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Source: Journal of Economic Entomology, 100(4):1194-1200.
Published By: Entomological Society of America
DOI: http://dx.doi.org/10.1603/0022-0493(2007)100[1194:OLAHFO]2.0.CO;2
URL: http://www.bioone.org/doi/full/10.1603/0022-0493%282007%29100%5B1194%3AOLAHFO%5D2.0.CO%3B2

Overwintering Locations and Hosts for Onion Thrips (Thysanoptera: Thripidae) in the Onion Cropping Ecosystem in New York

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J. Econ. Entomol. 100(4): 1194–1200 (2007)

ABSTRACT Identifying locations where onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), overwinter and subsequently disperse is important for designing control strategies. In upstate New York from 2003 through 2006, potential overwintering sites in the commercial onion, *Allium cepa* L., cropping system were investigated early in the spring before onion seedling emergence and again late in the season after onions were harvested. Onion thrips adults were sampled directly from the soil and indirectly from the soil by using emergence cages. Sampling locations included onion field interiors and edges and areas outside of these fields, including woods. Host material sampled included onion culls; volunteer onions, which sprout from cull onions left behind after harvest; and weeds. Onion thrips adults were found in all sections of onion fields and in locations outside of onion fields, with the fewest emerging from woods. Emergence began in early May and extended into June. Peak emergence occurred during the last half of May, at which time 50–75% of the population had emerged. Adults colonized volunteer onions as early as late March and as late as mid-November. No adults were found overwintering in onion cull piles. Adults also colonized several weed species, especially pigweed, *Amaranthus hybridis* L., and lambsquarters, *Chenopodium album* L., late in the fall. Our results indicate that onion thrips adults overwinter in the soil within and near onion fields and that they probably colonize volunteer onion plants before subsequent generations infest the onion crop in the spring. Volunteer onions and weeds also provide onion thrips with a host after onions are harvested. Consequently, onion thrips management strategies should include tactics that reduce volunteer onion and weed abundance.

KEY WORDS *Thrips tabaci*, onions, overwintering, emergence, volunteer onions

Onion, *Allium cepa* L., is one of the most important high-value crops in New York where an estimated area of 5,700 ha was dedicated to onion production in 2006 (NASS 2007). Onions in New York are predominantly grown in pockets of "muck" soils, which are high in organic matter and originated from lakes that were drained early in the 20th century. Onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), are the key insect pest of onions in New York. Onion thrips feeding results in silvering, curling of the leaves and eventually bulb size and weight reduction (Childers 1997). Onion thrips also is a vector of Iris yellow spot virus, which is a Tospovirus that has had a significant detrimental impact on bulb and seed onion crops in the western United States (Gent et al. 2004). Iris yellow spot virus was found in New York in 2006 (Hoepting et al. 2007). Onion thrips in New York are managed principally with insecticides, but this tactic has become increasingly difficult as many commonly used products provide only a moderate level of control (Nault and Hessney 2006) and resistance to the most commonly used insecticide λ-cyhalothrin has been documented in New York and Ontario, Canada (Shelton et al. 2003, 2006; Allen et al. 2005).

A key question for understanding onion thrips ecology is to identify sources from which they annually infest onion crops. Less than 5% of onion fields in New York are rotated, and almost all are often surrounded by woodlots, forage, and grain crops and other vegetable crops. These habitats, as well as the onion field itself, could offer overwintering and early season feeding sites before and after the onion-growing season. Volunteer onions, which are produced from cull onions left behind after harvest, can be present in high densities within onion fields as early as March and as late as November. Volunteer onions could be an important host for onion thrips when the commercial onion crop is not available.

Little information is available on the overwintering ecology of onion thrips in onion fields. Onion thrips are also a key pest in cabbage fields in New York, and they have been reported to overwinter successfully

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within winter wheat, *Triticum aestivum* L.; alfalfa, *Medicago sativa* L.; and weedy vegetation (North and Shelton 1986a). When these plants are no longer suitable due to senescence or harvesting practices, populations of onion thrips migrate and colonize adjacent cabbage crops (North and Shelton 1986b). Such population interchange is also assumed to occur in the agroecosystem where onions are grown, and it probably results in variable temporal and spatial patterns of onion thrips infestations in onion fields. However, a study that examined the distributional characteristics of onion thrips in six commercial New York onion fields found surprisingly little differences in the within-field distribution (e.g., borders and interior sections), although sampling was done in the middle of the season when populations were highest and when invasion of the field may have already taken place from other sources (Shelton et al. 1987).

In a study examining onion thrips adult movement within and around onion fields in New York, Gangloff (1999) found no distinct immigration trends. Because onion fields are generally not rotated, it is possible that onion thrips overwinter within onion fields and recolonize the onion crop in the spring. There are also other hosts for onion thrips when the onion crop is not available such as cull onions, which are bulbs left in the field after harvest or discarded in large piles near onion fields, volunteer onions, which sprout from these culls, and weeds. Implications of such a closed system could include a greater risk of developing an insecticide-resistant population, which may reside over a longer period within or in proximity to the onion field. Recent studies suggest that this may be occurring in New York (Shelton et al. 2003, 2006). Furthermore, the threat of onion thrips transmitting Iris yellow spot virus evokes another reason to investigate the potential contribution of an overwintering vector population on the epidemiology of the virus.

Knowledge of overwintering sites would be valuable for understanding the origins and subsequent dispersal of onion thrips and for adjusting control methods accordingly to avoid insecticide resistance development and manage Iris yellow spot virus. The current study had the following objectives: 1) identify locations within and near onion fields in which adults overwinter; 2) determine the onset and duration of adult emergence from overwintering sites; and 3) identify hosts within and outside onion fields, such as volunteer onions and weeds, that may support populations of onion thrips before and after the onion-growing season.

Materials and Methods

Overwintering Locations of Adult Onion Thrips. Overwintering locations of onion thrips were determined by collecting soil from commercial onion fields located in three major onion-growing areas: Orleans, Oswego, and Yates counties, NY, from 2003 through 2005. Fields were not planted or sprayed before soil sampling, which was initiated in late March 2003 and early April 2004 and 2005. In total, five, four, and five onion fields were sampled in 2003, 2004, and 2005, respectively. The number of sites sampled varied per year but included the field edge (first 5–7 m of the crop extending from the edge into the field), field interior, random locations throughout the field where cull onions were found, and habitats adjacent to the field (i.e., outside the field). In 2003, the number of soil samples taken per site was three, three, three, and zero, respectively. In 2004 and 2005, the number of samples removed per site was two, two, two, and four and three, three, three, and three, respectively. Samples taken from the field edges and field interior consisted of bare ground or cull onions where appropriate and those outside the field that had weedy vegetation.

Soil was sampled using soil augers, 15 cm in depth by 10 cm in diameter, and a single soil core had a surface area of 78.5 cm^2. In 2003 and 2004 each sample (i.e., sampling unit) consisted of six soil cores (each sample = 471 cm^2). In 2005, each sample consisted of five soil cores. In 2003 and 2004, the sample was placed into a plastic bin (25 by 33 by × 21 cm, width by length by height) with one 8-cm by 11-cm yellow sticky card (Olympic Horticultural Products, Bradenton, FL). The top of the bin was sealed with no-thrips screening, and the bins were placed in a greenhouse maintained between 20 and 30°C. After 4 wk, the sticky cards were examined for adult onion thrips. In 2005, the protocol was modified to facilitate onion thrips emergence. Soil cores were introduced separately into clear polystyrene cylinders (30 cm in height by 10 cm in diameter) with two screened ventilation holes (5 cm in diameter). The bottom of the cylinder was blocked with a plastic lid, and the top was covered with thrips-proof mesh (180 μm) and secured with a rubber band. One yellow sticky card (8 by 11 cm) was placed in each cylinder. All samples were kept in a greenhouse at 25°C for 8–10 wk with cards being checked every 2 wk for thrips emergence. Data from soil cores within a sample were pooled to produce a consistent sampling unit among years. The mean number of overwintering thrips per soil sample was extrapolated to the same sampling unit so that the sampling unit was the same for each year. Results per year were analyzed with one-way analysis of variance (ANOVA) to test the abundance of thrips in different locations and data were log $(x + 1)$ transformed to achieve normality when necessary with the statistical package MINITAB 13.5 (Minitab, Inc. 2001). Untransformed means ± SE are presented.

Overwintering Adults on Cull Onions and Cull Abundance. In late March 2003, to estimate onion thrips density on the culls, three samples of 20 cull onions plus some soil next to the onions were collected from each field. The amount of soil collected next to the culls was equivalent to the quantity of soil collected in the soil samples. In the laboratory, the cull onions were washed in ethyl alcohol. The washings were examined for the presence of onion thrips. The surrounding soil was placed in a bin with a sticky card as with the soil samples. In early April 2004, the density of cull onions and onion thrips found on them were estimated in the same fields where soil samples were collected. Cull onion density was estimated in each field by counting the culls exposed on the surface in three areas of 22.9 m^2.

In early April 2004 and 2005, three samples were collected from a large cull pile to determine whether cull piles could be a source of onion thrips. Cull pile sampling consisted of placing $\approx$0.12 m^3 of onion debris in a bin and monitoring with a sticky card as was done for the soil samples.

Timing and Duration of Overwintering Adult Emergence. Timing of overwintering onion thrips emergence and their abundance was documented using emergence traps in one commercial onion field in Yates County from 2004 to 2006. In 2004, the field was sampled from 29 March to 27 May, whereas in 2005 and 2006 the same field was sampled from 5 April to 26 June and from 3 April to 26 June, respectively. Fields were planted on 9 April 2004, 14 April 2005, and 6 April 2006. Sites where samples were taken were similar to those described above, the field interior, field edge, outside the field on the weedy border and surrounding woodlots with three to six traps per site, for a total of 16 traps in 2004 and 19 trap in 2005 and 2006. The onion grower continued his normal activities (planting, spraying) around the traps.

In 2004, emergence traps consisted of a Plexiglas box (35 by 48 by 35 cm, width by length by height) covered with no-thrips screen on the top, and one yellow sticky card (8 by 11 cm) was placed in each trap. Sticky cards were replaced weekly, and the number of onion thrips adults was recorded. In 2005 and 2006, emergence traps were modified slightly by drilling two ventilation holes (15 cm in diameter) at the front and back of the traps and one on each side of the box. All holes were screened with thrips-proof mesh (180 μm). The top of the box was covered with a wooden surface on the underside of which a Tangle-foot coated yellow card (30 by 45 cm) was held in place with Velcro tape. As the season progressed and onion thrips were flying in the field, sticky cards were protected in plastic boxes before and after removal from the emergence cages to avoid contamination.

In 2004–2006, numbers of emerging onion thrips adults were too low to justify the use of repeated measures ANOVA to separate the means among different sampling sites per date and across years. The mean total number of emerging onion thrips per sampling site for each year was analyzed with one-way ANOVA, Fisher least significant difference (LSD) test ($P > 0.05$) (MINITAB 13.5). Data were log ($x + 1$) transformed when necessary.

Hosts within Onion Fields before and after the Onion Season. *Volunteer Onion Plants.* Volunteer onion plants were collected weekly in autumn 2005 (21 October–7 November), early spring 2006 (22 March–25 May) and autumn 2006 (18 October–6 November) from an onion field in Yates County. Ten plants from each of three sites within the field (each site = 100 m^2) were collected, sealed individually in plastic bags, and onion thrips adults and larvae were extracted after 48 h in Berlese funnels (60-W bulb). In autumn 2006, five plants each were sampled from the

Table 1. Mean ± SE number of onion thrips adults collected per soil sample (471 cm^2) during March or April 2003–2005 in upstate New York (2003, n = 5; 2004, n = 4; and 2005, n = 5)

Location	2003	2004	2005
Field edge	0a	0.1 ± 0.1a	0.3 ± 0.1a
Field interior	0.3 ± 0.1a	0a	0a
Throughout field with culls	0.07 ± 0.07a	0.2 ± 0.1a	0.7 ± 0.4a
Outside field		0.25 ± 0.15a	0.8 ± 0.2a

Means within a column followed by same letters are not significantly different ($P > 0.05$; one-way ANOVA, Fisher LSD test).

field edge and field interior. The mean number of thrips adults and larvae per volunteer onion plant collected from the field edge and interior was analyzed with Student's t-test (MINITAB 13.5).

Weeds. In autumn 2005, weeds along the periphery of the Yates County field noted above were collected for adult onion thrips during the same period as the volunteer onions. Five plants were sampled from three sites of 100 m^2 for each of the following species: lambsquarters, *Chenopodium album* L. (Chenopodiaceae); evening primrose, *Oenothera biennis* L. (Onagraceae); yellow nutsedge, *Cyperis esculentum* L. (Euphorbiaceae); and pigweed, *Amaranthus hybridus* L. (Amaranthaceae). Onion thrips extraction took place in Berlese funnels, as described above. Differences in the mean number of adults recovered from weed species at different sampling dates were analyzed using one-way ANOVA ($P > 0.05$; Fisher LSD test) (MINITAB 13.5), and data were log (x +1) transformed when necessary.

Results

Overwintering Locations of Adult Onion Thrips. Onion thrips adults were recovered from areas in the field interior, field edges, outside the field, and culls throughout the field (Table 1). In 2003, there was no significant difference among the sampling locations ($F = 1.40$; df = 2, 14; $P > 0.05$). Onion thrips adults were recovered from locations within and outside the field, but no significant differences among sites were detected in 2004 and 2005 ($F = 0.88$; df = 3, 15; $P >$ 0.05 and $F = 2.67$; df = 3, 19; $P > 0.05$, respectively). Each year onion thrips were recovered from soil samples collected throughout the field containing culls but still not in significantly higher numbers than other locations.

Overwintering Adults on Cull Onions and Cull Abundance. No onion thrips were recovered from the cull washings in 2003 but 0.2 ± 0.2 (mean ± SE; n = 5) thrips were recovered from the remaining soil. Similarly no onion thrips adults were recovered from cull pile samples in 2004 and 2005. Cull density in the five fields examined in 2004 ranged from 7 to 31 per site for a mean of 0.64 ± 0.08 culls per square meter for all fields.

Timing and Duration of Overwintering Adult Emergence. In 2004, onion thrips emerged from outside the field in the beginning of May and from the

Table 2. Emergence time and mean number (trap ± SE) of onion thrips adults collected on sticky cards in emergence cages at different sampling sites, Yates County, NY, from 2004 to 2006

Site	Yr	3 April	8–29 April[a]	6 May	13 May	20 May	27 May	3 June	10 June	17 June
Field interior	2004	0	0	0	0	0.2 ± 0.2	—[b]	—	—	—
	2005	0	0	0	0.2 ± 0.2	1.4 ± 0.7	0.6 ± 0.4	0.2 ± 0.2	0.2 ± 0.2	0.2 ± 0.2
	2006	0.2 ± 0.2	0	0	0.4 ± 0.2	0.4 ± 0.2	0	0	0.4 ± 0.4	0.2 ± 0.2
Field edge	2004	0	0	0	0	0	—	—	—	—
	2005	0	0	0	0	0.6 ± 0.6	0.6 ± 0.4	0	0.2 ± 0.2	1.0 ± 0.8
	2006	0	0	0	0	0	0	0.2 ± 0.2	0	0
Outside field	2004	0	0	0.2 ± 0.2	0	0.2 ± 0.2	—	—	—	—
	2005	0	0	0	0	0.8 ± 0.5	1 ± 0.6	0.2 ± 0.2	0.2 ± 0.2	0
	2006	0	0	0	0	0	0	0	0	0
Woods	2004	0	0	0	0	0.3 ± 0.3	—	—	—	—
	2005	0	0	0	0.3 ± 0.3	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0

[a] Sampling in weekly intervals, pooled data are shown.
[b] Dashes indicate no data collection.

field interior and surrounding woods toward the end of the sampling period on 20 May (Table 2). In 2005, most onion thrips emerged in mid-May (70.7%) from all the sampling sites, and they were captured throughout the sampling period until 17 June (Table 2). In 2006, onion thrips adults emerged as early as 2 April and throughout May and June (Table 2). There was no significant difference in the mean total number of thrips emerging from different sampling sites for the sampling period of 2004 ($F = 0.72$; df = 3, 31; $P > 0.05$) (Fig. 1). For the total sampling period of 2005, significantly fewer onion thrips adults emerged from surrounding woodlots ($F = 1.47$; df = 3, 47; $P < 0.05$) than areas within the field, field edge, and outside the field (Fig. 1). In the 2006 sampling period, significantly more thrips emerged from areas within the field ($F = 5.81$; df = 3, 47; $P < 0.05$) than field edges or outside the field and woodlots (Fig. 1). Between 2004 and 2006, mean trap catches from field interiors, field edges, outside the field, and woods translated to densities of 2 to 18, 2 to 14, 2 to 13, and 2 onion thrips per m^2, respectively.

Hosts within Onion Fields before and after the Onion Season. *Volunteer Onions.* In autumn 2005, between 8.6 and 12.5 onion thrips adults and between 1.2 and 2.9 larvae were recovered per plant (Table 3). From 1 to 15 November 2006, significantly more adults were recorded on volunteer plants from sites in the field edge than in the field interior (for 25 October, $t = 1.20$, df = 58, $P > 0.05$, whereas for the three November dates, $t = 2.75$, 3.21, and 3.34; df = 58; $P \leq 0.05$). No significant differences between numbers of larvae in field edges or field interior existed on any date in the fall of 2006 ($P > 0.05$). In spring 2006, volunteer onion plants harbored onion thrips adults on all sampling dates, and larvae were observed on over half of the sampling dates (Table 4).

Weeds. Onion thrips adults were recovered from all weed species sampled (Table 5). *A. hybridus* and *C. album* hosted more onion thrips adults than *C. esculentum* and *O. biennis* on 21 October ($F = 9.03$; df = 3, 59; $P \leq 0.001$) and on 28 October ($F = 46.19$; df = 3, 59; $P \leq 0.001$). Densities of onion thrips adults on *A. hybridus* were similar to those on *C. album* during

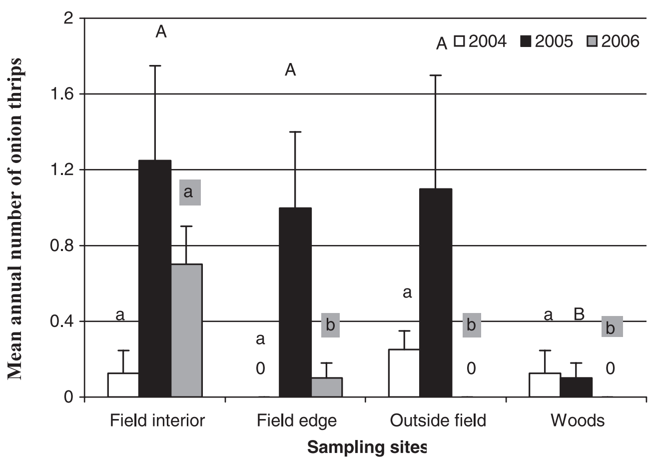

Fig. 1. Mean annual number of onion thrips adults collected on sticky cards in emergence cages at different sampling sites, Yates County, NY, from 2004 to 2006. Means within a year followed by same letters are not significantly different ($P > 0.05$; one-way ANOVA, Fisher LSD test).

Table 3. Mean ± SE number of onion thrips adults and larvae per volunteer onion plant in autumn 2005 and 2006 ($n = 5$)

Locations	Yr	Stage	Sampling date			
			25 Oct.	1 Nov.	8 Nov.	15 Nov.
Throughout field	2005	Adult	12.5 ± 1.4	11.7 ± 0.6	8.6 ± 1.2	
Field edge	2006	Adult	0.8 ± 0.2a	0.8 ± 0.2a	1.1 ± 0.2a	0.7 ± 0.1a
Field interior	2006	Adult	0.5 ± 0.1a	0.3 ± 0.1b	0.3 ± 0.1b	0.1 ± 0.1b
Throughout field	2005	Larva	2.9 ± 0.6	1.2 ± 0.5	2.6 ± 0.5	
Field edge	2006	Larva	0.2 ± 0.1a	0.6 ± 0.1a	0.2 ± 0.1a	0.3 ± 0.1a
Field interior	2006	Larva	0.03 ± 0.03a	0a	0.03 ± 0.03a	0.03 ± 0.03a

Means within a column followed by same letters are not significantly different (Student's *t*-test).

October sampling dates, but no onion thrips were found on *C. album* and on *O. biennis* on 7 November ($F = 11.02$; df = 3, 59; $P \leq 0.001$).

Discussion

Onion thrips overwinter in the soil within onion fields and in habitats adjacent to onion fields in New York. Although the mean number of onion thrips that emerged was low in our study, we found them in field interiors, field edges, and in habitats near onion field edges as well as in adjacent woods. Densities of overwintered thrips, as recorded by soil sampling, were similar among the sampling sites. Although our sample numbers were low, this should be taken in context of the relatively small sample units in this study. Because of the expansive area of muck and surrounding land, the total numbers of onion thrips overwintering in the soil would be quite large and may be a major source of onion thrips in onions. However, soil management practices to reduce overwintering thrips populations would be difficult over such an expanse. Abundance of onion thrips in woodlots, as recorded by the emergence data, was significantly lower than that in other habitats, although woodlots have been suggested to offer complementary habitats such as overwintering, mating, or foraging sites for onion thrips (Lewis and Navas 1962). Nevertheless, the importance of surrounding woodlots on overwintering of onion thrips should not be neglected given the vast area they occupy around muck systems in New York.

Onion thrips adults emerged from both field edges and field interiors, and, although in 2006 more adults emerged from within the field, the low numbers encountered in total from the emergence traps that year prohibit a strong indication of site preference. Overwintering adults were recovered from soil samples in field interiors only in 2003, and during all the sampling years, onion thrips adults were recovered from soil accompanying cull onions throughout the field. In 2004 and 2005, no thrips were recovered from field interior soil samples, but the low numbers from field edge soil samples is not sufficient to support anecdotal evidence of increased thrips populations in field edges during onion-growing season.

Onion thrips adults also were recovered from areas bordering the muck fields. Previous studies in New York reported onion thrips overwintering within winter wheat, alfalfa, and weedy vegetation (North and Shelton 1986a). Onion thrips adults have been recovered from soil but in lower numbers than from litter, winter crops, and hosts in North Carolina (Cho et al. 1995). Onion thrips overwinter as adults in alfalfa and clover in southern Idaho (Shirck 1951) and in large numbers in the soil during the winter in Texas (Chambers and Sites 1989). Such findings, in combination with the poor recovery of onion thrips from our soil samples, suggest the influence of winter plant species and weeds in the overwintering of onion thrips needs to be examined further.

During the three study years, most onion thrips adults emerged from the soil in May when air temperatures ranged between 12.5 and 20.5°C. The duration of their emergence spread into June, and this could be attributed to fluctuations in the air temperature and rainfall throughout the years, and perhaps a longer experimental period would reveal additional emerging thrips populations. In addition to such environmental parameters, the amount of snowfall also should be considered because it influences the depth of frost in the ground and it could affect the emergence time or survival of the overwintering population. Long-duration emergence periods also have been observed in the pear thrips, *Taeniothrips inconsequens* (Uzel), in Vermont, and they have been attributed to climatic factors (Skinner and Parker 1996). Similarly, *Frankliniella occidentalis* (Pergande) adults emerge gradually and over a fairly extended period from both wild areas and nectarine, *Prunus persica* var. *nucipersica,* orchards in British Columbia (Pearsall and Myers 2000).

Volunteer onion plants serve as a suitable host for onion thrips before the onion crop emerges in the spring and again after the onion crop is harvested in

Table 4. Mean ± SE number of onion thrips adults and larvae per volunteer onion plant in spring 2006 ($n = 5$)

Stage	Sampling date						
	22 Mar.	30 Mar.	7 April	4 May	11 May	18 May	25 May
Adult	0.23 ± 0.1	0.1 ± 0.05	0.3 ± 0.1	0.03 ± 0.01	0.07 ± 0.04	0.1 ± 0.5	0.5 ± 0.1
Larva	0.06 ± 0.04	0.03 ± 0.03	0	0	0	0.03 ± 0.03	0.3 ± 0.1

Table 5. Mean number of onion thrips adults recovered from weeds surrounding onion fields in Yates County NY, during autumn 2005 ($n = 5$)

Weed species	*T. tabaci* adults		
	21 Oct.	28 Oct.	7 Nov.
A. hybridus	3.1 ± 0.5a	3.1 ± 0.4a	1.4 ± 0.5a
C. album	3.7 ± 1.1a	2.7 ± 0.5a	0 ± 0c
C. esculentum	0.5 ± 0.2b	0 ± 0b	0.5 ± 0.1b
O. biennis	0.3 ± 0.1b	0 ± 0b	0 ± 0c

Means within a column followed by same letters are not significantly different ($P > 0.05$; one-way ANOVA, Fisher's LSD test).

the fall. In 2006, recovery of onion thrips adults from volunteer onion plants occurred in late March (40–60 d before the newly seeded onions emerged), and volunteers supported onion thrips in mid-November (90–135 d after onion harvest). Although volunteer onion plants do not remain green throughout the winter in New York, onion culls remaining in the fields may provide an overwintering site for adults as well as feeding and oviposition sites in the spring. In Georgia in the United States, harvested peanut fields supporting volunteer peanut plants and weeds have been considered important winter reservoirs for Tomato spotted wilt virus and viruliferous thrips vectors such as *Frankliniella fusca* (Hinds) (Chamberlin et al. 1993).

Abundance of overwintered onion thrips populations on volunteer onion plants may be correlated to abundance on the onion crop before harvest, but further studies would need to be conducted. A density of 0.64 culls per m^2 observed in 2003 would be considered a major problem if a high percentage of these culls become volunteer onion plants and provide suitable feeding and oviposition sites early and late in the season. The density of volunteer onions would fluctuate depending on harvest conditions, onion size at harvest, field sanitation practices, cover crop, and winter temperatures. Detection of larger numbers of onion thrips adults on volunteer plants toward the field edge than the field interior could provide a useful tool when scouting for onion thrips before planting. Additionally, volunteers could be removed or destroyed during the early growth of onion plants. *Amaranthus hybridus* weeds hosted onion thrips adults after onion harvest, until mid-November. Although the limited period of weed sampling does not allow us to draw many conclusions on their role in onion thrips population dynamics, the polyphagous feeding nature of onion thrips and the occurrence of consistent, infested weed vegetation in and around onion fields indicate that weeds, along with volunteer onion plants, may be critical to onion thrips survival near onion fields.

Knowledge of the overwintering ecology of onion thrips is important for predicting the abundance and dispersal of onion thrips in an onion ecosystem, the spread of genes for insecticide resistance or susceptibility and the transmission of Iris yellow spot virus from surviving overwintering adults. Tomato spotted wilt virus can be transmitted to many plants by viruliferous overwintering populations of *F. fusca* and onion thrips (Groves et al. 2001, Jenser et al. 2003). The impact of overwintering onion thrips in the epidemiology of Iris yellow spot virus in New York onion growing areas remains to be examined. Our results indicate that onion thrips are present in nonrotated onion fields throughout the winter and that volunteer onion plants may serve as a bridge between thrips emergence and infestation of the onion crop and also as a late season host after harvest. A site effect between field interiors and field edges was not detected by soil sampling and emergence traps, nevertheless volunteer distribution and abundance could strongly affect subsequent dispersal and spread of onion thrips in an onion field. Therefore, sanitation of onion fields and destruction of volunteer onion plants seems to be important cultural management tactics that can reduce onion thrips overwintering sources and early season population increases.

Acknowledgments

We thank cooperating growers and extension specialists (Carol McNeil, Christy Hoepting, and Jan VanderHeide). This research project was supported in part by the New York State Onion Growers Research and Development Program and the Pest Management Alternatives Program.

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Received 30 March 2007; accepted 24 May 2007.