

PHEROMONE TRAPPING OF MALES AND PREDICTION OF CRAWLER EMERGENCE FOR SAN JOSE SCALE (HOMOPTERA: DIASPIDIDAE) IN VIRGINIA APPLE ORCHARDS

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San Jose scale (SJS), *Quadraspidiotus perniciosus* (Comstock), is an important pest in apple orchards (Brunner, J. F., and A. J. Howitt. 1981. Tree fruit insects. N. Cent. Reg. Ext. Publ. 63, 60 p.), requiring annual control measures because of very low levels of fruit infestation tolerated. Control measures usually consist of a dormant or delayed dormant application of oil and an insecticide, followed by one or two applications directed against first-generation crawlers (first instar nymphs). In severe cases, insecticides are also directed against second-generation crawlers in August.

Insecticide applications timed for crawler control must be critically timed. Although the total period of crawler activity may extend for two weeks, individual crawlers may be exposed to sprays for less than 24 hours (Gentile, A. G., and F. M. Summers. 1958. The biology of San Jose scale on peaches with special reference to the behavior of males and juveniles. *Hilgardia* 27: 269-85).

A pheromone trap has recently been made available for the detection of flight activity by male SJS, and trapping techniques have been discussed [Hoyt, S. C., P. H. Westigard, and R. E. Rice. 1983. Development of pheromone trapping techniques for male San Jose scale (Homoptera: Diaspididae). *Environ. Entomol.* 12: 371-5]. The potential of using pheromone trap data to time insecticide applications against male SJS has been examined [Rice, R. E., S. C. Hoyt, and P. H. Westigard. 1979. Chemical control of male San Jose scale (Homoptera: Diaspididae) in apples, pears, and peaches. *Can. Entomol.* 111: 827-31]. Although effective, male flight generally occurs too close to the bloom period of apple to serve as a target for insecticide applications without endangering pollinators. Rice et al. (1979) reported that male flight occurred near petal fall on early varieties and full bloom on later varieties in western states, and in New York males are also active during bloom [Mague, D. L., and W. H. Reissig. 1983. Phenology of the San Jose scale (Homoptera: Diaspididae) in New York state apple orchards. *Can. Entomol.* 115: 717-22].

The most likely use of SJS pheromone traps is to serve as a cue or biofix to initiate degree-day accumulation and monitoring for SJS crawlers. Research to develop such techniques has been initiated in New York [Mague and Reissig 1983; Reissig, W. H., R. W. Weires, D. W. Onstad, B. H. Stanley, and D. M. Stanley. 1985. Timing and effectiveness of insecticide treatments against San Jose scale (Homoptera: Diaspididae). *J. Econ. Entomol.* 78: 238-41], but before data on degree-day accumulation may be applied in Virginia, data must be collected under local conditions. Confirmation and validation of data collected in other regions are required. The purpose of this study was to determine the degree-day accumulation required between first pheromone trap catch of SJS males and first crawler emergence.

Male Flight — Pheromone traps (obtained from Zoecon Corp., Palo Alto, CA 94304) were hung during the last week of April in an apple (*Malus* × *domestica*

Borkhausen cv. Red Delicious) orchard at Fairfield (524 m above sea level) (Rockbridge County) in 1982 and in that orchard plus orchards in Troutville (457 m) (Botetourt County), Tyro (274 m) (Nelson County) and Batesville (305 m) (Albemarle County) in 1983. The first two orchards are west of the Blue Ridge; the latter orchards are east of the Blue Ridge. Traps were checked daily for adult emergence.

Crawler Emergence — Crawler emergence was monitored using black plastic sticky tape wrapped tightly around a scale-infested tree limb, sticky side outward, resulting in a band ca. 6 cm wide. Starting after the third week of May in both years, tapes were checked daily for entrapped crawlers. When tackiness of tapes wore off, tapes were replaced. Use of tapes was supplemented with examination of scale-encrusted bark using a 10x hand lens.

Temperature Records — Daily temperature records were obtained using a hygrothermograph and a maximum-minimum thermometer in one orchard on each side of the Blue Ridge Mountains (Nelson and Botetourt Counties) in 1983. In calculating degree-days (DD), a developmental threshold of 10.0°C was used (Mague and Reissig 1983), and the equation for degree-days presented by Brunner and Howitt (1981).

In 1982, first male flight occurred on May 7 and first crawlers were caught on June 2. These phenological events for the four orchards in 1983 are recorded in Table 1. Crawler emergence, a critical event in SJS management, may vary by as much as 13 days between orchards in a single year, and by nearly as much (12 days) between years in a single orchard.

Table 1. Phenological dates for first generation San Jose scale at four locations in Virginia in 1983.

County	First Male Flight	First Crawler Emergence
Nelson	May 3	June 1
Albemarle	May 5	June 3
Botetourt	May 9	June 6
Rockbridge	May 14	June 14

Data for DD accumulation from March 1 until male flight and crawler emergence are given in Table 2 from both Virginia and New York (Mague and Reissig 1983). Values from the two states are similar; between-state differences in DD for each event accumulate in only one or two days.

Table 2. Degree-day accumulation from March 1 before male flight and crawler emergence in Virginia* and New York† (base 10.0 C).

Event	Virginia	New York
Male flight	154	90 - 140
Crawler emergence	350	360

* Virginia data based on two locations.

† New York data from Mague and Reissig (1983).

Degree-days were accumulated between first male capture and first crawler capture. Crawler emergence occurred at 208.5 ($\pm$ 3.4 S.E.) DD after first male

capture. This is somewhat earlier than the value of 230 DD given by Mague and Reissig (1983) for western New York State (approximately 700 km north of the present locations). The difference of approximately 22 DD is the number of thermal units accumulating over two or three days at this season.

In conclusion, SJS phenological events show a roughly similar relation with thermal unit accumulation in Virginia and New York State, although fewer DD were required between male flight and emergence of crawlers in Virginia.

Thermal unit accumulation offers an improved method of predicting SJS crawler emergence over simple calendar days, even when calendar day summation begins at a male flight biofix. In the two orchards for which temperature data were recorded, the interval between male flight and emergence of crawlers varied by five days. When degree-days are used, the difference of 21.5 DD represents thermal units normally accumulated over one or two days at the time of year of crawler emergence. Reissig et al. (1985) found that the use of DD was superior to calendar days for predicting crawler emergence in New York, and was preferable to the tedious search for crawlers in scale management.

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