The Seasonal History of the White Peach Scale (Homoptera: Diaspididae) and its Hymenopteran Natural Enemies in North Carolina[1]

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ABSTRACT Hymenopteran parasites (adults) and mobile stages (crawlers, adult males) of white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), were monitored biweekly (1986) or weekly (1987) in a peach orchard from April to December. The scale exhibited three peaks of crawler emergence, and a partial fourth generation was observed in both years. Three species of hymenopteran parasites consistently collected from traps were the primary parasites *Encarsia berlesi* (Howard) and *Aphytis proclia* (Walker), and the hyperparasite *Marietta carnesi* (Howard). Populations of all three parasites showed seasonal peaks of activity that differed in the two years of this study. Winter samples taken in 1985, and from 1987 through 1989 indicated differences between years in the ratio of parasites to hyperparasites overwintering.

KEY WORDS *Pseudaulacaspis pentagona,* white peach scale, biocontrol, parasites, phenology.

White peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), is a cosmopolitan pest that is believed to be native to China or Japan (Gossard 1902). It is polyphagous, with a host range that includes all non-coniferous plants (Ferris 1937). Hosts most seriously damaged by this insect in the southeastern United States are woody ornamentals (including chinaberry, *Melia azedarach* L., flowering cherries, *Prunus* sp., privet, *Ligustrum sinense* Loureiro, persimmon, *Diospyros virginiana* L., mulberry, *Morus rubra* L.) and peaches, *Prunus persica* (L.) (Smith 1969, Van Duyn & Murphy 1971, Bobb et al. 1973, Yonce and Jacklin 1974).

Insecticides prove ineffective against white peach scale unless they are timed to coincide with crawler hatch — three generations per year in North Carolina (Smith 1969). Sprays applied to foliage at biweekly intervals beginning at petal fall for plum curculio, oriental fruit moth and catfacing insects give some degree of control because applications may coincide with crawler hatch of the first two scale generations. Such control, however, is fortuitous, as North Carolina growers currently do not monitor for crawlers (J.R.M., personal observation). When scale populations are high, crawlers remain clustered beneath the armor of the adult female and are protected from insecticides. Current practice for control of white peach scale in North Carolina peach orchards is to apply two dormant oil sprays, two weeks apart prior to bud break (Ritchie et al. 1989).

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White peach scale first became the object of biological control programs early in this century, when Italy imported the aphelinid *Encarsia berlesi* (Howard) from the USA (Berlese 1915). Subsequent programs in Europe, South America, Bermuda and the United States indicated that some degree of control could be achieved in most cases (Clausen et al. 1977). Resurgence of the white peach scale since the 1950's in areas where it had been previously held in check by natural enemies has been attributed to the use of insecticides in Italy, France and the United States (Monti 1956, Benassay 1958, Collins and Whitcomb 1975).

We could find no record that the natural enemies of white peach scale have ever been identified in North Carolina. The goals of this study were 1) to determine the phenology of white peach scale in North Carolina, 2) to identify its parasites, and 3) to determine if management practices could be designed to conserve the natural enemies present.

Materials and Methods

The study was conducted in a 0.35 ha block of peach trees ('Norman' and 'Biscoe' cultivars) on the west side of a 1.75 ha orchard at the Horticultural Crops Research Station in Clinton, NC. The orchard was established in February, 1980 with trees grafted to 'Loring' rootstocks the previous year. Trees were set 5m apart in rows 6m apart.

In 1984 and 1985, the experimental block received biweekly applications of fenvalerate ((Pydrin® (Shell Chemical Co., Houston, TX) 2.4 EC @ 2.5 liters/ha)) during the first 3 months following petal fall (April-June) to control catfacing insects and fruitworms. No foliar sprays were applied in 1986-1988, but trunk and scaffold limbs were sprayed to drip (0.25 liters/tree) during the week of 1 September (1984 and 1986) with endosulfan ((Thiodan® (FMC Corporation, Philadelphia, PA) 3 EC @ 1 liter/200 liters water) to suppress peachtree borers, *Synanthedon* spp. Dormant oil sprays (70 second superior oil @ 4 liters/200 liters water) were applied in February (1985 and 1988), using 1400 liters of dilute spray/ha, to reduce overwintering scale populations.

Hymenopteran parasites (adults) and mobile stages (crawlers, adult males) of white peach scale were monitored biweekly (1986) or weekly (1987) in the field from April through November using emergence traps made from 35 mm film canisters (Nalepa 1987). Traps were distributed on 20 infested peach trees, 1-6 traps per tree. In 1986, 25 traps were placed in the field on 22 April and the vials collected biweekly; in 1987, 50 traps were placed in the field on 8 April and monitored weekly. Collections from traps were also made approximately once per month from December through February in both years. Traps were moved to a new location on the tree after each collection. Vials were taken back to the laboratory for inspection; Hymenoptera and male scales present were identified and counted. In 1986 only presence or absence of scale crawlers was noted; in 1987 all crawlers were counted.

Overwintering material was obtained by collecting infested peach branches removed during normal pruning of the orchard in February during four winters (1985, 1987, 1988, 1989). These branches were incubated in laboratory emergence boxes at 20°C and the insects collected, identified and counted after they emerged.

Results

White Peach Scale. In 1986, at least a few crawlers of white peach scale were present in 14 of the 18 collections, including two of the three winter collections (17 December, 23 February). In 1987, 25 of 37 collections contained crawlers, including all four winter collections (9 and 24 December, 20 January, 16 February). In 1987, crawler emergence peaked during the weeks of 6 May, 15 July, and 2 September (Fig. 1). The collection on 21 October, however, included 28 crawlers from five separate traps, indicating the possibility of a partial fourth generation in North Carolina. In 1986 crawlers were present in the 18 November collection, after having been absent from the previous three collections, corroborating the possibility of a partial, late fall generation.

In 1986 and 87, respectively, male flights peaked during the weeks of 3 June, 10 June (first generation), 12 August, 5 August, (second generation) and 7 October, 14 October (third generation (Fig. 1). A few males were collected in early November in 1986, and in 1987, the third peak of males was very broad; males were present from September 17 to November 25. No males were present in winter collections.

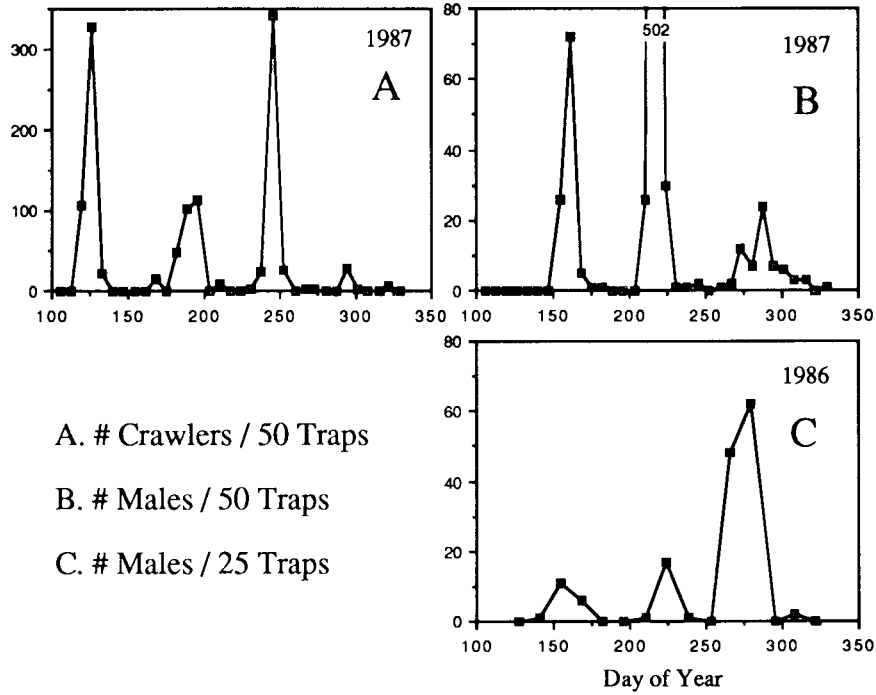

Fig. 1. Seasonal emergence of crawlers and adult males of *Pseudaulacaspis pentagona* in a North Carolina peach orchard (N = 25 traps in 1986, n = 50 traps in 1987).

Parasites. Three species of Hymenoptera were consistently collected from the traps: the primary parasites *Encarsia berlesi* (Howard) and *Aphytis proclia* (Walker), and the hyperparasite *Marietta carnesi* (Howard) (Aphelinidae). The emergence patterns of the three Hymenoptera were roughly similar within years but different between years (Fig. 2). In 1986, populations of both *A. proclia* and *M. carnesi* peaked twice, once early and once late in the season; however, in 1987, both showed an emergence peak in mid summer. Major peaks of hymenopteran emergence corresponded to the major peaks of emergence of male scales (third peak in 1986 and the second in 1987). Peaks of parasite emergence, however, were not always obvious. In 1987, at least some adults of *E. berlesi* emerged continuously from 27 May to 30 September. Winter field trapping indicates that both *E. berlesi* and *A. proclia* may emerge on warm days in winter.

While the hyperparasite *M. carnesi* dominated the overwintering sample in 1984 - 85, *E. berlesi* dominated winter samples in all subsequent years (Table 1). Low levels of *A. proclia* were present in each winter collection.

Other possible parasites of white peach scale were collected, but only sporadically and in low numbers: *Ablerus clisiocampae* (Ashmead) (Aphelinidae, total collected from all trapping methods over entire study, n = 17), *Azotus marchali* Howard (Aphelinidae, n = 13), *Physcus varicornis* (Howard) (Aphelinidae, n = 1), *Ceraphron* sp. (Ceraphronidae, n = 1), *Metaphycus* sp. (Encyrtidae, n = 1), *Dendrocerus* sp. (Megaspilidae, n = 3), *Megaspilus* prob. *fuscipennis* (Ashmead) (Megaspilidae, n = 1), *Amitus* sp. (Platygastridae, n = 5).

Discussion

Pseudaulacaspis pentagona is a multivoltine species reported to have three generations per year in North Carolina (Smith 1969). Data presented here indicate that a partial fourth generation occurs and that eggs may be released and hatch on warm days in winter. Four generations of white peach scale are reported in central Georgia, with 68, 49 and 47 days between successive generations (Yonce & Jacklin 1974). These intervals are in agreement with the 1987 data reported here, with 70, 47 and 48 days between successive generations.

The aphelinid *Encarsia berlesi* is the most common parasite of white peach scale reported in the literature and has a good historical record of control, especially prior to the advent of widespread pesticide use (Clausen et al. 1977). It is an endoparasite, and can reduce white peach scale infestations to levels which result in only minor damage to peach trees in undisturbed areas (Collins and Whitcomb 1975). Parasitism varies widely in managed orchards, however, and biological control of white peach scale is inadequate. In addition to insecticides, parasitism of white peach scale by *E. berlesi* is known to be affected by road dust and both macro- and micro-climate (Benassay 1958).

Although we lack direct evidence, *E. berlesi* is apparently the host of the obligate hyperparasite *Marietta carnesi. Marietta* sp. have been observed attacking developing stages of *Encarsia* (Liebregts and Sands 1989), and *E. berlesi* and *M. carnesi* were the only two aphelinids reared from white peach scale in Pennsylvania (Stimmel 1982). Some authors feel that secondary parasites greatly decrease the effectiveness of *E. berlesi* (Van Duyn and Murphy 1971), but others have suggested that the number of hyperparasites did not vary with host populations in a density dependent manner (Collins and Whitcomb 1975).

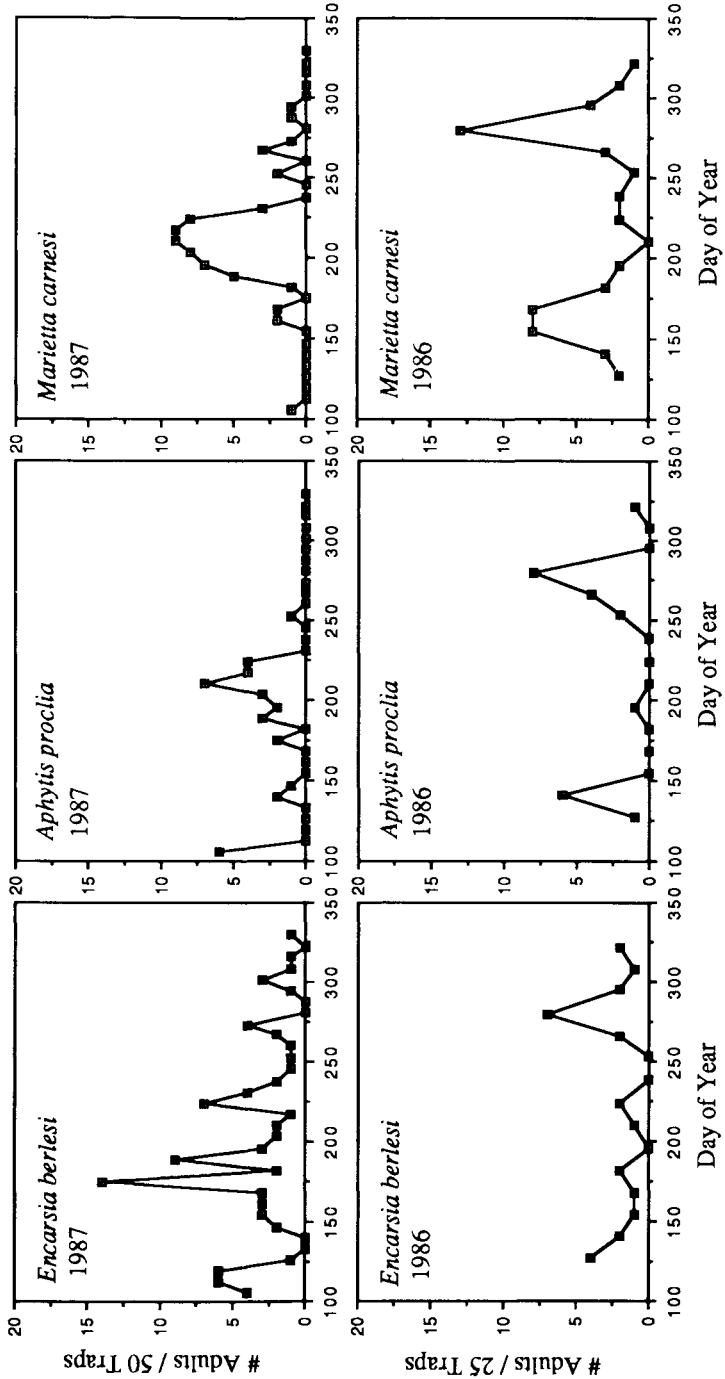

Fig. 2. Seasonal emergence of adult hymenopteran parasites of white peach scale. *E. berlesi* and *A. proclia* are primary parasites; *M. carnesi* is a hyperparasite (n = 25 traps in 1986, n = 50 traps in 1987).

Table 1. Number of parasites collected from winter prunings. Number in parentheses is the proportion of the total.

	Encarsia berlesi	*Marietta carnesi*	*Aphytis proclia*	Total
1985	17 (2.5%)	632 (92.9%)	31 (4.6%)	680
1987	1367 (84.9%)	105 (6.5%)	139 (8.6%)	1611
1988	344 (70.4%)	126 (25.8%)	19 (3.9%)	489
1989	925 (94.0%)	37 (3.8%)	22 (2.2%)	984

Aphytis proclia is a cosmopolitan primary ectoparasite of various scale insects and has been the main control of white peach scale in Bermuda since its introduction to that island in 1925 (Simmonds 1958). Although *A. proclia* was found at low levels in this study, its impact may be greater than its proportional presence in the winter samples indicates. Members of this genus kill as many hosts by predatory host feeding as they do by parasitism. Stages of the host not suitable for oviposition, such as first instar larvae, are readily utilized for host feeding (Rosen and DeBach 1979). Natural enemies of *Aphytis* are of little consequence from a population dynamics standpoint, with the exception of the adverse effects of ants on adults (Rosen and DeBach 1979, Bennett 1981, Viggiani 1984). Several species of ants fed at the leaf nectaries in our test orchard, including *Formica integra* Nylander, *Formica subserica* Say and *Lasius alienus* (Foerster) (Formicidae).

Although Collins and Whitcomb (1975) found *A. proclia* only in areas where *E. berlesi* parasitism was either very low or absent, Rosen and DeBach (1979) maintain that it is possible for endoparasites to complement the action of *Aphytis* in controlling scale infestations. The co-existence of *Aphytis* and endoparasites such as *Encarsia* is explained by the fact that they are not strict ecological homologues; the endoparasite may attack host stages not available to *Aphytis*.

If the data in this study are representative, the emergence peaks of the hymenopteran natural enemies of white peach scale vary too widely from year to year to reliably predict their presence in the field. It would therefore be difficult to design insecticide spray schedules that do not affect adult parasites. In general, the number of generations of aphelinids per year varies with local climatic conditions and is independent of the host generation cycle (Viggiani 1984). The peaks of activity of all three hymenopterans in this study indicate that they are responding to environmental cues roughly in the same manner, but those cues were different in the two years of the study. In both years, a pesticide spray targeting third generation crawlers would miss major peaks of emergence of the primary parasites, but all flights of male scales coincided with a flight of one of the primary parasites.

In the winter samples the proportion of *A. proclia* remained relatively stable, but the proportion of *E. berlesi* to *M. carnesi* fluctuated. Although it may be suggested that the differences seen between years in these samples may represent a change in the balance of the host-parasite complex following the cessation of insecticide spraying, we have no direct evidence, and there were probably other contributing factors.

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