Effect of Dormant Oil Treatments on White Peach Scale (Homoptera: Diaspididae) and its Overwintering Parasite Complex[1]

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ABSTRACT The effect of dormant oil treatments on the overwintering parasite complex of white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) was evaluated in a peach orchard in the southern coastal plain of North Carolina in 1988 and 1989. Oil treatments resulted in significant reductions in the emergence of adult hymenopteran parasites in both years. However, mortality was not complete, and a sufficient number of parasites survived to repopulate the orchard in spring.

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

White peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), populations on peach (*Prunus persica* (L.)) trees growing in the southern coastal plain of North Carolina support several species of hymenopteran parasites. These natural enemies include the primary parasites *Encarsia berlesi* (Howard) and *Aphytis proclia* (Walker), and the hyperparasite *Marietta carnesi* (Howard). The emergence peaks of these parasites vary widely from year to year (Nalepa and Meyer 1990), so it is not possible for peach growers to schedule summer insecticide applications to kill crawlers of *P. pentagona* without endangering populations of the beneficial insects.

In some instances, summer insecticide applications for control of white peach scale may be avoided by using dormant oil during late winter (late January to early March); two applications of a 70 second superior oil (4 liters/200 liters of water applied 10-14 days apart) are currently recommended (Smith 1969). Several recent workers have reported the effects of chemical pesticides on adult aphelinid parasites (Rosenheim and Hoy 1988, Masoodi et al. 1989, for example), but none have addressed the effects of dormant oils on the overwintering stages of these Hymenoptera.

This study was undertaken to assess the effect of dormant oil treatments on survival of the white peach scale and its overwintering parasite complex.

Materials and Methods

The experiment was conducted in 1.75 ha of peach trees ('Norman' and 'Biscoe' cultivars) located at the Horticultural Crops Research Station in Clinton, NC. A

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description of the orchard and its spray history is given in Nalepa and Meyer (1990).

During the course of the experiment, four methods were used to evaluate scale and parasite populations: 1.) direct counts (number of female scales per 25 cm^2 of bark), 2.) visual observation (density of crawlers, ranked from lowest to highest), 3.) laboratory emergence cages (number of parasites emerging from 200 cm^2 of bark surface area), and 4.) field canister traps (see Nalepa 1987). Living tree branches with moderate to heavy infestations of white peach scale were tagged with vinyl flagging in January 1988 and 1989 and left unpruned. These branches were then randomly assigned to one of three (1989), or one of five (1989) treatment categories (Table 1).

Table 1. Treatment schedule.

		1988			1989		
		Treatment Date	Parasite Sample Date	Crawler* Sample Date	Treatment Date	Parasite Sample Date	Crawler† Sample Date
Untreated Controls	I	-	Feb 17	-	-	Feb 3	-
	II‡	-	-	-	-	Feb 20§	-
	III‡	-	-	-	-	Mar 7§	Apr 4§
1st Oil Appl.		Feb 22	Mar 1	-	Feb 14	Feb 20	Apr 4§
2nd Oil Appl.		Mar 8	Mar 15	Apr 26 to May 23	Feb. 28	Mar 7	Apr 4

* Using canister traps in field.
† Branches collected for laboratory emergence of crawlers when females initiated oviposition in the field.
‡ Time controls (see Materials and Methods).
§ Branches covered during treatment(s).

Oil applications (70 second superior oil @ 4 liters/200 liters water) were applied to the entire orchard with a Swanson air blast sprayer calibrated to deliver 1400 liters/ha of dilute spray from eight nozzles directed at the tree canopy. Applications were made only when the air temperature was above 15°C. Tree branches assigned to the "untreated control" category were covered with plastic bags just prior to each oil application; those assigned to the "1 treatment" category were covered during the second application. All bags were removed as soon as the residue was dry.

Tree branch samples were collected prior to the first oil application (controls) and seven days after the final application for each treatment. These samples were cut to give a standardized sample of 200 cm^2 of bark surface area. The length of each branch sample was based on its mid-point diameter using the formula:

$$\text{Length of branch sample (cm)} = \frac{200 \text{ cm}^2 \text{ of surface area}}{3.14159 \times \text{mid-point diameter (cm)}}$$

Each sample branch was placed in an individual emergence cage constructed from cardboard tubing (the core of a carpet roll). The open end of a transparent glass vial was inserted into a hole cut in the cardboard near its mid-point. Each cage was sealed at both ends with opaque plastic. These emergence cages were held at 25 ± 1° C under a 12L:12D photoperiod.

Parasites were collected from the vials as they appeared, and from the debris within the tube when it was evident that no further emergence would occur (approximately 60 days). A total of 87 samples from 38 different trees was collected in 1988 (29 from each of three treatments); 150 samples from 127 trees (30 from each of 5 treatments) were collected in 1989. The two additional treatments in 1989 were "time controls," i.e., branches that were covered during the spray treatments, then collected at the same time as branches exposed to the oilsprays. The purpose of these controls was to account for any naturally occurring mortality or emergence of parasites during the time interval of the experiment. Parasite emergence data were analyzed with pairwise t-tests.

In 1988, the emergence of white peach scale crawlers was monitored by attaching 25 canister traps (Nalepa 1987) to infested branches that had received two applications of oil. The canister traps were placed in the field prior to the first peak of crawler emergence (26 April 1988) and removed afterward (23 May 1988). The data from these traps were compared to similar baseline data collected from 25 canister traps the previous year (22 April to 20 May 1987) when oil was not applied.

In 1989, the population density of white peach scale was measured by counting the number of adult female scales on 25 cm^2 of bark from each of 15 infested branches collected on 3 February. On 4 April 1989, prior to the start of foliar insecticide applications, 30 infested branch samples were collected from the unsprayed control, and from treatments receiving one or two applications of dormant oil (total of 90 samples) (Table 1). Using the formula above, these branches were cut to 25 cm^2 of bark surface area, then sealed in plastic bags and held at 21 ± 1°C. After emergence was complete, crawler density was evaluated by visually ranking the 90 samples from least to most infested. Data were analyzed non-parametrically using a Kruskal-Wallis three-sample rank sum test.

Temperature (max-min) and rainfall data were obtained from records kept at the Horticultural Crops Research Station for the Climatological Record of the National Oceanic and Atmospheric Association. Observations of maximum and minimum temperatures were recorded daily at 1600 hours for the preceding 24 hour period.

Results

Encarsia berlesi was the predominant parasite species recovered from emergence cages in both 1988 and 1989. This species represented 73% of all Hymenoptera collected in 1988 (510 of 700 individuals from 87 cages) and 93% of the total in 1989 (5779 of 6202 individuals from 150 cages). *Marietta carnesi,* a hyperparasite (probably of *E. berlesi,* see Nalepa and Meyer 1990), accounted for 143 of 700 insects collected in 1988 (20%), but declined to 3% of the total (199 of 6202 insects collected) in 1989.

Oil treatments resulted in reductions in parasite numbers in both 1988 and 1989 (Table 2). The numbers of emerging *E. berlesi* dropped 30% after the first

Table 2. Effect of dormant oil applications on the overwintering parasite complex of white peach scale in 1988 (n = 29 per treatment) and 1989 (n = 30 per treatment).

	Mean (S.D.) wasps emerged/200cm² infested bark					
	E. berlesi	P*	*M. carnesi*	P*	*A. proclia*	P*
1988						
Control	7.9 (13.0)		2.5 (4.7)		0.6 (1.2)	
1 Appl.	5.5 (6.4)	0.38	1.6 (2.1)	0.35	0.5 (1.0)	0.91
2 Appl.	4.2 (4.6)	0.15	0.9 (1.1)	0.08	0.2 (0.6)	0.17
1989						
Control I	46.6 (73.3)		1.3 (1.9)		1.6 (2.1)	
Control II	40.8 (62.4)	0.74	1.6 (2.2)	0.58	1.7 (2.6)	0.96
Control III	41.4 (60.5)	0.77	1.6 (2.7)	0.66	1.5 (3.8)	0.83
1 Appl.	44.3 (59.4)	0.89	1.6 (3.3)	0.70	0.4 (0.8)	<0.01
2 Appl.	19.5 (42.0)	0.08	0.5 (0.9)	0.03	0.1 (0.5)	0.00

* p = probability that the treatment does not differ from the control (pairwise, independent samples t-test).

spray and another 24% after the second spray in 1988. *M. carnesi* had similar declines of 36% and 46% respectively. Because of the high variance in numbers of Hymenoptera, however, in 1988 the decline in parasite numbers was significant ($p < .10$) for *M. carnesi* only. In 1989, populations of *E. berlesi* and *M. carnesi* dropped significantly (by 55% and 67% respectively) ($p<.10$), but only after application of the second oil treatment. Pairwise t-tests showed no significant differences among the three time controls in 1989.

The effect of oil treatments on white peach scale crawler populations was more evident in 1988 than in 1989. Crawlers collected in canister traps decreased 93% in 1988 when compared to the baseline data gathered in 1987 (Nalepa and Meyer 1990) when no oil sprays were applied to the orchard (229 and 17 crawlers in 25 traps in 1988 and 1989, respectively). The scale population grew sharply during 1988, resulting in a mean of 577 female scales per 25 cm² of bark on test branches in early 1989 (n = 15, S.D. = 191, range = 284 to 930). Crawlers were so abundant on test branch samples collected in 1989 that it was impractical to make direct counts. Visual ranking of these branches (based on the density of settled crawlers) showed that lower rank values (lower populations) were most commonly associated with branches that had received one or two applications of dormant oil. Figure 1 illustrates the distribution of rank percentiles for the three treatment groups. A Kruskal-Wallis three-sample rank sum test yielded a Chi^2 value of 2.2 (2 df, p = .25).

Heavy rainfall (7.8 cm) was recorded at the Clinton, NC station during the last two weeks of February, 1989 following the first application of dormant oil. Another 4.8 cm of rain fell during the two weeks following the second oil application in 1989. By contrast, only 2.8 cm of rainfall was recorded in 1988 during the entire

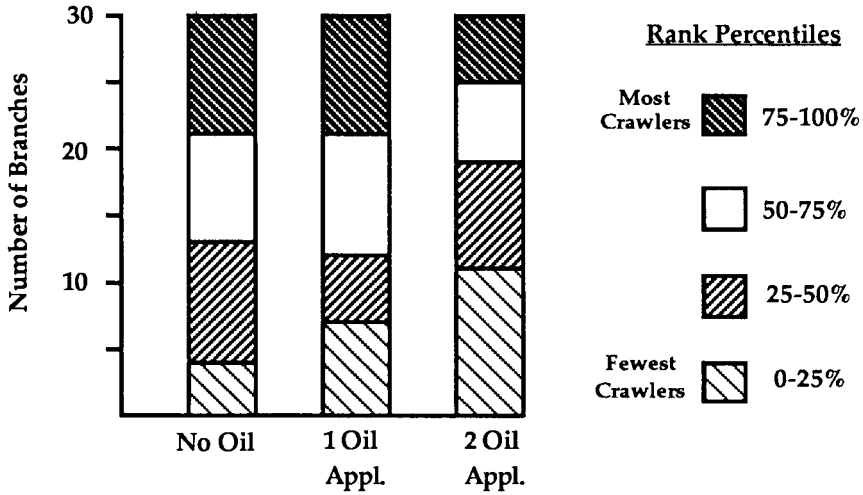

Fig. 1. Effect of oil applications on crawler density in 1989. All 90 branches were pooled and visually ranked based on crawler density.

four week interval from 22 February to 15 March. Air temperatures recorded in 1988 ranged from -8 to 31°C, and from 9 to 28° C in 1989.

Discussion

In this experiment, parasite mortality may have been caused directly, by toxicity of the oil sprays, or indirectly, by host mortality. The overall effect of the sprays and their mode of action probably depends heavily on the developmental stage of the parasite at the time of treatment. In either case, single applications of dormant oil reduced white peach scale parasite populations 25 - 55% in 1988 and 58 - 75% in 1989.

Despite the high mortality rates, parasite populations showed a strong rebound in 1989 suggesting that oil treatments may be compatible with stable populations of the parasite complex. The rebound cannot be attributed to immigration from adjacent sites because the Clinton orchard is relatively isolated and none of the trees were unsprayed. Declining rates of hyperparasitism and the increase in host material may have been partially responsible for the 6-fold increase seen in *E. berlesi* between 1988 and 1989, but phenological synchrony between the white peach scale and its parasites probably plays a much larger role in the dynamics of these populations.

The mechanism by which dormant oil sprays work to kill scales and the influence of any sublethal effects are unknown. Chapman et al. (1952) reported that oil sprays work by suffocating insects, however, because scales die for a period of up to 3 weeks after treatment, it is probable that they are killed by a more generalized poisoning (Bachmann 1974), or a combination of both (Johnson 1985). Smith (1969) demonstrated that scale mortality is enhanced by chronic exposure (two applications are needed for efficacy), but the parasites studied in

this experiment showed similar percentage mortality after each application in 1988, and after the second application in 1989. Acute exposure from a single treatment, then, is likely to cause higher mortality in the parasites than in the scale. Poor control of scale and low mortality of parasites following the first oil spray in 1989 probably reflect loss of coverage of the dormant oil due to intense rainfall (7.8 cm) during the period 14 - 28 February, 1989.

A lack of significant differences among the time control treatments (I through III, Table 2) in 1989 confirms our 1988 assumption that parasite populations suffered negligible mortality during the treatment period (February and March) and experienced little adult emergence despite a wide range of abiotic conditions (e.g., 9 to 28° C).

This study indicates that oil treatments may be compatible with populations of the natural enemies of white peach scale in commercial peach orchards. Despite significant mortality, annual resurgence of surviving parasites appears to sustain the orchard population. Scales that survive/escape exposure to the oil serve as hosts to these parasites.

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