Relative Abundance of *Frankliniella bispinosa* and Other Species of Thysanoptera Emerging from Soil Beneath 'Navel' Orange Trees in Florida During Spring Flowering[1]

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ABSTRACT Sixteen species of thrips in three families were identified from slide-mounted specimens collected from emergence traps placed beneath and between citrus trees in southwest and central Florida between 1989 and 1992. Species in the family Thripidae included: *Chirothrips spiniceps* (Hood), *Frankliniella bispinosa* (Morgan), *F. kelliae* Sakimura, *Microcephalothrips abdominalis* (D. L. Crawford), *Scirtothrips* sp., and *Scolothrips pallidus* (Beach); in the family Aeolothripidae: *Stomatothrips crawfordi* Stannard; and the family Phlaeothripidae: *Adraneothrips decorus* Hood, *Aleurodothrips fasciapennis* (Franklin), *Eurythrips* sp., *Haplothrips gowdeyi* (Franklin), *Hoplandrothrips raptor* (Crawford), *Hoplothrips marginalis* (Hood), *Leptothrips cassiae* Hood, *L. macroocellatus* Watson, and *Nesothrips lativentris* (Karny). *F. bispinosa* was the most abundant species comprising 84 to 99% of the thrips collected from emergence traps. *F. kelliae* was the second most abundant species with frequencies ranging from 3 to 12% in Lee and Hendry counties. No propupal or pupal stages of *Frankliniella* spp. were recovered from ground traps placed beneath the dripline of navel orange trees during flowering cycles at either location in southwest Florida. Only first and second instars and adults of *F. bispinosa* were collected from the ground traps.

KEY WORDS Emergence traps, *Frankliniella,* Thysanoptera, citrus.

A problem with reduced fruit set on 'Tahiti' lime, *Citrus aurantifolia* Swingle, was first recognized in southwest Florida in 1983. By 1987, reduced fruit set spread to other citrus varieties including 'Navel' and 'Valencia' oranges, *C. sinensis* (L.) Osbeck. A fungal pathogen, *Colletotrichum gloeosporioides* Penzig (Penzig and Saccardo), in Penzig was subsequently isolated from floral parts of both limes and oranges (McMillan and Timmer 1988, Sonoda and Pelosi 1988). Earlier work by Fagan (1979), in Belize, had identified *C. gloeosporioides* as the causative organism of the disease called postbloom fruit drop. None of the research in Belize addressed the possibility of arthropod involvement. However, the possibility of one or more arthropod species contributing to reduced fruit set and/or disease transmission exists.

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Large numbers of adult and immature thrips were collected from citrus flowers and developing floral buds in more than 80 groves throughout Florida between 1986 and 1990. *Frankliniella bispinosa* (Morgan) was the most abundant species accounting for 92% of collected specimens from Dade to Volusia counties (Childers et al. 1990). In a second survey of thrips on citrus flowers during February and March 1991 in Indian River, St. Lucie, Martin, Palm Beach, Dade, Hendry, Lee, and DeSoto counties, *F. bispinosa* accounted for 65% of the thrips collected (Childers and Beshear 1992). *F. kelliae* Sakimura was second in abundance with 7 and 34% in the first and second surveys of open flowers, respectively. A total of 18 species was identified from citrus flowers and developing floral buds during the two surveys. Also, *F. bispinosa* was consistently the most abundant species collected in surveys of vegetable crops in Collier, Hendry, Lee, DeSoto, and Manatee counties between 1986 and 1990 (Frantz and Mellinger 1990).

Both larvae and adults of *F. bispinosa* feed on the ovary, style, floral disk, petals, and anthers of both swollen buds and open flowers of navel orange which resulted in cellular evacuation, cellular collapse, necrosis, and plasmolysis (Childers and Achor 1991). Such injury can result in premature flower and fruitlet drop. Suppression of *F. bispinosa* populations in navel orange during flowering resulted in increased fruit set in three of four experiments where insecticides were applied compared with untreated trees (Childers 1992).

Limited information is available concerning the emergence patterns of thrips species associated with citrus in Florida. Because most species pupate in the ground, a study was conducted from 1989 to 1992 to collect and identify thrips that emerge from beneath citrus trees during and immediately following the spring flowering cycle.

Materials and Methods

Study Sites. Navel orange groves with previous problems of poor fruit set were selected for this study in four different counties. Two of the four grove sites had considerable postbloom fruit drop during 1987. The fungal pathogen, *C. gloeosporioides* was previously identified from both groves by plant pathologists (Agostini et al. 1992).

The Turner grove, approximately 13 ha, was located 14 km northwest of Immokalee in Lee County. The Duda grove, approximately 20 ha, was located 8 km south of LaBelle in Hendry County. The Raley grove, approximately 8 ha, was located in Winter Haven in central Polk County while the Chain-of-Lakes grove, approximately 12 ha, was located 9 km southwest of Holopaw in Osceola County.

Ground Traps. The life stages of thrips dropping from tree canopies were sampled at 5 to 7 day intervals using ground traps that consisted of clear plastic boxes 40.6 by 27.3 by 9.5 cm filled with 0.95 liter of ethylene glycol. Each trap was placed beneath a flowering navel orange tree just within the dripline of the canopy and replicated two or four times at the Turner and Duda sites during 1989. Samples were partially processed in the field by removing the trap from beneath the sample tree and separating any debris from the solution. The

remaining solution was poured through two stacked sieves (1 mm and 150 μm mesh) into a 3.8-liter plastic container. Any material collected in each sieve was washed twice with a 1:1 solution of ethylene glycol and water into a labeled 174-ml glass jar. Labeled jars were returned to the laboratory and the thrips were separated with the aid of a stereomicroscope.

Emergence Traps. Three emergence trap designs A, B, and C described by Childers (1993) were used in these studies between 1989 and 1992.

The method of trap placement and rotation beneath citrus trees next to the tree trunk, inside the canopy dripline and between two trees within a row were compared (Childers 1993). In this study, only traps placed under the dripline were used to compare emergence patterns of *F. bispinosa*. Adhesive-coated Plexiglas® (Harmon Glass Co., Winter Haven, FL) lids or shell vials were changed at 3 or 4 day intervals during sampling.

Thrips Identification. Species of thrips were initially recorded as adult *Frankliniella* spp. or "other" adult or larval thrips. Random subsamples of 20 to 40 thrips identified as *Frankliniella* and all "other" thrips per emergence trap were carefully removed from the Tangle-Trap adhesive (Tanglefoot Co., Grand Rapids, MI) using a fine brush repeatedly dipped in petroleum naphtha (mineral spirits) and applied over the thrips on the lid. The adhesive readily dissolved thus allowing removal of individual specimens from the adhesive-coated lids. Thrips were transferred to watch glasses with mineral spirits for removal of the adhesive. The thrips were later slide-mounted in Hoyer's medium (Krantz 1978) and identified as to species and sex.

Voucher specimens were deposited in the Division of Plant Industry, Gainesville, FL.

Results and Discussion

Sixteen species of thrips in three families were identified from slide-mounted specimens collected from emergence traps placed beneath and between citrus trees in southwest and central Florida between 1989 and 1992 (Table 1).

Family Thripidae

Frankliniella bispinosa (Morgan). This was the most abundant species with 84 to 99% of the thrips collected from emergence traps during this study in both southwest and central Florida (Table 1). *F. bispinosa* was also the most numerous species found in developing buds and open citrus flowers with 95 and 97% of the identified specimens collected from navel orange during two surveys (Childers et al. 1990, Childers and Beshear 1992).

A total of 2,975 first and second instars of *Frankliniella* spp. were recovered from ground traps beneath the dripline of navel orange trees between 7 March and 28 April 1989 at the Turner site and 306 first and second instars were collected from similar traps at the Duda site between 20 March and 17 April 1989. *F. bispinosa* was the most abundant species both within citrus tree canopies (Childers 1992) and from ground trapping of emerging adults at these two sites. Both interior and dripline trap positions beneath navel orange trees had significantly higher numbers of *F. bispinosa* than did traps exposed within rows between trees (Childers 1993).

No propupal or pupal stages of *Frankliniella* spp. were recovered from ground traps at either location. Only *Frankliniella* larvae and adults of *F. bispinosa* were collected from both developing floral buds and open flowers of various citrus species and varieties (Childers 1992). This provides strong evidence that this species does not pupate within citrus tree canopies. The life cycle of *F. bispinosa* within citrus groves during the flowering cycle is shown in Fig. 1.

Emergence patterns of adult *F. bispinosa* and their comparative numbers by county and year are shown in Fig. 2. Differences in peak emergence patterns reflect variability in the duration and intensity of the flowering cycle each year (Childers 1992). General trends in emergence patterns of *F. bispinosa* show similarities between Turner and Duda during 1990 and Chain of Lakes and Raley during 1991 (Fig. 2). However, each year there were considerable differences in numbers of emerging adults between grove sites. For example, a maximum of 36 *F. bispinosa* adults emerged from the Chain of Lakes grove on 15 April 1991 compared with 267 adults from one emergence trap on 8 April at Raley during the same year. The Raley grove had the highest mean numbers ($x = 117$) of *F. bispinosa* emerging from beneath trees compared with all sites and years sampled (Fig. 2).

***Frankliniella kelliae* Sakimura.** This was the second most abundant thrips species collected in emergence traps (Table 1) with frequencies ranging from 3 to 12% in Lee and Hendry counties. The known distribution of *F. kelliae* does not extend into Polk or Osceola counties based on previous surveys (Childers et al. 1990, Childers and Beshear 1992). *F. kelliae* was the second most abundant species collected from developing buds and open flowers of citrus with 4 and 2% of the thrips collected from orange during surveys between 1986 and 1991 (Childers et al. 1990, Childers and Beshear 1992).

***Chirothrips spiniceps* (Hood).** A single adult was collected from an emergence trap on 30 March 1992 at the Duda site (Table 1). This species infests grasses. More than 50 species in the genus *Chirothrips* breed in grass flowers (Mound et al. 1976).

***Microcephalothrips abdominalis* (D. L. Crawford).** Two females were collected from an emergence trap at the Turner site between 15 and 19 February 1990 and one female was collected from the Duda site between 12 and 15 February of the same year (Table 1). This species has not been reported from developing buds or open flowers of citrus (Childers et al. 1990). However, this species was collected in citrus groves from a composite flower on 1 December 1987 in a 'Tahiti' lime grove about 16 km west of Immokalee in Lee County. Five adults were collected from yellow *Aster* flowers on 15 October, two adults from *Bidens* flowers on 14 October, and one adult from *Bidens* on 9 October 1987 at the same location.

M. abdominalis is a cosmopolitan species that feeds and develops on flowers of Compositae (Bailey 1937). The life cycle is completed in the flower heads and the eggs are inserted in the flower parts, stems and buds. According to Bailey (1937), the pupae are found in the flower heads along with all the other life stages of this species. Nakahara and Hilburn (1989) collected *M. abdominalis* on composite species including: *Zinnia, Wedelia trilobata* (L.) A. S. Hitchcock, *Bidens* sp., *Borrichia arobrescens, Pluchea odorata, Tagetes* sp., *Salvia farinacea*

Table 1. Species composition of thrips collected from emergence traps in 'Navel' orange groves in Florida during 1989-1992.

Thrips species	N	Number and percentage of thrips identified from each county by year						
		Lee County		Hendry County			Polk County	Osceola County
		1989	1990	1989	1990	1992	1991	1991
Thripidae								
Frankliniella bispinosa (Morgan)	2,874 (97%)	280 (97%)	1,145 (98%)	52 (90%)	597 (98%)	212 (84%)	506 (99%)	82 (98%)
Frankliniella kelliae Sakimura	40 (1%)	7 (2%)	9 (<1%)	3 (5%)	9 (1%)	12 (5%)	0	0
Chirothrips spiniceps (Hood)	1 (<1%)	0	0	0	0	1 (<1%)	0	0
Microcephalothrips abdominalis (D. L. Crawford)	3 (<1%)	0	2 (<1%)	0	1 (<1%)	0	0	0
Scirtothrips sp.	1 (<1%)	0	0	0	0	0	1 (<1%)	0
Scolothrips pallidus (Beach)**	6 (<1%)	3 (<1%)	0	3 (5%)	0	0	0	0
Aeolothripidae								
Stomatothrips crawfordi Stannard**	4 (<1%)	0	0	0	0	4 (<1%)	0	0
Phlaeothripidae								
Adraneothrips decorus Hood	20 (<1%)	0	2 (<1%)	0	0	18 (7%)	0	0
Aleurodothrips fasciapennis (Franklin)**	1 (<1%)	0	0	0	0	0	0	1 (1%)
Eurythrips sp.	1 (<1%)	0	0	0	0	1 (<1%)	0	0

Table 1. Continued.

Thrips species	N	Number and percentage of thrips identified from each county by year						
		Lee County		Hendry County			Polk County	Osceola County
		1989	1990	1989	1990	1992	1991	1991
Phlaeothripidae (continued)								
Haplothrips gowdeyi (Franklin)	3 (<1%)	0	0	0	0	1 (<1%)	2 (<1%)	0
Hoplandrothrips raptor (Crawford)	1 (<1%)	0	0	0	0	1 (<1%)	0	0
Hoplothrips marginalis (Hood)	1 (<1%)	0	0	0	0	0	1 (<1%)	0
Leptothrips cassiae Hood**	2 (<1%)	0	2 (<1%)	0	0	0	0	0
Leptothrips macroocellatus Watson**	6 (<1%)	0	4 (<1%)	0	2 (<1%)	0	0	0
Leptothrips sp**	2 (<1%)	0	0	0	0	0	2 (<1%)	0
Nesothrips lativentris (Karny)	1 (<1%)	0	0	0	0	1 (<1%)	0	0
Tubulifera sp.	2 (<1%)	0	0	0	0	0	1 (<1%)	1 (1%)
Total specimens identified	2,969	290	1,164	58	608	252	513	84

* N = total number of identified individuals per species.
** = predaceous thrips

LIFE CYCLE OF *Frankliniella bispinosa* (Morgan)

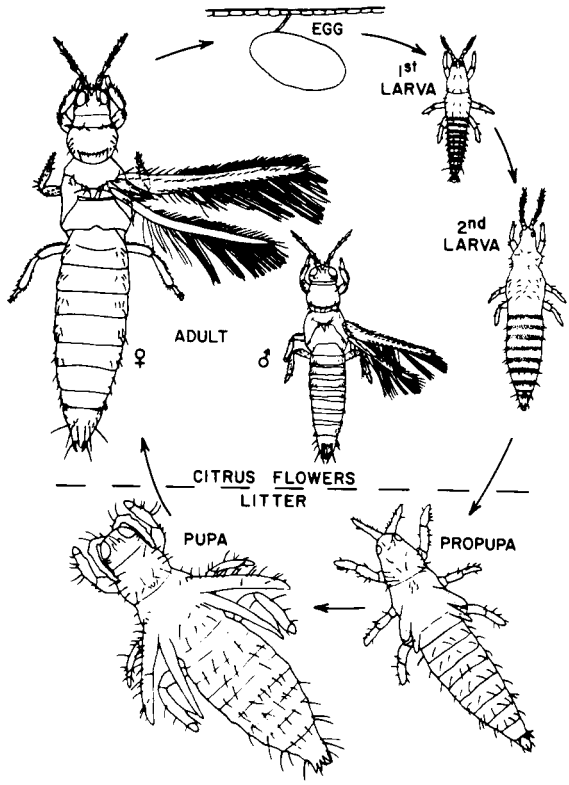

Fig. 1. Life cycle of *Frankliniella bispinosa* (Morgan) in Florida citrus during and following flowering cycles.

Bentham, and *Solidago* sp. Jagota (1961) reported that *M. abdominalis* was an economic pest in India causing considerable damage to garden plants of Compositae. Heavy infestations reportedly caused injury to the corolla, stamens, and developing seeds which were then predisposed to subsequent fungal attack. Most of the ground beneath citrus trees is plant free due to the shading effect of the canopy. Little vegetation was present beneath the canopies of the trees sampled due to restricted light availability and grower use of herbicides. It appears that this insect will pupate in the soil.

***Scirtothrips* sp.** One male emerged from beneath a navel orange tree on 25 March 1991 at the Raley site (Table 1). Mound and Palmer (1981) reported that 10 species of *Scirtothrips* were pests on various crops worldwide. At least three species of *Scirtothrips* are considered serious pests of citrus. The citrus thrips,

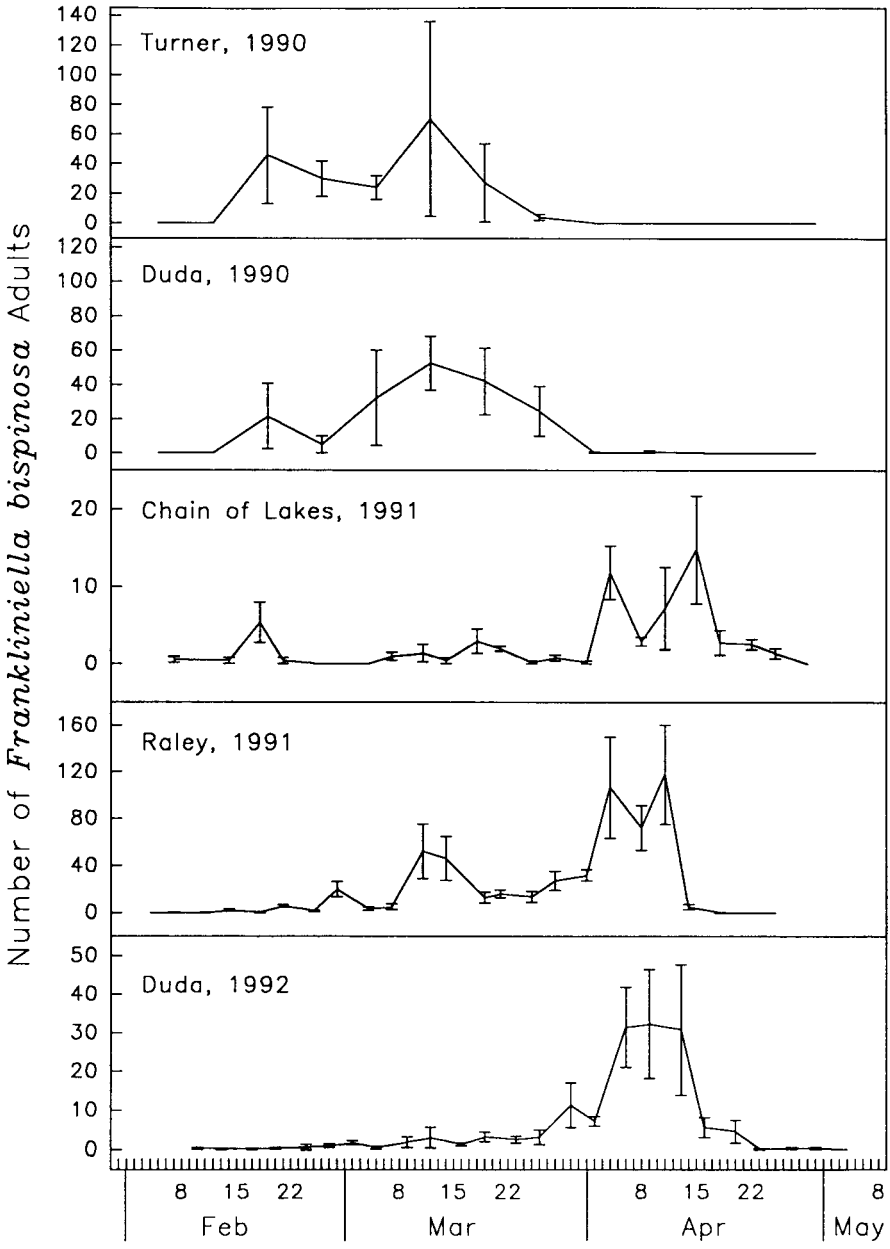

Fig. 2. Comparative emergence patterns of *Frankliniella bispinosa* from beneath navel orange trees in four grove sites between 1990 and 1992.

S. citri (Moulton), is known from California, Arizona, and northern Mexico and is recognized as a key pest of citrus in both California and Arizona (Immaraju and Morse 1990). *S. citri* causes serious rind blemish problems on citrus due to feeding injury beneath the sepals on developing immature fruit 5 to 6 wk following petal fall (Rhodes et al. 1986). *S. citri* also attacks young twigs and leaves causing the latter to become leathery, deformed and frequently curled. Severe injury to buds can result in multiple bud formation and twig growth causing a rosette type of injury (Jeppson 1989). Flowers (1989) reported *S. citri* occurring on grapes in Florida. However, the identity of *Scirtothrips* species in Florida is currently being reviewed (S. N., unpublished data). *S. aurantii* Faure is considered to be a serious pest of citrus in South Africa and Zimbabwe (Samways 1986). In Japan, *S. dorsalis* Hood is a pest of citrus and tea (Kodomari 1978) and grapes (Shibao et al. 1990).

***Scolothrips pallidus* (Beach).** A total of six specimens were collected only from the emergence trap B design in the Turner and Duda sites during 1989 (Table 1). Adult females were collected from emergence traps at the Turner site on 24 February and between 3 and 6 March 1989. This species was collected in low numbers on 8 and 9 July 1987 from flowers and developing buds of 'Tahiti' lime about 16 km west of Immokalee in Lee County. *S. pallidus* is a predator of spider mites on various plant species (Priesner 1950, Jacot-Guillarmod 1974).

Family: Aeolothripidae

***Stomatothrips crawfordi* Stannard.** Four individuals were collected from emergence traps between 27 February and 19 March 1992 at the Duda site (Table 1). Little is known about the biology of species in this genus. However, they occur on a wide variety of plants and are considered to be predaceous (Bailey 1952). *Stomatothrips brunneus* Crawford was collected from soil in a peach orchard in Lafayette County, AR, Crawford (1940).

Family: Phlaeothripidae:

***Adraneothrips decorus* Hood.** This species was collected from emergence traps at the Turner site between 12 and 15 February and 19 and 22 March 1990 (Table 1). Fourteen females and four males were collected from emergence traps at the Duda site between 9 March and 14 May 1992. This species occurs from Cuba and Florida north to Georgia and west to Texas and Mexico and is found mainly on dead leaves and branches (Stannard 1968). Sakimura (1986) reported *Adraneothrips decorus* to be abundant on *Sporobolus indicus* and from coconut inflorescence in Jamaica.

***Aleurodothrips fasciapennis* (Franklin).** One specimen was collected from an emergence trap on 8 April 1991 in the Chain of Lakes grove site in Osceola County (Table 1). *Aleurodothrips fasciapennis* was previously collected from citrus leaves and flowers (Childers et al. 1990, Childers and Beshear 1992). This predaceous thrips has been found in association with scale insects (Medina-Gaud 1961, Beshear 1975). It was found to be the primary biological agent that resulted in suppression of *Aonidiella aurantii* (Maskell) on citrus in China during 1983 (Beattie 1985).

***Eurythrips* sp.** One specimen was collected from an emergence trap on 6 April 1992 at the Duda site (Table 1). *Eurythrips* species are often found in grass clumps, particularly *Andropogon* sp., and forest litter. None are known to be of economic importance (Stannard 1968).

***Haplothrips gowdeyi* (Franklin).** Specimens were collected from emergence traps during 4 and 8 April 1991 at the Raley site and on 26 March 1992 from the Duda site (Table 1). This was the most abundant tubuliferan found in Jamaica on many different weeds, grasses, and ornamentals (Sakimura 1986). *Haplothrips gowdeyi* is considered a general flower feeder. Nakahara and Hilburn (1989) reported *H. gowdeyi* from *Bidens pilosa* L., *Carpobrotus edulis* (L.) L. Bolus, *Citharexylum spinosum* L., and unidentified grass species from Bermuda.

***Hoplandrothrips raptor* (Crawford).** One specimen was collected on 30 April 1992 from an emergence trap at the Duda site (Table 1). *Hoplandrothrips* species are considered fungus-feeders associated with hyphae on both dead twigs and leaves. However, most of the Afrotropical species feed on green leaves and one is a minor pest of coffee (Mound and Walker 1986).

***Hoplothrips marginalis* (Hood).** A single specimen was collected from an emergence trap on 15 April 1991 at the Raley site (Table 1). All species in this genus are fungus-feeders, associated with hyphae on dead branches, twigs, or leaf litter (Mound and Walker 1986, Sakimura 1986, Stannard 1968).

***Leptothrips cassiae* Hood.** Two specimens were collected from emergence traps at the Turner site on 8 and 19 March 1990 (Table 1).

***Leptothrips macroocellatus* Watson.** Four specimens were collected from an emergence trap at the Turner site between 15 and 19 March 1990 and two adults were collected from emergence traps at Duda between 12 and 15 February 1990 (Table 1). *L. mali* (Fitch) previously reported from orange flowers (Childers et al. 1990) is a misidentification of *L. macroocellatus* (S. N.). *Leptothrips* species are considered predaceous (Johansen 1987).

***Leptothrips* sp.** Two specimens were collected from emergence traps on 18 February and 8 April 1991 at the Raley site (Table 1).

***Nesothrips lativentris* (Karny).** A single specimen was collected on 20 February 1992 from an emergence trap at the Duda site (Table 1). This species was abundant on many different plants, particularly various grasses in Jamaica. It is a fungal spore feeder known from tropical areas of the world. In the New World, it is reported from Trinidad, Virgin Islands, Puerto Rico, Dominican Republic, Bahamas, Cuba, Jamaica, Caymans, Florida, and Panama (Sakimura 1986). According to Mound and Walker (1986), *Nesothrips* species are found at the base of grasses and on dead leaves, twigs and branches.

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