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SPATIAL AND TEMPORAL DISTRIBUTION OF PHYTOSEIID MITES IN TEXAS CITRUS GROVES[1]

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Abstract. **Eleven species of predaceous mites belonging to the family Phytoseiidae have been collected from citrus foliage in the Lower Rio Grande Valley of Texas.** Euseius denmarki **sp. N. Rakha & McCoy was by far the most prevalent species, accounting for 94.3% of all phytoseiids recovered in the 39-grove survey. This species and 4 others were recovered in at least 11 months of the year from citrus foliage, and appeared most numerous in untreated groves (60.4%) as opposed to groves under periodic (31.6%) or scheduled (8.0%) treatments. In general, phytoseiid numbers were highest in June of both sample years, increasing from low overwintering populations. The patterns in treated groves were not as clear as in the untreated groves.**

The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) is the major arthropod pest associated with citrus production in the Lower Rio Grande Valley (LRGV) of Texas (2). Regular pesticidal applications are necessary to keep this pest from inflicting economic damage on the fresh market crop of grapefruit and oranges. In addition, the Texas citrus mite *Eutetranychus banksi* (McGregor) can cause economic damage to citrus, and often is the target of acaricidal applications. The presence of these two pests, and more recently the introduction of the citrus red mite *Panonychus citri* (McGregor) into the LRGV (3, 4) have brought about the need for additional pest management tools. Other pests of citrus, particularly the armored scales, have been brought under biological control through the introduction of effective natural enemies, and the preservation of these natural enemies is important in preventing pest upsets. Little is known, however, regarding the endemic natural enemies attacking the phytophagous mite complex on Texas citrus. In other citrus production areas where mites are a threat, surveys have been conducted to identify the major predator species, and in some areas, more effective predator species have been imported to increase the biological control of mites. In Florida, for example, the phytoseiid mite fauna has been documented on a wide variety of host plants (7), and citrus has proven to be rich in phytoseiid diversity. Similarly, in California, the phytoseiid fauna on citrus has been described (10), and importations of additional species have been made. McMurtry (6) studied the natural control of *P. citri* in California citrus groves, and documented the influence of predators and pathogens on population levels (7).

The investigations reported herein were undertaken to identify the phytoseiid mite fauna associated with citrus foliage in Texas and to provide information on predator/pest associations. This information will provide the background for importation of exotic phytoseiid species with potential to reduce mite pest populations.

Materials and Methods

The survey for phytoseiid mites was conducted throughout the citrus producing area of the LRGV, and was concentrated primarily in commercial groves. Sample groves were selected to represent 3 basic production systems: groves under routine pest control programs, including scheduled acaricide and insecticide applications; groves in which pesticide applications were made as needed; and groves in which pesticidal applications were rarely if ever applied. The latter included several groves which were abandoned and received minimum care of any kind. The working hy-

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pothesis was that these 3 grove care types should differentially affect the predaceous mite fauna found therein. Thirteen groves of each pest control type were located across the citrus production area and were sampled every 21 days beginning in April, 1982. Within a grove, 4 leaves were selected from each of 30 randomly chosen trees, for a total of 120 leaves per sample location. One leaf was taken from each quadrant of the canopy within an individual tree, and the leaves represented the vertical zone between ground level and 6 ft. Leaf samples were placed in a 1-qt widemouth glass jar containing a 0.5% detergent solution (5) and transported to the laboratory. Processing of the samples involved removing the leaves and rinsing them into the collection jar. The detergent solution then was filtered onto a 4-inch black cotton organdy disc in a Buchner funnel. All arthropods contained in the sample jar thus were deposited and the disc was placed into a plastic petri dish for microscopic examination. Samples were either counted immediately following this step or were stored at reduced temperature for later counting. Phytoseiid mites were removed from the organdy discs and singly slide mounted in Hoyer's chloral hydrate (1). Cleared specimens then were examined and sorted by species, life stage, and sex. Data then were summarized for each sample location and date.

Results and Discussion

The survey has resulted in the identification of 11 species of phytoseiid mites belonging to two subfamilies (Table 1). Nine genera are represented in the samples from citrus foliage, and only *Euseius* and *Proprioseiopsis* contributed more than 1 species. With the exception of *E. vivax* Chant and Baker, all of the species have been reported from Florida citrus groves (8, 9). *Euseius denmarki* sp. N. Rakha and McCoy recently has been described from specimens taken on citrus near Lake Alfred, Florida (9). On the other hand, of the species identified here, only *P. asetus* (Chant) was recovered from California citrus (10).

Table 1. Phytoseiid mites recovered from citrus foliage in the Lower Rio Grande Valley, Texas, 1982-83.

Subfamily Amblyseiinae:
- *Euseius denmarki* Sp. N. Rakha & McCoy
- *E. vivax* Chant & Baker
- *Fundiseius cesi* (Muma)
- *Proprioseiopsis asetus* (Chant)
- *P. dorsatus* (Muma)
- *Typhlodromalus peregrinus* (Muma)
- *Typhlodromips dentilus* (DeLeon)

Subfamily Phytoseiinae
- *Clavidromus transvaalensis* (Nesbitt)
- *Galendromus helveolus* (Muma)
- *Paraseiulella elliptica* (DeLeon)
- *Typhlodromina subtropica* Muma & Denmark

The relative numbers of phytoseiids collected in the survey are illustrated by species in Table 2. *Euseius denmarki* was by far the most commonly encountered, comprising ca. 94% of all mites sampled. Only 3 other species, *Galendromus helveolus* (Muma), *Paraseiulella elliptica* (DeLeon), and *Typhlodromips dentilus* (DeLeon) accounted for more than 1% of the mites sampled. Of the 39 sites sampled, 2 failed to yield phytoseiids, while *E. denmarki* was recovered from the remaining 37. Sites of recovery for the other species ranged from 1 to 26 sites.

The majority (60%) of specimens were recovered from untreated groves, followed by those groves receiving treatment as needed (Table 2). The trends were consistent for each species, pointing to real differences in grove types in their ability to support these predators. Possible explanations include the sensitivity of phytoseiids to the pesticide applications, a numerical response to decreased host population numbers, or differences in the presence of alternative food sources such as pollen. The groves under scheduled treatments tended to support a more sterile environment, with few weed or arthropod species present. The sterility of this environment may reduce the survival of these predators, as well as other beneficial organisms. Promising, however, are the numbers of phytoseiids surviving in groves treated with pesticides on an as-needed basis. This figure (ca. 32% of the total) points to the ability of the mites to survive under limited pesticide pressure, an important attribute of effective natural enemies.

Two of the species, *E. denmarki* and *Typhlodromalus peregrinus* (Muma), were recovered from at least 1 location during every month of the year (Fig. 1), and an additional 3 species occurred in at least 10 calendar months. *Typhlodroamlus peregrinus* is the most common phytoseiid in Florida citrus (8). Continual occurrance of a species throughout the year demonstrates the adaptability of the species under LRGV climatic conditions, and alludes to a long term stability of the species in the citrus ecosystem. Intermittent recovery of a species over time may indicate that the species generally occurs in low numbers, and only thrives under specific conditions. Such a species probably would not contribute significantly to population suppression of a pest organism over time.

A summary of phytoseiid numbers recovered by month

Table 2. Relative frequencies of phytoseiid mites recovered from 3 citrus grove types, Lower Rio Grande Valley, Texas, 1982-83.

Species	No. of sites[z]	No. specimens recovered by treatment strategy: Scheduled treatment	Treatment as needed	Untreated	Total (%)
Clavidromus tranvaalensis	1	—	1	—	1 (0.1)
Euseius denmarki	37	639	2,815	5,224	8,732 (94.3)
E. vivax	1	—	1	—	1 (0.1)
Fundiseius cesi	5	—	2	3	5 (0.1)
Galendromus helveolus	26	22	53	115	190 (2.1)
Paraseiulella elliptica	25	10	22	71	103 (1.1)
Proprioseiopsis asetus	6	1	3	9	13 (0.1)
P. dorsatus	13	4	15	32	51 (0.6)
Typhlodromalus peregrinus	15	—	7	10	17 (0.2)
Typhlodromina subtropica	8	—	3	15	18 (0.2)
Typhlodromips dentilus	12	7	2	119	128 (1.4)
Total (%)		737 (8.0)	2,924 (31.6)	5,598 (60.4)	9,259 (100)

[z]Total of 39 groves sampled.

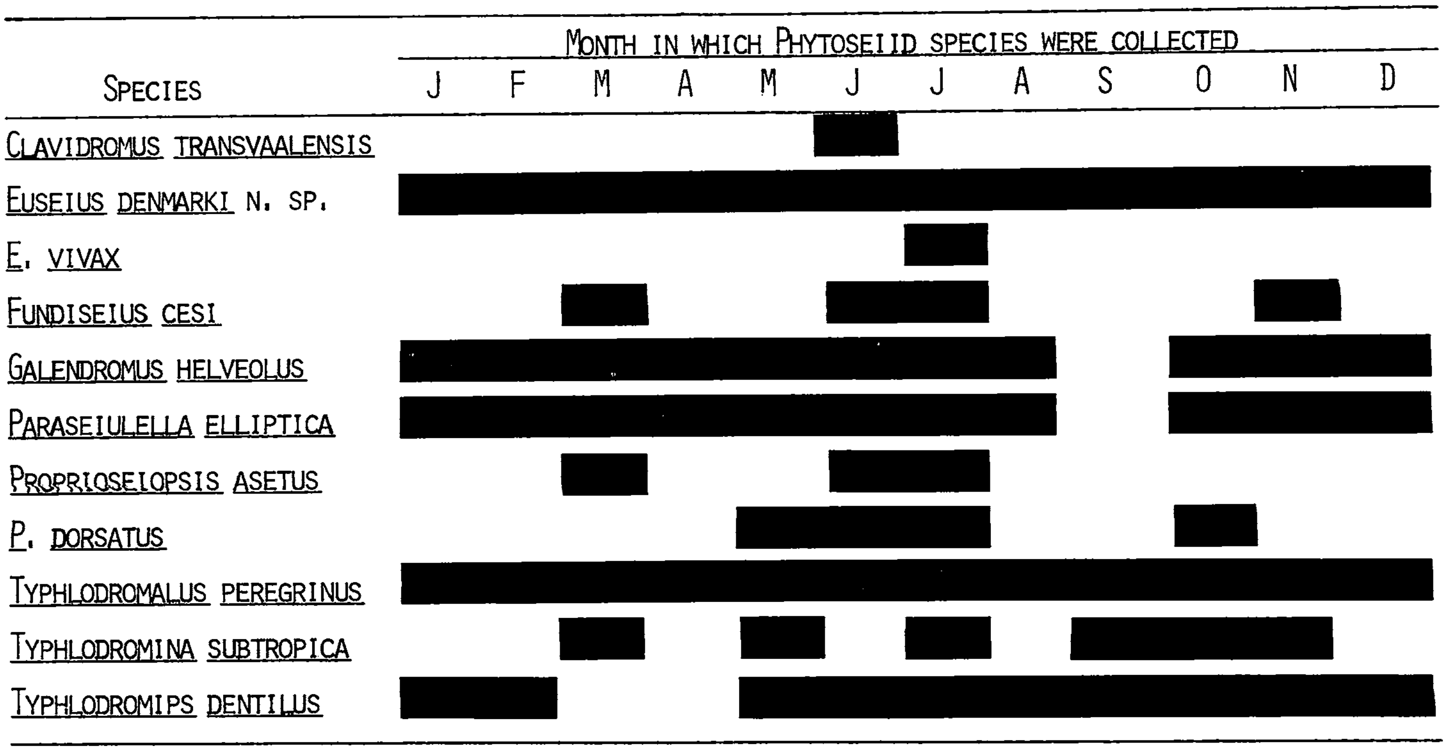

Fig. 1. Monthly occurrence of phytoseiid mite species on citrus foliage, Lower Rio Grande Valley, Texas, 1982-83.

Table 3. Seasonal occurrence of phytoseiid mites recovered from 3 grove types, Lower Rio Grande Valley, Texas, 1982-83.

	No. specimens recovered by treatment strategy			
Month	Scheduled treatment	Treatment as needed	Untreated	Total (%)
1982				
April	2	51	0	53 (.6)
May	4	48	66	118 (1.3)
June	30	474	1,026	1,530 (16.5)
July	71	166	259	496 (5.4)
August	91	26	35	152 (1.6)
September	4	72	53	129 (1.4)
October	2	104	90	196 (2.1)
November	15	153	246	414 (4.5)
December	5	40	82	127 (1.4)
1983				
January	10	112	148	270 (2.9)
February	4	61	155	220 (2.4)
March	18	190	208	416 (4.5)
April	67	90	347	504 (5.4)
May	54	581	397	1,032 (11.1)
June	77	423	1,437	1,937 (20.9)
July	126	328	357	811 (8.8)
August	157	5	692	854 (9.2)
Total	737 (8.0)	2,924 (31.6)	5,598 (60.4)	9,259 (100)

over the sample period demonstrates temporal distribution of the mites (Table 3). In the untreated sample groves, highest numbers occurred in June of both years, increasing gradually from low late winter and early spring levels. Following this peak, populations tended to decrease as summer progressed. Conversely, population levels in treated groves were not as predictable, rising and falling with no apparent pattern. Disruption of normal population fluctuations by pesticide application is a possible explanation. As not all groves were treated simultaneously, these figures represent a mosaic which possibly could mask individual trends. Further analysis of population fluctuations in specific locations may shed light on these findings.

The spatial and seasonal trends exhibited by the various phytoseiid species discussed above are undoubtedly governed by the availability of food and harborage. Fluctuations in populations of predators may be a response to host population changes (density-dependent response), but often these relationships are difficult to define. Of the 11 phytoseiid species identified from citrus foliage in the LRGV, food habits are known for only 1. *Galendromus helveolus* has been reported to readily feed on *Eutetranychus banksi* and *Panonychus citri* in the laboratory (8), but no food associations have been reported for other species. Without this important bibiological information, relationships of predator numbers to phytophagous mite populations would only be conjectural. Continued research into the factors responsible for the observed distributions must elucidate predator/food relationships, and with this accomplished, can assess the usefulness of individual phytoseiid species in population regulation of some of Texas' most serious citrus pests.

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NAPHTHOQUINONE PRODUCTION BY FUSARIUM SOLANI FROM BLIGHTED CITRUS TREES: QUANTITY, INCIDENCE AND TOXICITY[1]

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Abstract. **Diseased fibrous roots of blighted citrus trees were collected from 12 locations throughout the Central Florida citrus growing area. Sixty-five isolates of** Fusarium solani **(Mart.) Appel & Wr. emend. Snyd. & Hans. cultured from these roots were examined for their ability to produce phytotoxic compounds. When grown as shake cultures on a mineral salts-glucose medium with NH_4NO_3 as the N source, all isolates produced varying quantities of** cis- **and** trans-**dihydrofusarubin and fusarubin. These naphthoquinone compounds were highly toxic to radish roots, inhibiting growth by 97-99% at 100 ppm. A number of isolates also produced other naphthoquinone derivatives, including marticin, isomarticin, and bostrycoidin. Among the isolates studied, there was no apparent geographical trend in total naphthoquinone production or type of compounds produced.**

A number of studies have suggested that the soilborne fungus *Fusarium solani,* when favored by certain soil conditions or cultural practices, contributes to citrus blight symptoms (12, 15, 16). Severe root pruning, resulting in wilting and stunting, occurs when citrus seedlings are inoculated with *F. solani* (14). *F. solani* infection in the field is generally restricted to fibrous feeder roots, and it is rarely found in larger living roots (15). Although it does occur as a colonizer of rotted pioneer roots, the presence of these decayed larger roots is not considered essential to blight (13). Therefore, if *F. solani* is involved in blight, aboveground symptoms such as vessel plugging, zinc accumulation, or leaf deficiency patterns may be a result of phytotoxins elaborated by the pathogen.

Selected isolates of *F. solani* obtained from roots of blighted citrus trees have been studied in detail for their ability to produce toxins (1, 2). Preliminary examination of a small number of isolates revealed a large variation in the capacity for toxin synthesis. Several of these isolates produced a variety of naphthoquinone derivatives in relatively high yield, some of which were phytotoxic when tested on citrus or radish roots (2). Eleven naphthoquinones have now been identified in culture filtrates of *F. solani* from citrus (17). Variation in toxicogenic potential has been invoked as a possible explanation of differing pathogenicity among isolates tested on citrus seedlings (15).

This survey was undertaken to determine the frequency with which *F. solani* isolates from blighted trees synthesized naphthoquinones on a standard culture medium, and the amount of specific toxins produced. Isolates obtained from different locations were examined for variations in total toxin synthesis and for yield of specific toxins.

Materials and Methods

Samples of fibrous roots were collected from blighted trees in 12 locations of the Central Florida citrus area. Collections were made from trees which exhibited moderate to severe symptoms, had no visible evidence of foot rot, and which were in groves where blight was prevalent. Steles of diseased fibrous roots, from which cortical tissue had sloughed naturally, were plated on a modified Komada's medium for isolation of *F. solani* (9). Cultures of emerging colonies were maintained on potato-dextrose agar (PDA) slants.

Isolates were evaluated for toxin production by growing them on a previously described mineral salts-glucose liquid medium containing NH_4NO_3 as the N source (2). Flasks (200 ml of medium/500 ml Erlenmeyer) were inoculated with spore suspensions obtained by releasing spores grown on PDA slants with sterile distilled water. Cultures were grown for 3 days at 27°C on a Junior Orbital shaker operating at 150 rpm. Cultures were then filtered through cheesecloth and the filtrate extracted twice with equal volumes of ethyl acetate. The combined extracts were dried with sodium sulfate, reduced to approximately 8 ml on a vacuum rotary evaporator, made up to 10 ml with ethyl acetate in a volumetric flask, and stored at 4°C.

Total naphthoquinone content and dihydrofusarubin content were determined with an Aminco DW-2a spectrophotometer. With the exception of bostrycoidin and anhydrofusarubin, all naphthoquinones identified from *F. solani* absorb at or near 304 nm (17). Absorption at this wavelength was therefore taken as a measure of total naphthoquinone content, when compared to absorption of a known standard of crystalline naphthoquinones. Absorption at 394 nm was used to measure levels of dihydrofusarubins, since these are the only naphthoquinones from *F. solani* which absorb at this wavelength. Absorptions were compared to a standard curve prepared with pure *trans*-dihydrofusarubin. Fusarubin and marticin levels were determined by thin-layer chromatography (TLC) of extracts on 250μm silica gel GF plates. Plates were developed in benzene-nitromethane-acetic acid (150-50-4) and compared to similarly run dilution series

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