditions. The data obtained were used to construct life tables to compare the different treatments by calculating intrinsic rate of increase (r_m).

MATERIALS AND METHODS

Longevity and fecundity of Pseudaulacaspis pentagona at different temperatures on potato tubers

As the laboratory host we used potato tubers, on which 5–6-cm-diameter circles were drawn with a special glue (Tangle Trap). Approximately 50 male and 50 female *P. pentagona* eggs, which can be distinguished by differences in color, females being reddish-pink and males yellowish-white (4,13,14,17,19), were transferred into this area. The

Received July 30, 1996; received in final form Dec. 16, 1996.
[1] Plant Protection Research Institute, 01321 Adana [Fax: +90-322-4820; e-mail: uygunnd@pamuk.cc.cu.edu.tr].
[2] Dept. of Plant Protection, University of Çukurova, 01330 Adana, Turkey.

number of crawlers within this area and the development time of different stages were recorded daily. Adults were allowed to copulate, after which all males were removed. Females were enclosed again by special glue, within a 1.5–2-cm-diameter circle, to enable counts of the number of crawlers per female. Experiments were conducted in climate-controlled chambers at 15°, 20°, 25° and 30°C, with 60% relative humidity (r.h.) and 16:8 L:D light regime, using 35 females per treatment.

Longevity and fecundity of Pseudaulacaspis pentagona on different hosts

Potato tubers (cv. 'Ilona'), squash, and 2-year-old peach trees (cv. 'June Gold') were used as hosts in experiments conducted at 25°C, 60% r.h. and 16:8 L:D light regime, with 35 females per treatment. For potato and squash, the same experimental procedure was followed as in the temperature experiments. On peach trees, an area of 1.5 × 2.5 cm was marked on the trunk.

Statistical analyses were done to compare longevity and fecundity data and the data obtained from these experiments were used to construct fecundity tables according to Andrewartha and Birch (1) and Southwood (18).

RESULTS

Longevity and fecundity of Pseudaulacaspis pentagona at different temperatures on potato tubers

Settling percentage of crawlers ranged between 50.5% and 57.5% at temperatures from 20° to 30°C; at 15°C, only 26% of the crawlers settled.

The duration of immature stages decreased as the temperature rose, with significant differences for all temperatures tested. The length of the preoviposition period decreased from 36.1 days at 15° to 16.5 days at 30°C. No significant differences were observed for the oviposition and postoviposition periods between 25° and 30°C, but they were significantly shorter at these temperatures than at 15° and 20°C (Table 1).

P. pentagona produced the largest number of crawlers at 25° (76.1 crawlers/female), with significantly fewer crawlers at 15° (18.9 crawlers/female) and 30°C (11.8 crawlers/female) (Table 1).

Logarithmic regression analysis was used to determine the relationships between different temperatures and the longevity of different development stages (Fig. 1). According to the positive regression coefficient between development stages and temperature (r=0.990), development time decreased as temperatures increased. The development threshold of *P. pentagona* was 9.8°C for the sum of first and second female instars' development period.

The life tables, survival curves and age-specific fecundity rates of *P. pentagona* are given in Figure 2. Mortality during the first nymphal stage was high at all temperatures tested. At 15°C only 30% of the females started to lay eggs, whereas at 20°, 25° and 30°C approximately 50% of the females reproduced. Overall longevity of *P. pentagona* was strongly affected by high temperatures, being 60 days at 30°, in contrast to 200 days at 15°C. The number of female crawlers per female produced over the life span (R_o=16.13) was highest at 25°C, at which temperature also the highest intrinsic rate of increase (r_m=0.059) was obtained. The shortest mean generation time (T_o=41.93) was found at 30°C, which increased with decreasing temperatures.

Fig. 1. Development velocity of first and second stage female larvae of *Pseudaulacaspis pentagona* at constant temperatures (°C).

Longevity and fecundity of Pseudaulacaspis pentagona on different hosts

The settling percentage of crawlers was found to be 60.5% on young peach trees, 50.5% on potato and 32.5% on squash.

The development time of *P. pentagona* was generally longer on peach than on the two other hosts tested. However, these effects were of minor importance, although statistically significant. The highest fecundity was observed on potato, with 76.1 crawlers/female. On peach and squash only 45.9 and 29.5 crawlers/female, respectively, were produced (Table 2).

As calculated from the fecundity tables, the highest r_m values were for potato and peach, whereas this value was less than half for squash. No significant differences in generation time among the three hosts tested were observed, between 47.1 days on potato and 49.9 days on peach (Table 2).

Figure 3 shows that the mortality during the development period was high on squash (70%) and potato (50%). Total longevity was affected by host, lasting approximately 65 days on squash and potato, but 110 days on peach. The number of female crawlers per female produced during her life span ((R_o=16.13) was high on potato. The intrinsic rates (r_m) were higher on potato (0.059) and peach (0.052) than on squash (0.024). The mean generation times were similar on the different hosts: between 49.4 and 47.1 days.

DISCUSSION

The development time of *P. pentagona* became shorter with increasing temperatures, which supports the results reported earlier by Azim (2) and Ball (3). The highest fecundity rate was observed at 25°C, as already recorded by Oda (15) and Park and Kim (16). The development threshold was calculated as 9.8°C for larval stages, in agreement with the results obtained by Park and Kim (16). However, these workers arrived at the threshold (10.3°C) by linear regression; on a logarithmic scale the results are more realistic, because

TABLE 1. Mean development time of various stages of *Pseudaulacaspis pentagona* on potato tubers at four constant temperatures

Temperature (°C)	Development time (days)					Duration of different periods (days)			Fecundity (number of crawlers/female)
	Male			Female					
	First instar	Second instar	Pupae	First instar	Second instar	Preoviposition	Oviposition	Postoviposition	
15	20.9 a*	32.3 a	23.2 a	21.5 a	33.4 a	36.1 a	26.5 a	39.4 a	18.9 c
20	11.3 b	17.9 b	11.5 c	11.8 b	18.3 b	27.0 b	22.7 b	29.7 b	56.6 b
25	9.4 c	13.7 c	10.2 d	9.5 c	13.6 c	20.8 c	13.3 c	10.1 c	76.1 a
30	7.4 d	12.5 c	13.9 b	7.3 d	13.1 c	16.5 d	13.5 c	9.1 c	11.8 c

* Within columns, means followed by the same letter do not differ significantly (P=0.05) by the LSD range test.

TABLE 2. Mean development time of various stages of *Pseudaulacaspis pentagona* on three different hosts

Host	Development time (days)					Duration of different periods (days)			Fecundity (number of crawlers/female)
	Male			Female					
	First instar	Second instar	Pupae	First instar	Second instar	Preoviposition	Oviposition	Postoviposition	
Peach	9.7 a*	14.8 a	13.9 a	9.6 a	16.4 a	21.9 a	13.8 a	29.5 a	45.9 b
Potato	9.4 a	13.7 b	10.2 c	9.5 a	13.6 c	20.8 b	13.3 a	10.1 b	76.1 a
Squash	8.7 b	14.4 ab	13.4 b	8.7 b	15.7 b	18.7 c	13.2 a	9.8 b	29.5 c

* Within columns, means followed by a common letter do not differ significantly (P=0.05) by the LSD range test.

Fig. 2. Survival curve (l_x) and age-specific fecundity rate (m_x) of *Pseudaulacaspis pentagona* at different constant temperatures.

Fig. 3. Survival curve (l_x) and age-specific fecundity rate (m_x) of *Pseudaulacaspis pentagona* on three different hosts.

the development stages become shorter as temperatures increase, especially above 25°C. The temperature effects on development velocity between 15° and 20°C did not parallel those at 25–30°C (Fig. 1).

The temperature-dependent life table results showed that net reproduction rates (R_o) and intrinsic rates of increase (r_m) were highest at 20° and 25°C. The lowest (R_o) value and the shortest generation time (T_o) were at 30°C. At the lowest temperature tested (15°C) the R_o value was low, but generation time was longer than at the other temperatures, which means *P. pentagona* is able to pass the winter months alive, but with almost no reproductive activity.

According to field studies which we conducted in the east Mediterranean region of Turkey (6), overwintering *P. pentagona* females started to produce crawlers about mid-April, when the daily mean temperatures were approximately 15–20°C. The second population peak was usually observed in July, at an average daily mean temperature of 25°C. The first and second generations usually had the highest fecundity. *P. pentagona* continued to produce crawlers, albeit at declining rates, throughout the rest of the year. In the mountain area the first population peak is delayed until June, because of the slower increase in daily mean temperature.

Those field observations are strongly supported by the present laboratory experiments at comparable temperature regimes. Life table results also proved that the reproduction rate was closely correlated with changes in temperature. There were differences between generation time observed in the field and the results obtained in the laboratory. Under field conditions the life span of the first generation lasted 71.6 days (average temperature 20–25°C) and that of the second to fourth generations varied between 61.2 and 66.3 days (average temperature 25–30°C) (5). In the laboratory, however, generation time was much shorter at comparable temperatures. This may be because under field conditions some other factors, beside temperature, are involved in determining the life span of *P. pentagona*.

Different hosts have had only a slight effect on development time of *P. pentagona*, but strongly affected the longevity and fecundity. These differences may be because *P. pentagona* is adapted to living on the wooden parts of plants, as confirmed by the study of Hanks and Denno (9). These authors found differences in settling percentage by *Morus alba* L., *Catalpa speciosa* Warder and *Juglans nigra* L. on different host species, but no differences in survival rate.

In conclusion, our studies have shown that temperature changes affect net reproduction rate, intrinsic rate and generation time under constant temperature conditions, and that the host affects net reproduction rate and intrinsic rate.

ACKNOWLEDGMENT

The authors are grateful to Dr. U. Kersting for his kind editorial comments.

REFERENCES

1. Andrewartha, H.G. and Birch, L.C. (1970) The Distribution and Abundance of Animals. Univ. of Chicago Press, Chicago, IL, USA.
2. Azim, A. (1963) Systematic and biological studies on the genus *Aphytis* Howard (Hymenoptera:Aphelinidae) of Japan. *J. Fac. Agric. Kyushu Univ.* 12:291-321.
3. Ball, J.C. (1980) Development and fecundity of the white peach scale at two constant temperatures. *Fla. Entomol.* 63:189-194.
4. Bennett, F.D. and Brown, S.W. (1958) Life history and sex determination in the diaspine scale, *Pseudaulacaspis pentagona* (Targ.) (Coccidae). *Can. Entomol.* 90:317-324.

5. Erkiliç, L. (1995) [Distribution, biology and natural enemies of *Pseudaulacaspis pentagona* (Targ.-Tozz.) (Homoptera: Diaspididae) on peach trees in the East Mediterranean region of Turkey.] Ph.D. thesis, Ç.Ü. Science Institution, Adana, Turkey (in Turkish).
6. Erkiliç, L. and Uygun, N. (1995) Distribution, population fluctuations and natural enemies of white peach scale, *Pseudaulacaspis pentagona* (Targ.-Tozz.) (Diaspididae) in the East Mediterranean region of Turkey. *Isr. J. Entomol.* 29:191-198.
7. Gürkan, S. (1983) [Bio-ecological studies on mulberry scale (*Pseudaulacaspis pentagona* Targ.) on peach trees in the Marmara region.] *Bitki Koruma Bül.* 22:179-197 (in Turkish).
8. Hanks, L. and Denno, R.F. (1993) The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Hom.: Diaspididae): life history in Maryland, host plants and natural enemies. *Proc. Entomol. Soc. Wash.* 95:79-98.
9. Hanks, L. and Denno, R.F. (1993) The role of demic adaptation in colonization and spread of scale insect populations. pp. 393-411. *in:* Kim, K.C. and McPheron, B.A. [Eds.] Evolution of Insect Pests, Patterns of Variation. John Wiley and Sons Inc., New York, NY.
10. Keyder, S. (1952) [Weather effects on *Diaspis pentagona*.] *Tomurcuk* 1:7 (in Turkish).
11. Keyder, S. (1952) [Morphology and biology of *Diaspis pentagona*.] *Tomurcuk* 1:16-17 (in Turkish).
12. Kiroğlu, H. (1981) [Studies on morphology, bio-ecology and control methods of *Pseudaulacaspis pentagona* Targ. on peach trees in the Black Sea region.] Tar. Bak. Zir. Müc. Zir. Kar. Gn. Md. Yay. Ser. Diyarbakir Bölg. Zir. Müc. Aras. Enst. 2:54 (in Turkish).
13. Kozarzevkaja, E.F. (1988) [Characteristics of reproduction of the mulberry scale *Pseudaulacaspis pentagona* (Targ.-Tozz.) (Hymoptera, Coccidea).] *Entomolog. Obozr.* 67:257-265 (in Russian).
14. Monti, L. (1956) [Investigations on the bionomics of two coccids, *Diaspis pentagona* and *Mytilococcus ulmi*, in Romagna.] *Bull. Ist Entomol. Bologna* 21:141-165 (in Italian).
15. Oda, T. (1963) Studies on the dispersion of the mulberry scale, *Pseudaulacaspis pentagona. Jpn. J. Ecol.* 13:41-46.
16. Park, J.D. and Kim, K.C. (1990) Effects of temperatures on development and distribution of mulberry scale, *Pseudaulacaspis pentagona*, within tree. *Korean J. Appl. Entomol.* 29:238-243.
17. Seuge, L. (1972) Sex determination of *Pseudaulacaspis pentagona* (Coccidae: Diaspinae) reared on potato tubers and their sprouts cultured artificially influence the physiological age of the plant material.] *C. R. Séances Soc. Biol.* 166 (in French).
18. Southwood, T.R.E. (1976) Ecological Methods. Chapman and Hall Ltd., London, UK.
19. Tremblay, E. (1958) Ovoviviparity behaviour of virgin females, sex of nymphs and nymphal cephalic glands of *Diaspis pentagona. Boll. Lab. Entomol. Portici* 16:215-246.
20. Van Duyn, J. and Murphey, M. (1971) Life history and control of white peach scale, *Pseudaulacaspis pentagona* (Homoptera: Coccoidea). *Fla. Entomol.* 54:91-93.