DISTRIBUTION OF *NEOSEIULUS CUCUMERIS* (ACARINA: PHYTOSEIIDAE) AND ITS PREY, *THRIPS PALMI* (THYSANOPTERA: THRIPIDAE) WITHIN EGGPLANTS IN SOUTH FLORIDA

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ABSTRACT

The distribution of the predacious mite *Neoseiulus cucumeris* (Oudemans) and its prey, *Thrips palmi* Karny, was studied in eggplant plots in Homestead, Florida. *Neoseiulus cucumeris* was more abundant on fruits ($\bar{X} = 3.39 \pm 0.20$) than on leaves ($\bar{X} = 0.95 \pm 0.16$) and it was not found in the flowers. *Thrips palmi* was more abundant on the leaves ($\bar{X} = 17.97 \pm 5.07$) than on the fruits ($\bar{X} = 3.22 \pm 0.70$) and flowers ($\bar{X} = 0.93 \pm 0.03$). Predacious mite populations on the fruits and leaves increased with *T. palmi* populations increase. Both predator and prey populations were low on the youngest leaf ($\bar{X}_{predator} = 0.00 \pm 0.00$; $\bar{X}_{prey} = 1.75 \pm 0.28$) and high on the oldest leaf ($\bar{X}_{predator} = 1.92 \pm 0.79$; $\bar{X}_{prey} = 50.83 \pm 11.64$). *Neoseiulus cucumeris* and *T. palmi* were more abundant on the adaxial surface of the leaf ($\bar{X}_{N. cucumeris} = 1.58 \pm 0.56$; $\bar{X}_{T. palmi} = 42.77 \pm 8.29$). Predators aggregated mostly on the adaxial base of the midrib vein. The fourth leaf is recommended for population sampling studies because the predators aggregate at the base of the adaxial midrib and *T. palmi* population levels are not extreme on that leaf.

Key Words: thrips, predacious mites, distribution, biological control

RESUMEN

Fue estudiada la distribución del ácaro depredador *Neoseiulus cucumeris* (Oudemans) y de su presa, *Thrips palmi* Karny, en Homestead, Florida. *Neoseiulus cucumeris* fue más abundante en los frutos ($\bar{X} = 3.39 \pm 0.20$) que en las hojas ($\bar{X} = 0.95 \pm 0.16$) y no fue encontrado en las flores. *Thrips palmi* fue más abundante en las hojas ($\bar{X} = 17.97 \pm 5.07$) que en los frutos ($\bar{X} = 3.22 \pm 0.70$) y flores ($\bar{X} = 0.93 \pm 0.03$). En los frutos y las hojas, la población del ácaro depredador aumentó con la población de *T. palmi*. Ambas poblaciones fueron bajas en la hoja más joven ($\bar{X}_{depredador} = 0.00 \pm 0.00$; $\bar{X}_{presa} = 1.75 \pm 0.28$) y altas en la hoja más vieja ($\bar{X}_{depredador} = 1.92 \pm 0.79$; $\bar{X}_{presa} = 50.83 \pm 11.64$). *Neoseiulus cucumeris* y *T. palmi* fueron más abundantes en el envés de la hoja ($\bar{X}_{N. cucumeris} = 1.58 \pm 0.56$; $\bar{X}_{T. palmi} = 42.77 \pm 8.29$). Los depredadores se agregaron mayoritariamente en la base de la vena central, en el envés de la hoja. Se recomienda la cuarta hoja para estudios de muestreo porque los depredadores se concentran en la base del envés de la vena central y porque los niveles polacionales de *T. palmi* no son extremadamente altos o bajos en esa hoja.

The melon thrips, *Thrips palmi* Karny, is an important vegetable pest in South Florida, attacking beans, cucurbits, eggplants, peppers, and potatoes (Seal & Baranowski 1992). *Thrips palmi* was described from Sumatra in 1925. It was considered an insect without economic importance for more than 50 years, but since 1978 it became a major threat to vegetable growers in Asia (Sakimura et al. 1986). In 1985 *T.*

palmi was detected in the Caribbean (Denoyes et al. 1986), and in 1991 it was found in Homestead, Florida (South 1991). Losses of more than 10 million dollars caused by *T. palmi* were reported on peppers in Palm Beach County, Florida, in 1993 (Nuessly & Nagata 1995).

The predacious mite *Neoseiulus cucumeris* (Oudemans) has been tested in the field as a potential biological control agent for suppression of *T. palmi* on eggplants (Castineiras et al. 1997). *Neosiulus cucumeris* is mass reared on fungus mites in wheat bran and sold for release in commercial greenhouses (Hoy & Glenister 1991). In eggplants, *N. cucumeris* is released by sprinkling the bran on top of the leaves (Castineiras et al. 1997).

To evaluate the efficacy of a biological control agent, both the predator and the prey must be monitored from the moment of release through harvest; thus, knowledge of their distribution within the plant is essential.

There is no information on the distribution of *N. cucumeris* in eggplant. *Thrips palmi* is known to be more abundant on eggplant leaves than on flowers and fruits (Kawai 1988). We examine here the distribution pattern of *N. cucumeris* and *T. palmi* within eggplants where controlled releases of the predator were made.

Materials and Methods

The study was conducted from Oct. 1995 through Apr. 1996 at the University of Florida Tropical Research and Education Center in Homestead. Three 11 × 12.5 m plots spaced 2.5 m apart were set in beds 0.2 m high and 0.9 wide, covered with black polyethylene mulch to retard weed growth. Five-week old eggplant (*Solanum melongena* var. Classic) seedlings were transplanted 0.6 m apart in double rows on 12 October 1995. A mix of maneb [1.38 kg (AI)/ha] and copper hydroxide [2.88 kg (AI)/ha] was sprayed weekly to prevent diseases. Weeds in the interbed spaces were controlled with a mixture of paraquat [0.87 kg (AI)/ha] and diquat [0.83 kg (AI)/ha].

Neoseiulus cucumeris (IPM Laboratories, Inc., Locke, NY) was released in wheat bran on the top of the leaves at a ratio of one predator per prey which is the recommended ratio for biological control of *T. palmi* by *N. cucumeris* (Castineiras et al. 1997). Number of *T. palmi* per plant was estimated before predator releases by averaging the number of larval and adult thrips on the second, fourth, and sixth leaves of 10 shoots on 10 randomly selected plants per plot and multiplying the mean by the average number of leaves per plant. The first leaf longer than 2.5 cm from the base to the apex on a shoot was considered the terminal leaf. One hundred predators per plant were released on week 7 after transplanting, when thrips population averaged 99.0 per plant, and 200 predators per plant were released on week 10 after transplanting, when thrips population averaged 198.5 per plant.

A sample of ten flowers, 30 fruits, and 30 leaves per plot was taken at random on the first and second week after each release. The fruit sample consisted of 10 small (2-4 cm long), 10 medium (5-10 cm long) and 10 large (15-20 cm long) fruit taken at random within each plot. The leaf sample consisted of the first, fourth, and seventh leaves of a shoot taken at random on each of 10 plants per plot. All samples were collected separately and taken to the laboratory in plastic bags.

The number of *T. palmi* larvae and adults and all stages of *N. cucumeris* inside the flowers, under the fruit calyx, and on the leaves was counted under the microscope. The leaf surface was divided in two halves, from the center to the tip and from the center to the base. Each half was also divided into 4 areas: Abaxial and adaxial leaf surfaces and abaxial and adaxial midribs.

The data from the four samplings were averaged for each replicate. Data were square root transformed and analyzed using general linear models (SAS Institute, Inc. Cary, NC). A one-way ANOVA was used for fruit data, and three-way ANOVAS were used for leaf data. Leaf position (first, fourth, and seventh), leaf side (abaxial and adaxial) and leaf area (tip, base, midrib tip and midrib base) were considered the main effects in the three-way ANOVAS. Curves for *N. cucumeris* against *T. palmi* populations on leaves and fruits were fit by nonlinear regression analysis using TableCurve 2-D (Jandel Scientific, Inc., San Rafael, CA).

Results and Discussion

Neoseiulus cucumeris was observed on the fruits ($\overline{X}$ =3.39 ± 0.20) and leaves ($\overline{X}$ = 0.95 ± 0.16) but not inside the flowers. The number of *T. palmi* was lower in the flowers ($\overline{X}$ = 0.93 ± 0.03) than on the fruits ($\overline{X}$ = 3.22 ± 0.70) and leaves ($\overline{X}$ = 17.97 ± 5.07), as previously documented (Kawai 1988).

Predators tend to aggregate where prey densities are high (Varley et al. 1974). Regressions of *N. cucumeris* density on *T. palmi* density yielded significant relationships for the leaves [No. *N. cucumeris* = 1.18 + 0.01(No. *T. palmi*)$^{1.23}$; r^2 = 0.99, F = 867.17] and fruits [No. *N. cucumeris* = -24.72 + 4.04(No. *T. palmi*)$^{0.77}$; r^2 = 0.95, F = 63.63]. The regression equations show that increases in prey population were followed by increases in predator population on both leaves and fruits. *Neoseiulus cucumeris* also congregates on cucumber and cabbage leaves with high thrips population densities after release (Gillespie 1989, Hoy & Glenister 1991).

Neoseiulus cucumeris and *T. palmi* populations increased with fruit size (Table 1). *Thrips palmi* was on the fruit from the developing ovary phase through fruit maturity. After petal abscission, when the fruits were 2-4 cm long and the calyx began to open, *T. palmi* and *N. cucumeris* aggregated under the sepals.

Neoseiulus cucumeris preferred the ridges of the underside of the fruit sepals over the leaves for oviposition. Eighty-nine percent of *N. cucumeris* eggs were found under the sepals and 11% on the leaves. On the leaves, predator eggs were always found at the base of the adaxial midrib, hidden under the trichomes.

In the shoots, numbers of *N. cucumeris* and *T. palmi* increased from the first through the seventh leaf (Table 2). Both predator and prey were more abundant on the adaxial surface of the leaves (Table 3). *Neoseiulus cucumeris* populations concentrated mostly on the midrib base. However, *T. palmi* populations distributed all over the leaf surface and seemed to avoid the midrib tip (Table 4).

Analyses of variance showed significant interactions of leaf position, leaf surface, and leaf area for both the predator and the prey (Tables 5 and 6). *Neoseiulus cucumeris* population density was highest on the adaxial midrib base of the seventh leaf. On

Table 1. Numbers of *N. cucumeris* and *T. palmi* on eggplant fruits of different sizes.

Fruit length	*N. cucumeris* (Mean ± SE)[1]	*T. palmi* (Mean ± SE)[2]
2-4 cm	1.23 ± 0.12	1.76 ± 0.08
5-10 cm	3.56 ± 0.12	3.40 ± 0.23
15-20 cm	5.36 ± 0.14	4.50 ± 0.15

[1]ANOVA on square root transformed data, untransformed means are presented. F = 257.69, p > 0.0001, df = 2, 6.

[2]ANOVA on square root transformed data, untransformed means are presented. F = 67.20, p > 0.0001, df = 2, 6.

TABLE 2. NUMBERS OF *N. CUCUMERIS* AND *T. PALMI* ON THE FIRST, SECOND AND THIRD LEAVES OF EGGPLANT SHOOTS.

Leaf position	*N. cucumeris* (Mean ± SE)[1]	*T. palmi* (Mean ± SE)[2]
First	0.00 ± 0.00	1.75 ± 0.28
Fourth	0.54 ± 0.30	20.04 ± 3.92
Seventh	1.92 ± 0.79	50.83 ± 11.64

[1]ANOVA on square root transformed data, untransformed data means are presented. F = 282.04, p > 0.0001, df = 2, 48.
[2]ANOVA on square root transformed data, untransformed data means are presented. F = 2702.70, p > 0.0001, df = 2, 48.

TABLE 3. NUMBERS OF *N. CUCUMERIS* AND *T. PALMI* ON THE ABAXIAL AND ADAXIAL SURFACES OF EGGPLANT LEAVES.

Leaf side	*N. cucumeris* (Mean ± SE)[1]	*T. palmi* (Mean ± SE)[2]
Abaxial	0.05 ± 0.03	5.63 ± 0.99
Adaxial	1.58 ± 0.56	42.77 ± 8.29

[1]ANOVA on square root transformed data, untransformed means are presented. F = 501.89, p > 0.0001, df = 1, 48.
[2]ANOVA on square root transformed data, untransformed means are presented. F = 3883.74, p > 0.0001, df = 1, 48.

the fourth leaf, predators were found only at the base of the adaxial midrib (Table 5). Highest *T. palmi* density was found on the adaxial tip of the seventh leaf (Table 6).

Considering that predator and prey only coincided on leaves and fruits, both leaves and fruits can be used for sampling proposes. It is more convenient to sample the leaves because they are easier to handle than the fruits. The fourth leaf is best for monitoring *N. cucumeris* and *T. palmi* because the predators aggregate at the base of

TABLE 4. NUMBERS OF *N. CUCUMERIS* AND *T. PALMI* ON DIFFERENT EGGPLANT LEAF AREAS.

Leaf areas	*N. cucumeris* (Mean ± SE)[1]	*T. palmi* (Mean ± SE)[2]
tip	0.00 ± 0.00	31.88 ± 11.52
base	0.38 ± 0.21	31.00 ± 10.61
midrib tip	0.08 ± 0.04	5.22 ± 1.10
midrib base	2.80 ± 1.05	28.72 ± 1.05

[1]ANOVA on square root transformed data, untransformed means are presented. F = 344.98, p > 0.0001, df = 3, 48.
[2]ANOVA on square root transformed data, untransformed means are presented. F = 443.89, p > 0.0001, df = 3, 48.

TABLE 5. NUMBERS OF *N. CUCUMERIS* ON EGGPLANT LEAVES. INTERACTION LEAF SURFACE × LEAF AREA × LEAF POSITION[1].

Leaf surface × leaf area	First leaf (Mean ± SE)	Fourth leaf (Mean ± SE)	Seventh leaf (Mean ± SE)
Abaxial tip	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Abaxial base	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Abaxial midrib tip	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Abaxial midrib base	0.00 ± 0.00	0.00 ± 0.00	0.68 ± 0.32
Adaxial tip	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Adaxial base	0.00 ± 0.00	0.00 ± 0.00	2.33 ± 0.44
Adaxial midrib tip	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.00
Adaxial midrib base	0.00 ± 0.00	4.33 ± 0.33	11.83 ± 0.44

1ANOVA on square root transformed data, untransformed means are presented. $F = 73.51$, $p > 0.0001$, $df = 6, 48$.

TABLE 6. NUMBERS OF *T. PALMI* ON DIFFERENT AREAS ON EGGPLANT LEAVES. INTERACTION LEAF SURFACE × LEAF AREA × LEAF POSITION.[1]

Leaf surface × leaf area	First leaf (Mean ± SE)	Fourth leaf (Mean ± SE)	Seventh leaf (Mean ± SE)
Abaxial tip	2.66 ± 0.33	19.33 ± 2.33	4.66 ± 0.57
Abaxial base	1.33 ± 0.33	4.00 ± 0.57	3.00 ± 0.00
Abaxial midrib tip	1.00 ± 0.01	3.00 ± 0.57	14.00 ± 1.52
Abaxial midrib base	0.00 ± 0.00	3.00 ± 0.57	11.66 ± 0.88
Adaxial tip	1.00 ± 0.01	28.00 ± 0.57	135.66 ± 3.92
Adaxial base	4.66 ± 0.33	53.00 ± 1.52	120.00 ± 1.15
Adaxial midrib tip	1.33 ± 0.33	5.33 ± 0.88	6.66 ± 0.33
Adaxial midrib base	2.00 ± 0.01	44.66 ± 0.66	111.83 ± 3.78

1ANOVA on square root transformed data, untransformed means are presented. $F = 253.66$, $p > 0.0001$, $df = 6, 48$.

the adaxial midrib and *T. palmi* population levels are not extremely high or low on that leaf.

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