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PARASITOIDS OF *CHIONASPIS PINIFOLIAE* (HOMOPTERA: DIASPIDIDAE) IN IOWA

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ABSTRACT

Three parasitoids (Hymenoptera: Encyrtidae: Aphelininae), *Aphytis diaspidis*, *Coccobius varicornis*, and *Marietta pulchella*, were recovered from field collections of the pine needle scale, *Chionaspis pinifoliae*, on *Pinus sylvestris* in central Iowa. Parasitoid mean time (± SEM) to emergence from overwintered scale mummies occurred at 46.6 (± 4.6) and 23.9 (± 1.3) days for *C. varicornis* and *M. pulchella*, respectively, using a 16L:8D photoperiod and a corresponding temperature regime of 22°C and 18°C. Growing-season parasitism level on field-collected female *C. pinifoliae* was 15%; parasitoid community composition was 86% *A. diaspidis*, 12% *C. varicornis*, and 2% *M. pulchella*.

The pine needle scale, *Chionaspis pinifoliae* (Fitch) (Homoptera: Diaspididae), is a native pest of many species of needle-bearing conifers in North America (Furniss and Carolin 1977, Drooz 1985). This insect has become the most commonly encountered insect pest of nursery conifers in Iowa during the last decade (Anonymous 1985, 1986). In this and surrounding states, nursery managers have experienced increased infestations on seedling and second-year conifers. Because movement of infested nursery stock may distribute pine needle scale to uninfested material, regulatory measures commonly have been used to halt sale and transport of infested nursery stock. Aesthetic damage resulting from infestations also has caused concern for established urban plantings in Iowa. A related species, *Chionaspis heterophyllae* (Cooley), is often present on the same host trees in the eastern United States and has occasionally been misidentified as *C. pinifoliae*, (D. G. Nielsen, Dept. of Entomology, Ohio State University-Wooster, pers. comm.). To date, however, *C. heterophyllae* has not been recovered in Iowa.

In the midwest, pine needle scale is bivoltine most years, with an occasional partial third generation reported (Shour 1986). The seasonal life cycle usually begins with the overwintered egg hatch and crawler dispersal in late April or early May. First-generation adults occur about midsummer. Eggs produced by late first-generation females or by second-generation females diapause, overwintering beneath the adult scale covering (Johnson and Lyon 1988).

Throughout its range, the insect is rarely a problem on coniferous hosts in undisturbed environments. Scale populations can increase to levels that are aesthetically displeasing, or in extreme cases, can contribute to decline and death of the tree (Luck and Dahlsten 1974, Johnson and Lyon 1988). Disruptive forces may affect trees, predisposing them to scale attack (Luck and Dahlsten 1975). Such disruption is most likely encountered within the urban environment or intensive culture plantings, such as nurseries.

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It has been suggested that low levels of predation and parasitism, sometimes associated with pesticide application for insects other than the scale, may contribute to pine needle scale outbreaks in high-value plantings (Cumming 1953, Dahlsten et al. 1969, Luck and Dahlsten 1974, 1975). Several species of hymenopterous parasitoids have been recovered during life history and phenological studies of pine needle scale, but the composition of the complex differs by geographic location (e. g., Cumming 1953, Luck and Dahlsten 1974). The study reported in this paper was carried out to identify the pine needle scale parasitoid complex operating in central Iowa. It is our intention that this may provide a foundation for future work that might assess the impact of the complex.

MATERIALS AND METHODS

Overwintering Survey. Preliminary surveys of overwintering pine needle scale indicated that at least one species of mummifying parasitoid was present within the scale population. Controlled rearings were performed to define the species present and to describe their post-diapause emergence patterns.

All collections of material were taken in the Ames, Iowa, area from Scots pine, *Pinus sylvestris*, 3 to 13 m tall, with a history of pine needle scale infestations. All samples were taken from trees with 10 or more scales per fascicle, and with no previous history of scale management. Samples of overwintering material were taken on 2 March 1985 and on 4 March 1986, from a 2.0 to 2.5-m zone of the lowest foliage-bearing branches. In each year, samples consisted of a total of 12 branch tips, selected nonrandomly on the basis of heavy infestations of scale, from each of four trees in three urban stands. Branch tips consisted of the leader and the first set of laterals. Each tip contained needles of three discernable age groups, early and late season growth from the previous season and old needles from prior years. The two flushes from the previous season are easily separated on the basis of needle and stem color, and in some cases, size. Prior foliage is separable on the basis of stem color and, to a lesser extent, relative position on the branch. Branch tips were returned to the laboratory in plastic bags and refrigerated at 4°C to inhibit insect development.

In the laboratory, needles were carefully stripped of scales by scraping them with a razor blade over a sheet of white paper. Scales and scale eggs were then transferred to labelled petri dishes. A series of dishes was rotated from the working area to the refrigerator to avoid prolonged warming of parasitized specimens. Some dead adult wasps of the species later identified as pine needle scale parasitoids were recovered and mounted on microscope slides.

Scale mummies were separated from the collections and individually placed into No. 1 gelatin capsules labeled with collection and rearing data. Mummies were incubated at a 16L:8D photoperiod with a corresponding fluctuating temperature regime of 22-:18°C. Relative humidity was maintained at 65–75%. In 1985, parasitoid rearings were started on either 4 March and 20 April; in 1986, rearing of all material was begun on 6 March. Material was not terminated until two months after cessation of the last adult emergence.

A daily census was taken of all scale mummies. Upon emergence, each parasitoid was identified tentatively to morphospecies and sex. All insects were either slide-mounted for immediate examination or frozen and stored for later study. Two months after emergence ceased and visual examination indicated no live insects remained, all dead, unemerged parasitoids, pine needle scale mummy remains, pupal exuviae, and meconia were either slide mounted or prepared for scanning electron microscopy.

Growing-Season Survey. A general survey was undertaken in 1986 to identify the parasitoids present during the growing season and to determine the relative population changes in the parasitoid complex during that time. Female pine needle scales were collected throughout the season from six sites on or adjacent to the Iowa State

University campus, each with two or more trees. A total of 29 trees was sampled. Samples were collected from the lower 2.5 m of the tree, a region including 25–35% of the foliage-bearing branches. This height range was selected to facilitate collecting, and because pine needle scale crawlers tend to colonize this region of foliage most heavily in conical-shaped trees (Nielsen 1970).

Collections were scheduled irregularly from April through November, 1986. Nine collections were made: 1 April, 22 May, 16 June, 4 July, 15 July, 6 August, 21 August, 25 September, and 26 November. The longer intervals reflected periods of cooler temperatures and slower scale development.

During the first part of the sampling period, five two-needle fascicles from the previous year's growth were collected from each of the four cardinal directions of each tree. New foliage was not sampled before the first visible evidence of second-generation crawler establishment on 15 July. Subsequently, an additional set of five fascicles from each cardinal direction was taken from the current year's growth. Needles were returned to the laboratory and refrigerated at 4°C until examination. Scales were removed from the needles and separated for parasitoid emergence as described for the overwintering survey. The number and condition of pine needle scales, parasitoid life stages, and parasitoid morphospecies were recorded.

Initial identifications of parasitoid adults were made in our laboratory and verified by personnel at the USDA Systematic Entomology Laboratory. Specimens have been deposited in the collections at the U.S. National Museum of Natural History, Washington, and Iowa State University.

RESULTS

Three species of parasitoids (Hymenoptera: Encyrtidae: Aphelininae) were recovered from pine needle scales in central Iowa: *Aphytis diaspidis* (Howard), a primary-level ectoparasitoid; *Coccobius varicornis* (Howard), a primary-level endoparasitoid; and *Marietta pulchella* (Howard), a secondary-level ectoparasitoid of *C. varicornis*.

Overwintering Survey. *Coccobius varicornis* and *M. pulchella* were recovered from overwintering pine needle scale (Table 1). *Coccobius varicornis* was recovered in approximately a 9:1 ratio to *M. pulchella*. Sixty-seven adult parasitoids emerged from 135 endoparasitized scales; of the 68 unemerged dead parasitoids, 98% were mature larvae and 2% were pupae. Divergent emergence patterns were evident between the two species for both years. The overall mean number of days to emergence (± SEM) was 23.9 (± 1.3) for *M. pulchella* and 46.6 (± 4.6) for *C. varicornis*. Only female *C. varicornis* were recovered; however, both sexes of *M. pulchella* were collected.

Growing-Season Survey. *Aphytis diaspidis, C. varicornis,* and *M. pulchella* were recovered during the 1986 growing season (Table 2), from 16,591 female scales. Parasitoid recoveries for all life stages, including emergence evidence occurred from 2,530 scales, for an overall implied parasitism level of 15.2%. This estimate does not include mortality induced by adult parasitoid feeding. Because this was a preliminary study of one season only, data from all needles were pooled for a summary description of the overall recovery trends.

DISCUSSION

Each species of parasitoid recovered from pine needle scale in central Iowa has been described previously from several other hosts (Krombein et al., 1979). Each has also been reported from *C. pinifoliae* from central and eastern Canada, and from Indiana in the United States (Cumming 1953, Martel and Sharma 1968, Shour 1986). In only the study by Martel and Sharma (1968), however, have these same

Table 1. — Parasitoid emergence from overwintering pine needle scales in 1985 and 1986.

Date collected	Date rearing initiated	n	Species	Parasitoid emergence[1] male	female	Days to emergence[2] $\bar{X} \pm SD$	Range of emergence[3] (in days)
2 Mar 85	4 Mar 85	60	*Coccobius varicornis*	0	26	49.5 ± 2.2	45–58
			Marietta pulchella	3	1	25.3 ± 0.5	24–27
2 Mar 85	20 April 85	40	*Coccobius varicornis*	0	16	47.9 ± 9.9	42–57
			Marietta pulchella	2	0	27.5 ± 2.1	26–28
4 Mar 86	6 Mar 86	35	*Coccobius varicornis*	0	15	42.4 ± 1.0	40–47
			Marietta pulchella	1	1	19.0 ± 1.4	19–20

[1]Number of dead unemerged parasitoids by rearing date were 29, 20, and 18 respectively. Mummy content was not identified to species.
[2]Incubations were at 22°:18°C, 16L:8D photoperiod with 65–75% relative humidity.
[3]From initiation of incubation, rounded to nearest full day.

Table 2. — Parasitoid recoveries by life stage from 16,591 pine needle scales for the 1986 growing season.

Parasitoid	Larvae live	Larvae dead	Pupae live	Pupae dead	Adult Successful emergence	Adult Unsuccessful emergence	Total	% of total recoveries
Aphytis diaspidis	34	537	181	484	900	44	2180	86.1
Coccobius varicornis	92	49	27	16	114	10	308	12.2
Marietta pulchella	17	4	0	2	17	2	42	1.7
Total	143	590	208	502	1031	56	2530	

three species been reported from a single locality. In a study of pine needle scale parasitoids in California, all three species have been absent (Luck and Dahlsten 1974).

The major question that remains unanswered from all studies of this system is that of the impact of the parasitoid complex on the scale population. Before this question can be answered, sampling methodology applicable to these patchy habitats needs further definition. Information is also needed regarding the interactive population dynamics of the complex and, because all three parasitoid species have been described as polyphagous, the possible role of alternate hosts in the system.

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