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PREDATORY SPIDERS IN LIME ORCHARDS AND THEIR IMPORTANCE IN THE CONTROL OF CITRUS LEAFMINER, *PHYLLOCNISTIS CITRELLA* (LEPIDOPTERA: GRACILLARIIDAE)

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Abstract. **Predaceous spiders outnumbered green lacewings, coccinellids, and ants in lime orchards. The density of green lacewings (*Chrysoperla rufilabris*) was significantly higher than the coccinellids (*Harmonia* sp.) and ants (*Myrmelachista* sp.). Nine families, 25 genera and 16 identifiable species of spiders were recorded. Significantly more spiders were found in non-sprayed orchards than in sprayed ones. The same situation was observed for other predatory arthropods (i.e., lacewings, coccinellids, and ants). This finding suggests the probable negative effect of chemical sprays on predatory arthropods. Among the spiders, four species were found feeding on citrus leafminer (CLM) larvae and prepupae, *Chiracanthium inclusum* (Clubionidae), *Hibana velox* (Anyphaenidae), *Trachelas volutus* (Corrinnidae), and *Hentzia palmarum* (Salticidae). Our findings suggest that spiders are possibly important mortality factors of CLM.**

Introduction and Review of Literature

The citrus leafminer, *Phyllocnistis citrella* Stainton, is a widely distributed pest. It is considered a major pest where it is present. In the United States, this pest was first recorded in south Florida in late May 1993 (Heppner, 1993; Knapp et al., 1995). In less than a year the infestation spread into all major citrus growing areas of Florida, southern USA, the Caribbean Region, and the Americas (Heppner, 1993; Knapp et al., 1995; Schauff and La Salle, 1996). Economic damage has primarily occurred not only in established lime orchards but also on the new plantings in nurseries. Thus, both sites are the focus for efforts to manage this pest.

Pesticides provide a rapid means of suppressing CLM populations. During heavy infestation, the control of CLM in Florida and other countries is anticipated by spray regimes of various pesticides (Amalin, 1999). However, there is an urgent need to develop alternative non-chemical control measures because of insecticide resistance and major environmental concerns (Peña and Duncan, 1993; Tan and Huang, 1996).

Biological control appears to be the most promising control measure against CLM. Various species of natural enemies (pathogens, parasitoids, and predators) have been evaluated against CLM (Heppner, 1993; Zhang et al., 1994; Argov and Rossler, 1996). Worldwide, various species of parasitoids of CLM have been identified (Heppner, 1993; Ujiye et al., 1996; Browning and Peña, 1995; Browning et al., 1996). Predaceous arthropods are also believed to make an important contribution to the mortality of CLM. However, to date no systematic study has been made to identify these natural enemies of CLM in Florida or assess their effects on the pest's population. The objectives of this study are to determine the spider diversity in lime orchards, to compare the spider community in sprayed and non-sprayed lime orchards, and to identify the species of spider feeding on CLM.

Materials and Methods

Preliminary Survey of Predatory Arthropods. All samplings were conducted from June 15, 1995 through August 15, 1995 in three commercial 2.0-4.0 ha lime orchards in Homestead, Florida. In all the orchards, trees were planted 6.0 m between rows and 4.5 m between trees.

For each orchard, 15 randomly selected trees were surveyed every week for 8 weeks. Sampling of spiders was done by visually searching plant parts i.e., leaves, main stem, and branches, from 0.30 m to 1.7 m above ground. All the spiders were collected in 20-ml laboratory glass vials containing 70% ethyl alcohol. The collections were transported to the laboratory for sorting, counting, and identification. Spider identification was done using published keys by Kaston (1978) and Roth (1993). Verification of spider identification was provided by G. B. Edwards, spider taxonomist at Division of Plant Industry, Gainesville, Florida.

Spiders in Sprayed and Non-sprayed Lime Orchards. Spiders were sampled in six 2.5 to 4.5 ha lime orchards in Homestead, Florida. In all the orchards the trees were 4.5 m tall and had canopies of approximately 5.0 m in diameter.

In each orchard, 15 trees were selected randomly and trees were individually inspected every week from the middle of May 1996 to August 1996. A visual sampling method was used following the procedure described in the preliminary survey. After the visual examination, the same tree was further sampled using the shake-cloth method. This method consisted of using a 1m × 1m shake-cloth placed under five branches clumped together and beaten 10 times with a wooden yardstick. Groups of five clumps were randomly selected from the tree canopy. The number of spiders as well as the number of green lacewings, coccinellids, and ants was recorded. Spider samples were pooled for each sample date and orchard. Abundance was calculated for all the identifiable species of spiders as well as for green lacewings, coccinellids, and ants.

Results and Discussion

Preliminary Survey. Sampling of predatory arthropods in lime orchards showed that spiders significantly outnumbered the green lacewings, coccinellids, and ants (Fig. 1). The density of green lacewing (*Chrysoperla rufilabris*) was significantly more than coccinellid (*Harmonia* sp.) and ants (*Myrmelachista* sp.). Nine families, 24 genera, and 16 identifiable species of spiders were recorded (Table 1). Three families represented

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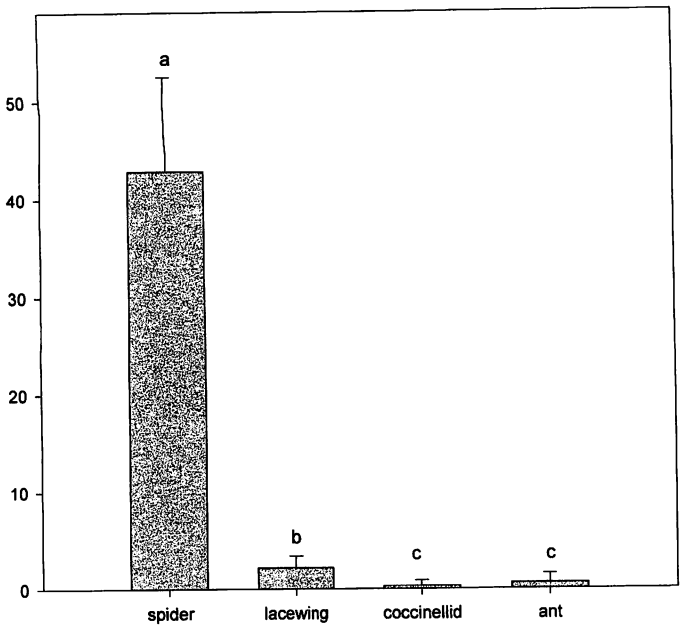

Figure 1. Abundance of predatory arthropods in lime orchards during summer, 1995 at Homestead, Florida. Vertical bars with the same letters are not significantly different according to Duncan Multiple Range Test ($P \leq 0.05$).

the web-building spiders, five families represented the hunting spiders, and one family represented the ambushers. When the weekly count was averaged for the three orchards, five species of web-building spiders were represented by five or more individuals. *Araneus* sp. had a weekly mean count of 8.5 ± 2.6; *Eriophora ravilla*, 8.8 ± 1.9; *Gasteracantha cancriformis*, 9.3 ± 2.7; *Leucauge venusta*, 7.2 ± 2.1; and *Theridion* sp., 37.0 ± 4.1. Among the hunting spiders, four species were recorded at five or more individuals namely, *Chiracanthium inclusum* (22.4 ± 3.5), *Hentzia palmarum* (8.0 ± 3.5), *Hibana velox* (39.4 ± 7.7), and *Trachelas volutus* (23.8 ± 3.8).

Table 1. Result of feeding test for the spider species collected in lime orchards on CLM larvae.

Guild	Species	Family	CLM association
Web building spiders	*Acacecia hamata*	Araneidae	no
	Araneus sp.	Araneidae	no
	Argiope catenulata	Araneidae	no
	Conophista sp.	Theridiidae	no
	Cyclosa sp.	Theridiidae	no
	Eriophora catenulata	Araneidae	no
	Gasteracantha cancriformis	Araneidae	no
	Latrodectus geometricus	Theridiidae	no
	Leucauge venusta	Araneidae	no
	Metapeira sp.	Araneidae	no
	Neoscona arabesca	Araneidae	no
	Nephila clavipes	Araneidae	no
	Tetragnatha sp.	Tetragnathidae	no
	Theridion sp.	Theridiidae	no
	Theridula sp.	Theridiidae	no
Hunting spiders	*Chiracanthium inclusum*	Clubionidae	yes
	Hentzia palmarum	Salticidae	yes
	Hibana velox	Anyphaenidae	yes
	Lycosa sp.	Lycosidae	no
	Lyssomanes viridis	Salticidae	no
	Metaphidippus vitis	Salticidae	no
	Phidippus regius	Salticidae	no
	Plexippus sp.	Salticidae	no
	Trachelas volutus	Corrinnidae	yes
Ambushers	*Misumenops* sp.	Thomisidae	no

The result of this preliminary survey showed a rich spider community in lime orchards in Homestead, Florida. Among the web-building spiders, *Theridion* sp. was the most abundant in lime orchards. In California, Carroll (1980) also found *Theridion* sp. dominating the canopy of citrus trees. They built delicate sheet webs across a single leaf, catching primarily small flies, midges and psocids, but also some thrips, wasps, mites and aphids. Likewise, *Theridion* sp. may also feed on various arthropod pests in lime orchards possibly on phytophagous mites, thrips, and aphids.

The wandering spider group in lime orchards was dominated by three species of sac spiders, *Hibana velox* (Anyphaenidae), *Chiracanthium inclusum* (Clubionidae), and Trachelas volutus (Corrinnidae). These sac spiders usually spend the day in loose silk nests in rolled leaves or other enclosed spaces. Carroll (1980) observed that sac spiders were the most abundant in California citrus orchards and wander rapidly at night over the citrus canopy, groping primarily for slow moving or sessile prey i.e., thrips, mites, insect eggs, and lepidopterous larvae. Laboratory feeding tests of different species of spiders on CLM confirmed that the three species of sac spiders, *C. inclusum*, *H. velox*, and *T. volutus* attacked CLM larvae and in some cases even prepupae (Amalin, 1999).

Spiders in Sprayed and Non-sprayed Orchards. In general, the number of predatory arthropods was significantly higher in the non-sprayed orchards than in the sprayed ones except for coccinellids (Table 2). Numbers of hunting spiders were significantly higher on non-sprayed than on the sprayed orchards; for the web-building spiders, there was no significant difference with the spider abundance between the sprayed and non-sprayed orchards (Fig. 2). The population of web building spiders was dominated by *Theridion* sp. This species of web-building spider hide in a delicate sheet web constructed on leaf adaxial surface usually on the edge of the major leaf veins (Carroll, 1980). The concealing habit of *Theridion* sp. probably protected them from the pesticide sprays as indicated by our survey result. On the other hand, the wandering spider group was dominated by the three species of sac spiders, *Hibana velox*, *Chiracanthium inclusum*, and *Trachelas volutus* and one species of jumping spider, *Hentzia palmarum*. These species of spiders roam around the plant canopy during their activity periods, which probably make them more vulnerable to pesticide

Table 2. Preliminary results of the survey of predatory arthropods in non-sprayed and sprayed lime orchards (Homestead, FL, summer 1995).

	Predatory arthropods*			
Location	Spider	Lacewing	Coccinellid	Ant
Non-sprayed				
1	7.44 b	0.07 b	0.04 a	0.04 a
2	14.24 a	0.53 b	0.07 a	0.02 b
3	6.97 b	1.33 a	0.00 a	0.42 a
Sprayed				
4	3.42 c	0.18 b	0.04 a	0.01 b
5	6.69 b	0.04 b	0.09 a	0.00 b
6	4.11 c	0.02 b	0.00 a	0.00 b

*Average count for 15 trees per location. Means in columns followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.

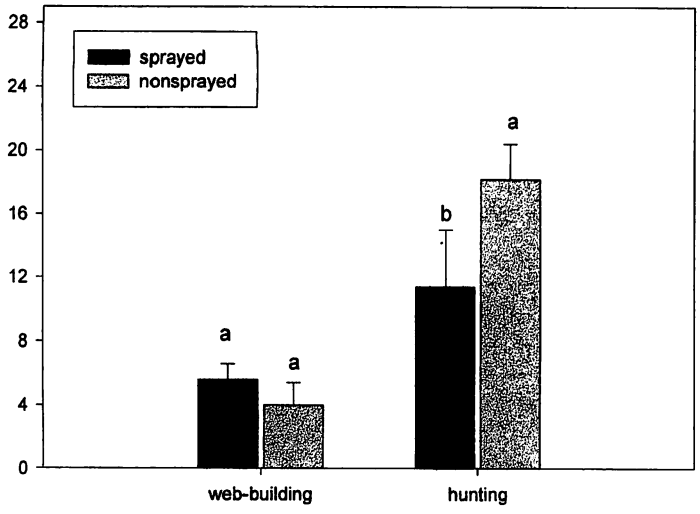

Figure 2. Difference in the abundance of the two spider guilds in non-sprayed and sprayed orchards. Bars with the same letter are not significantly different according to Duncan Multiple Range Test ($P \leq 0.05$).

sprays. Although it is evident from the result of the spider abundance and diversity in the sprayed and non-sprayed orchards that the spider-hunting group is more affected by pesticides, the impact of these pesticides on both the web building and wandering spider groups must be taken into consideration.

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A CENTURY OF RESEARCH WITH USDA IN MIAMI

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Abstract. **From its beginning as a plant introduction garden on 7 acres of rented land in downtown Miami, through 100 years of research efforts, this USDA-ARS station has persevered and focused on improving tropical horticulture. As South Florida has grown and changed, the needs and desires of the populace for agricultural commodities and ornamentals have kept pace. Originally envisioned as a facility for the importation, testing and distribution of plant material from around the world, this laboratory, since 1972 called the Subtropical Horticulture Research Station, has gradually shifted its focus as well as its location. Now occupying 197 acres of what was previously a bayside army aviation training center named for the first U.S. flier killed in France in World War I, Victor Chapman, the station currently has three missions. As a germplasm repository for numerous tropical species including mango, avocado, lychee, carambola, and sugarcane, one mission is to accumulate a collection of clones useful for breeding new cultivars better adapted to the needs of consumers and the local environment and for distribution to other research institutes. A second focus through much of the last 25 years has been studies on the**

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