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Diel Flight Pattern and Periodicity of Chilli Thrips (Thysanoptera: Thripidae) on Selected Hosts in South Florida

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Chilli thrips is a newly introduced pest in Florida and is dispersing quickly all over the state. It is a potential threat to our fruit, ornamental, and vegetable industries. Information on various aspects of this pest's biology in relation to its host crops is needed to develop an effective integrated pest management program. There is no published information on flight pattern and relationship between temperature and abundance of chilli thrips in multiple cropping systems. Knowledge of diel flight pattern is an important factor in developing a sound management program of *Scirtothrips dorsalis*. Several studies were initiated in Homestead, FL, in 2008 to study its biology and damaging potential to various host crops. Diel periodicity of the intra-plant dispersion of *Scirtothrips dorsalis* was observed on cotton, peanut, and pepper at 2-hour intervals every day, to find an association among their activity, dispersal, and microclimate of the habitat. Abundance of chilli thrips was found to be maximum on cotton followed by peanut and pepper. Also, with increase in height, decrease in chilli thrips abundance was observed. Peak flight activity of chilli thrips was observed between 1000 and 1400 Eastern Standard Time.

Due to the rich vegetation and neotropical atmosphere, Florida has always been a suitable target for the establishment of invasive flora and fauna (Ferriter et al. 2006). Chilli thrips *Scirtothrips dorsalis* Hood is a newly introduced insect pest in Florida. It is believed that *S. dorsalis* has originated in Southeast Asia or in the Indian subcontinent. It has been intercepted 89 times since 1984 by USDA–APHIS inspectors at various ports-of-entry on imported plant materials belonging to 48 taxa (Seal et al., 2006; USDA, 2003), and most commonly on cut flowers, fruits, and vegetables. *Scirtothrips dorsalis* Hood is a serious pest of various ornamental, vegetable, and fruit crops in southern and eastern Asia, Africa, and Oceania (Ananthakrishnan, 1993; CABI/EPPO, 1997; CAB, 2003).

Scirtothrips dorsalis is an important pest of chillies in India (Ramakrishna Ayyar, 1932; Ramakrishna Ayyar and Subbiah 1935), sacred lotus in Thailand (Mound and Palmer, 1981), and a serious pest of *Arachis* (Amin, 1979, 1980). In Japan, *S. dorsalis* is a pest of tea and citrus (Kodomari, 1978). On the African continent, it has been reported from South Africa and the Ivory Coast, with plant health quarantine interceptions suggesting a wider distribution across West Africa and a presence in East Africa (Kenya). Among the potential economically important hosts of this pest listed by Venette and Davis (2004) are banana, bean, cashew, castor, corn, citrus, cotton, cocoa, cotton, eggplant, grapes, kiwi, litchi, longan, mango, melon, peanut, pepper, poplar, rose, strawberry, sweetpotato, tea, tobacco, tomato, and wild yams (*Dioscorea* spp.). Besides these, it also posses strong viruliferous behavior for seven recorded viruses like Chilli Leaf Curl (CLC) Virus, Tomato Spotted Wilt Virus (TSWV), and Peanut Necrosis Virus (PBNV) (Amin et al., 1981; Ananthakrishnan, 1993; Mound and Palmer, 1981). In 2003, Rao et al. (2003) found chilli thrips as a vector of Tobacco streak virus (TSV) in groundnut crops in India. A recent report from Thailand has confirmed *S. dorsalis* as a vector of three tospoviruses, i.e., Watermelon silver mottle virus (WsMoV), Capsicum chlorosis virus (CaCV), and Melon yellow spot virus (MYSV) (Pissawan et al. 2008) in field crops. According to the Florida Nurserymen and Growers Association (FNGA), *S. dorsalis* is one of the 13 most dangerous exotic pest threats to the industry (FNGA, 2003).

In 2004, Venette and Davis proposed a potential geographic distribution of *S. dorsalis* in North America, which may extend from southern Florida to north of the Canadian boundary, as well as to Puerto Rico and the entire Caribbean region. This indicates the great possibility of establishment of this pest in South America and Central America. One or more *S. dorsalis* life stages occur on all the aboveground plant parts of its hosts, and cause scarring damage due to its feeding (Chang et al., 1995). This insect has been predicted to spread all over the United States, causing an annual damage of more than $2.0 billion.

Chemical insecticides continue to be the major means of controlling chilli thrips. Different classes of insecticides, including neonicotenoids, organophosphates, spintor and pyrole compounds, have been reported to be effective in the regulation of an abundance of chilli thrips (Seal et al., 2005). In addition to these, various biological controlling agents like minute pirate bugs, *Orius* spp. (Hemiptera: Anthocoridae), phytoseiid mites and entomopathogenic nematodes, *Thripinema* spp. (Tylenchida: Allantonematidae) have been reported to control field populations of chilli thrips. To exploit the maximum benefits of any manage-

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ment practice, it is important to have complete information about behavior, diel activity, and flight pattern of the target pest.

Almost all the experiments conducted to study the biology and behavior of chilli thrips have been carried out using a single crop as a host or using colored sticky traps. In the present study the abundance, diel flight pattern and activity of *S. dorsalis* were studied in a multiple-cropping system using three important hosts—cotton, pepper, and peanut—at the Tropical Research and Education Center, Homestead, FL. The objective of this study was to provide information to pest managers and growers about the peak time of their activity and damaging potential on a particular host in the presence of others. This information should assist growers, which may help in sampling and implementation of suitable management practices against this serious pest.

Material and Methods

As a vital component of a broad objective to study the effect of biotic and abiotic factors on population density, flight pattern, host preference and seasonal abundance of chili thrips in field crops, three experiments were conducted to study abundance, within-plant distribution, and flight behavior of *S. dorsalis* using three host crops ('Jalapeno' pepper, cotton, and peanut). In Oct. 2008, the study was initiated at Tropical Research and Education Center, Homestead, FL. The study was conducted in a greenhouse maintained at 78 ± 5 °F and 75% to 80% RH. The plants were grown individually by sowing seeds directly into the soil (Fafard mix) in 1-pint plastic pots. It was irrigated by adding 1 oz of water twice a day, and fertilized by using 1.0 oz of 20–20–20 twice a week. All plants were insect free at the initiation of this study.

In the first study, abundance of *S. dorsalis* on three hosts were conducted using four plants of each host (1-week-old) arranged in a randomized complete-block design replicated four times. Each replicate was placed at corners of the greenhouse surrounding source of the pests (10 plants of each hosts infested with chilli thrips) kept in the middle of greenhouse to have equal probability of infesting a particular host. Abundance of chilli thrips on each host crop was evaluated by recording all larvae and adults on individual plant at 48-h intervals for 10 sampling dates using a hand lens at 25×. Hourly flight activity of chilli thrips were determined to predict its diel periodicity on hosts by counting males and females on each plant at 2-h intervals from 0600 EST to 2000 EST once a week by using a hand lens at 25×.

In the second study, to determine the diel flight pattern of chilli thrips in four treatments (height: 1.5, 3, 4.5, and 6 ft) were evaluated. One-week-old plants of each host crop were selected and placed at four different heights on a setup made up of wooden planks placed at every 1.5-ft interval (1.5, 3.0, 4.5, and 6.0 ft) fitted on 8-ft wooden poles in the greenhouse. One such assembly was placed at each corner of the quadrant with three host crops at each height carrying four plants/host placed in a randomized complete-block design and replicated four times. At each height of the assembly, the plants were placed in four rows. Each row carried a plant from individual host, where the plants in each row are well separated from each other by a distance of 0.3 ft and separated from the adjacent row by a distance of 0.5 ft. Four yellow sticky cards at each height of the setup were placed once a week, facing towards the source to support the data obtained for flight pattern of chili thrips at each height. Plants were replaced at 6-week intervals by a fresh set of plants to avoid age-related avoidance.

With this setup of the experiment, we are also studying the within-plant distribution of chilli thrips, where each plant has been divided into three equal stratums: lower, middle, and upper part. Numbers of larvae and adults have been recorded once a week on each part of the plant. This entire experiment is planned to be continued for 52 weeks with the aim to determine seasonal abundance of *S. dorsalis* on three host crops and to observe the effect of multiple-cropping systems on the population dynamics. The result and discussion are based on 10 weeks of data.

Data analysis. Data obtained from sampling of chilli thrips (larva and adult, Fig. 1 a and b) on individual plants at each height were subjected to analysis of variance (ANOVA) (SAS Institute, 2003). Means were separated using Bonferroni (Dunn) *t* test and Tukey studentized range test at $P < 0.05$ (SAS Institute, 2003) to compare the significant difference among the treatments.

Results and Discussion

Host. In study no. 1, after getting established on hosts, the chilli thrips population was initially high on each host crop as the thrips prefer to feed on young host plants but decreased as the season progressed. For the first few sampling dates, numbers of larvae recorded were maximum on peanut, followed by cotton, and least on pepper (Fig. 2). But as the population started

Fig. 1a. Larva of the chilli thrips, S*cirtothrips dorsalis*, feeding on cotton leaf.

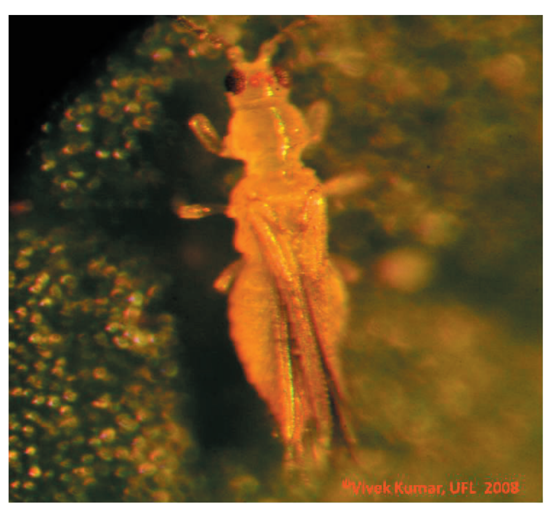

Fig. 1b. Adult female chilli thrips, *Scirtothrips dorsalis*, feeding on cotton leaf.

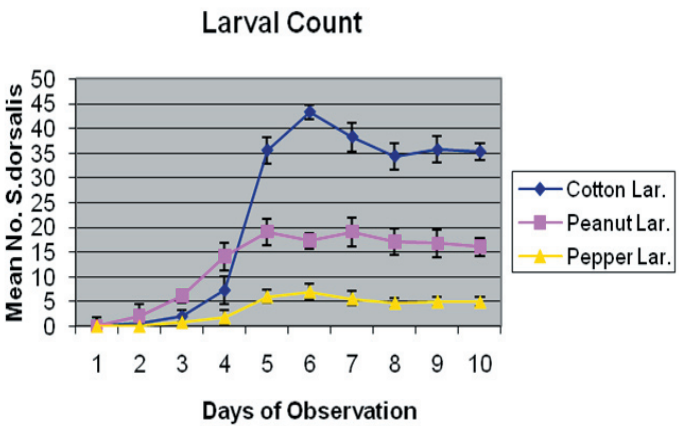

Fig. 2. The mean number of S*cirtothrips dorsalis* larvae on three hosts at each sampling day.

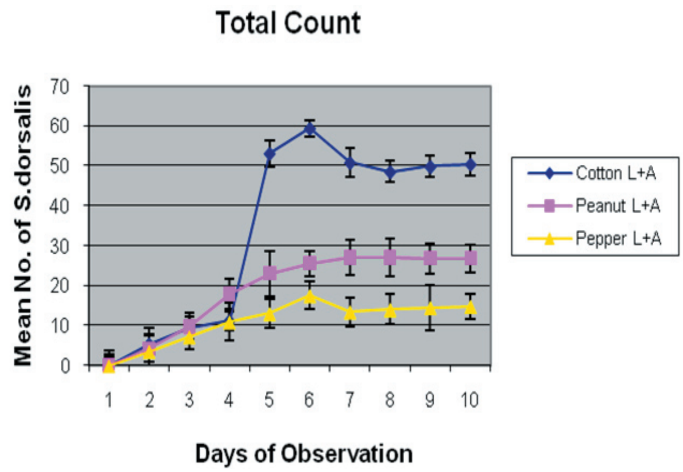

Fig. 4. The mean number of S*cirtothrips dorsalis* larvae and adults on three hosts at each sampling day.

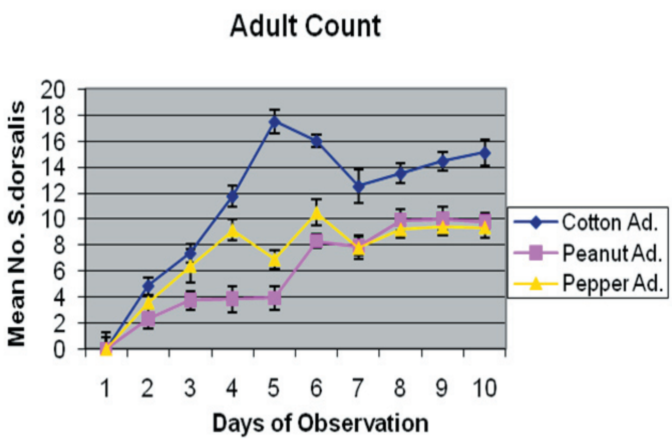

Fig. 3. The mean number of S*cirtothrips dorsalis* adults on three hosts at each sampling day.

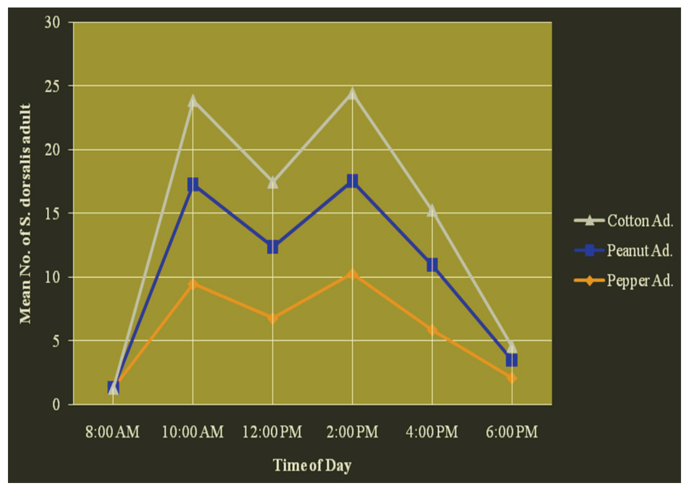

Fig. 5. The mean number of S*cirtothrips dorsalis* adults on three hosts at different times of the day.

establishing on hosts there was a remarkable increase in larval count on the fifth sampling date on cotton, followed by peanut, but increase on pepper was nonsignificant. Adult population was largest on cotton on all sampling dates (Fig. 3) when compared to peanut and pepper, where it fluctuated all through the sampling dates. Figure 4 depicts the abundance of total count (adults and larvae) of chilli thrips population, indicating cotton as their preferred source of food and reproductive host among these three reported host crops.

Diel periodicity. From hourly sampling, to determine the peak activity of chili thrips, it was observed that its population was highest at 1000 EST in the morning and 1400 EST afternoon on its host (Fig. 5). This could be explained on the basis of poikilothermic behavior of these small insects as they need to acquire an optimal amount of degree hours of light to provide heat to their muscles before initiation of flight (Ellington, 1980). According to Lewis (1973), Western flower thrips do not prefer to fly in dark, they require at least a light intensity of 1080 lux (100 f.c.) to initiate takeoff. After attaining the optimal energy required for the flight, they can cover long distances with rise and fall of diel convection currents (Lewis, 1973), resulting in corresponding rise and fall in their abundance on the host too. Information about the peak activity of the chilli thrips in the field will be beneficial to the growers so as to estimate the right time of sampling and application of pest management practice.

Flight pattern

Cotton. *S. dorsalis* larvae were most abundant at the lowest height (1.5 ft) and were found to decrease with the increase in height at which host plants were placed. However, adult count was highest on host plants placed at height of 3 ft when compared to the other heights (Fig. 6). Mean number of chilli thrips (adult + larvae) per cotton plant placed at 1.5 ft height on each sampling date was 62.5 ± 11.02 with 50.7 ± 9.1 on 3.0 ft and 26.04 ± 6.79 on 4.5 ft. Least count was on plants kept at height of 6.0 ft with observed values of 21.1 ± 6.8. The total count of chilli thrips on height 1.5 ft was significantly different ($P < 0.0001$; F = 33.61; df = 3.60) from other three treatments. However, there was no difference between treatments 3 and 4 but was significantly different from treatment 2.

Peanut. In peanut, mean number of larvae followed the same trend as in cotton and were highest on the plants kept at height 1.5 ft with 31.5 ± 11.7 (Fig. 7) and minimum count was at height

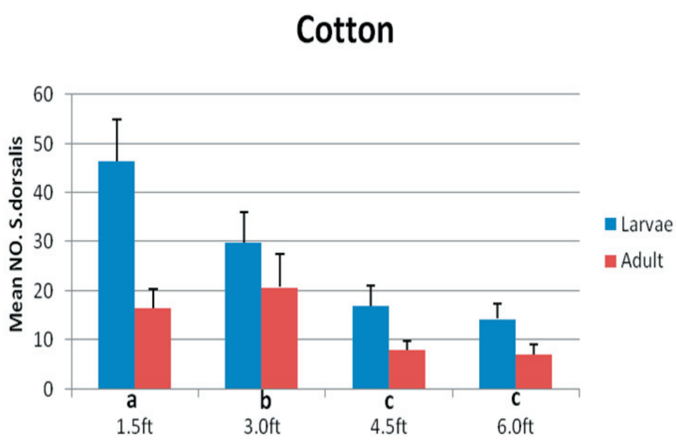

Fig. 6. The mean number of S*cirtothrips dorsalis* larvae and adult on cotton at each height (Means followed by the same letter do not differ significantly ($P > 0.05$).

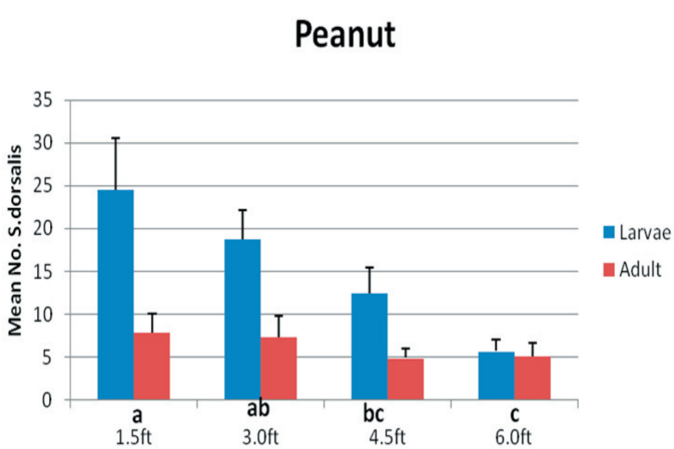

Fig. 7. The mean number of S*cirtothrips dorsalis* larvae and adult on peanut at each (Means followed by the same letter do not differ significantly ($P > 0.05$).

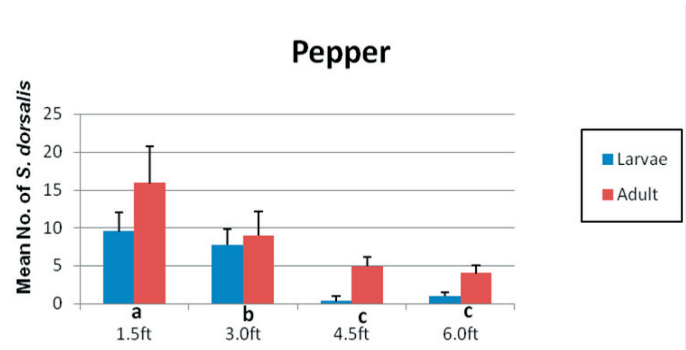

Fig. 8. The mean number of S*cirtothrips dorsalis* larvae and adult on pepper at each height (Means followed by the same letter do not differ significantly ($P > 0.05$).

6.0. Total count of chilli thrips in treatment 1 was significantly different ($P < 0.0001$; F = 14.3; df = 3,60) from treatment 3 and 4. However, results from treatment 2 were significantly different from treatment 4 but not from treatments 1 and 3.

Pepper. On 'Jalapeno' pepper both the number of larvae and adults were greatest on the plants kept at height 1.5 ft and least at 6.0 ft. These observations supported the earlier observed pattern where increases in height result in a decrease in abundance of chilli thrips. Here the results from treatment 1 were significantly different ($P < 0.0001$; F = 24.3; df = 3.60) from other treatments (Fig. 8) indicating its passive flying behavior.

In general, flight in insects occurs in response to food source, reproduction, repellence or avoidance, and attraction. In all instances, flight is oriented depending on the various environmental factors. Pearsall and Myers (2000) reported that western flower thrips tends to move into orchards near to ground surface in early spring (late April and early May) but flew higher as ground vegetation grew taller and temperatures increased. *F. fusca* has been found to have maximum density on peanut at 8:00 and 10:00 AM (Cho et al. 2000). All these studies were conducted in a single cropping system using colored sticky traps. Therefore, question lies whether the catch rate was biased due to an additional variable of attractive yellow or other colored traps. To minimize the effect of an additional variable using sticky card we approached the direct counting method of this pest on each host plant. Adults of *S. dorsalis* actively make short flights, once their populations get established at a reproduction site (Shinichi 2007). Pearsall (2002) while studying diel flight pattern of *F. occidentallis* reported that there was a negative correlation between increase in height at which sticky cards were placed and availability of western flower thrips. Height of flight in western flower thrips is influenced by two important factors (Pearsall, 2002): the height of prevalent vegetation and temperature, with mean height of flight increasing linearly with temperature. Considering the behavior of thrips proposed by Shinichi (2007) and Pearsall (2002) as stated above, highest infestation of chilli thrips on host crops placed at lower most heights could be explained. Proximity of susceptible host could be the reason behind their highest availability on the host plants placed at lowest height. Also to minimize intraspecific competition for food and habitat they are dispersed throughout on each host in variable number at different heights.

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