AGROECOLOGICAL NICHES AND THRIPS (THYSANOPTERA: THRIPIDAE) DYNAMICS[1]

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In 1975, Illinois experienced an exceptionally mild winter, followed by a warm spring. This sequence of climatic events resulted in a massive outbreak of the soybean thrips, *Sericothrips variabilis* (Beach), along with large numbers of the flower thrips, *Frankliniella tritici* (Fitch). The outbreak covered an area of over 600 thousand hectares (1.5 million acres) of soybean and was particularly heavy in the southern third of the state. In areas where thrips densities were particularly high early in the season, entire fields of young soybean seedlings began to die, causing panic within the farming community. In their attempts to resolve the situation, growers applied large quantities of pesticides to over 20,200 hectares (50,000 acres) during the first week after the crop had begun to emerge.

Heretofore, massive invasions of thrips had not been recorded in soybean; therefore, damage potential and yield reductions resulting from thrips attacks on this crop had not been quantified. Furthermore, the possibility existed that one or both species of thrips were capable of transmitting tobacco ringspot virus (Messieha 1969, Bergeson et al. 1964) from wild hosts or soybean, where it is transmitted through seeds of infected plants, to soybean. Infection by tobacco ringspot virus dramatically reduces the quality and quantity of soybean grain.

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[1]I wish to thank Dr. Bruce L. Parker and Dean Donald L. McLean for involving me in this important symposium and for providing such cordial hospitality. I am also grateful to the State of Vermont for providing the funds so that I could participate. I dedicate this paper to the memory of the late Dr. Lewis J. Stannard, a thrips systematist whose life was dedicated to enhancing the knowledge base of North American thrips.

Extension specialists had only tentative responses to farmer requests for information regarding the thrips outbreak in soybeans because no knowledge base existed.

The following commentary does not address the virus transmission issue. (As a point of information, tobacco ringspot virus was subsequently found not to be a consideration because *S. variabilis* apparently does not transmit the virus and *F. tritici* does so only very inefficiently.) Instead, this paper recounts the outcome of several experiments undertaken between 1975 and 1977 to determine the ecological niches occupied by those two thrips species in relation to soybean phenology (Irwin et al. 1979). This information should prove useful to the entomological community of Vermont and other sections of northeastern North America as they mobilize to resolve the problem of the pear thrips on sugar maple.

Phenology of Soybean and Developmental Stages of Growth

Soybean, *Glycine max*, is a very dynamic, widespread crop in the midwestern and north central United States. It was introduced into the United States from China in 1765, but only became known throughout the eastern and central portions of the United States after the end of the 19th century (Howell 1983). Like most annual row crops, soybean plants change dramatically as the season progresses. These changes are important to the spatial and temporal distribution of both thrips species and, thus, must be defined. What follows is a brief description of soybean growth, each stage of which is followed, in parentheses, by a code identifying that stage, adapted from Fehr & Caviness (1977).

Upon germination, the soybean plant emerges as a pair of thick, green cotyledons (V_0), followed about a week later by a pair of unifoliate leaves (V_1). Thereafter, throughout the first half of the growing season, the plant puts out a series of alternate trifoliolate leaves that are coded V_2 through V_n, the larger numbered trifoliolate leaves appearing later in the season and higher in the canopy. Depending upon soybean cultivar and local climate, flowers first appear (R_1) at around 40 days after planting. The field reaches full flowering (R_2) shortly thereafter. When a plant has at least one pod that is 5 mm in length at one of the four uppermost nodes on its main stem, it has reached the "beginning pod" stage (R_3). It reaches the "full pod" stage (R_4) when at least one pod at one of the four uppermost nodes on the main stem reaches 20 mm in length. The "beginning seed" stage (R_5) is reached when seeds in one of the pods at one of the four uppermost nodes on the main stem reach a length of 3 mm. When the green seeds in those pods completely fill the pod cavity, the "full seed" stage (R_6) has been reached. The beginning of maturity (R_7) is reached when one normal pod on the main stem has a mature, brownish or grayish pod color. "Full maturity" (R_8) occurs when 95% of the pods have reached their mature pod color. A coding of V_{12}, R_4, then, indicates that twelve nodes and thus twelve layers of leaves exist along the main stem and the plant is in the "full pod" stage of development.

Soybeans grow rather evenly, the heights of the different plants in a field being very similar; thus very even foliage with a smooth canopy is the rule. Soybean growth is dynamic. Plants begin as seedlings, increasing dramatically in terms of niches, both above and below ground, that are potentially occupied by fauna. Towards the end of the season, the leaves senesce and the plant becomes a naked frame containing bountiful pods at its nodes, each pod enclosing about three seeds. Thus, the niches available for thrips increases throughout most of the growing season, then decreases rapidly as the plant begins to senesce. The temporal component of niche availability is thus dictated by plant phenology.

Biology of Both Thrips Species

Adults of both species are probably migratory; they immigrate from the southern region of the central United States perhaps even Mexico. Early season migrant *S. variabilis* colonize alfalfa and other broad leaved plant species, then move to and reproduce on soybean throughout much of the growing season. Similarly *F. tritici* is found on many grass and broad leaved host plants, but, for the most part, colonizes flowering parts of these plants. *F. tritici* is attracted to maize when it is silking, but before and after silking, it often colonizes soybean.

Eggs of both species are laid in leaf tissue. First instars emerge from eggs and begin feeding by sucking fluids from individual plant cells, leaving silvery, streaked feeding damage. The first instar is followed by two further larval stages, the last of which, after having finished feeding, drops to the ground, enters a prepupal stage, then pupates in the soil, and ecloses as an adult a week to ten days later. After mating, egg laying commences.

Alighting Distribution of Thrips within a Soybean Field

Landing activity was monitored by sticky-coated green tile traps (Irwin 1980) set horizontally at canopy height within soybean rows (Irwin & Yeargan 1980). These traps have a reflectance spectrum very similar to soybean leaves; thus, the thrips should behave as though they were landing on foliage, neither being attracted to nor repelled from the traps. These traps, therefore, measure landing activity, not population abundance or density in the canopy.

In 1976, ten green tile traps were placed at 50 m intervals along a transect across an 3.2-hectare field of soybean, cv. Williams, in Tolono, Ill. The first and tenth traps were placed in grass strips outside of the field. Three species of thrips were trapped abundantly, the two that colonize soybean and a third, *Frankliniella fusca* F., that does not. For the two species that colonize soybean, a relatively uniform landing rate occurred across the field, but outside the field in the grassy strips, landing rates were relatively low. The reverse occurred for the *F. fusca*, a grass-inhabiting species. It is clear that both species that colonize soybean are more abundantly trapped within the field, while the species that does not colonize is most abundantly trapped in the grassy strips (Fig. 1). Furthermore, both soybean-colonizing species had relatively uniform landing rates within the field, when averaged over the growing season.

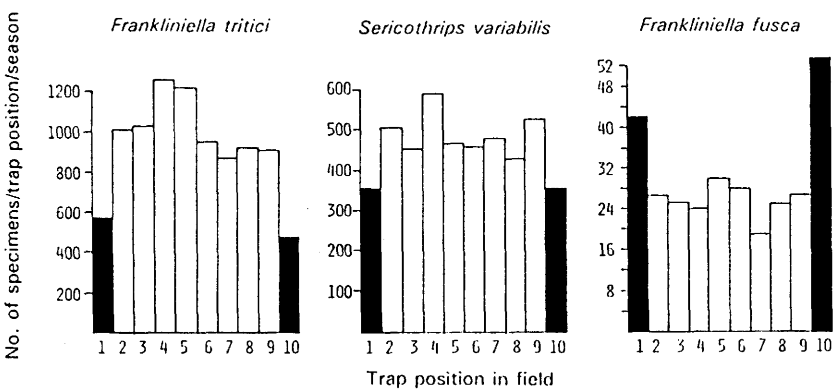

Figure 1. Distribution of three species of thrips in a south (S) to north (N) transect of a field of soybean, cv. Williams, in Tolono, Ill., 1976. Total specimens captured on horizontal green sticky traps during the growing season. Black bars represent traps located outside of the soybean field in grass borders. White bars represent traps located within the soybean field.

Seasonal Landing Rates of Thrips in a Soybean Field

The same soybean field in Tolono, Ill., was monitored for landing activity using horizontal sticky green tiles over two seasons, 1976 and 1977. Trends (Fig. 2) indicate a double activity peak of *F. tritici* both years even though there was a temporal displacement in peak activity one year over the other. A single peak of *S. variabilis* activity occurred each season; it too was displaced from one year to the next, earlier in 1977, later in 1976. I postulate that this may be due to a much colder winter preceding the 1976 than the 1977 season.

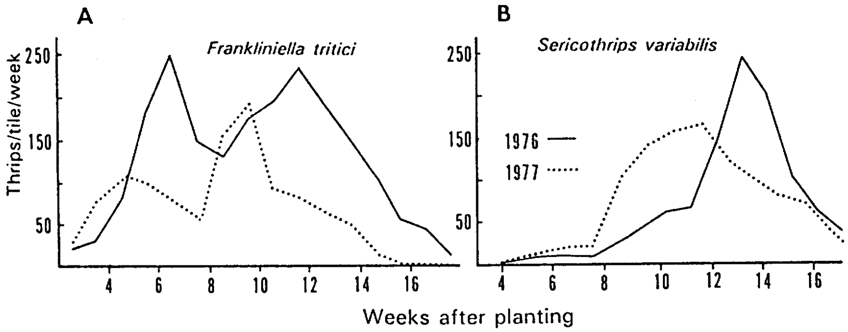

Figure 2. Flight activity curves of two thrips species in soybean for the 1976 and 1977 growing seasons Tolono, Ill. (A) *Frankliniella tritici*; (B) *Sericothrips variabilis*.

The Influence of Wind on Flight Direction

Thrips movement directly above the soybean canopy was monitored with a specially designed wind-directed trap. This trap (Fig. 3) was composed of a vein and shaft, which kept the axis oriented into the wind; and a set of four, small, clear plastic cups cut vertically in half--one half centered windward, the other centered leeward--and positioned perpendicular to the shaft. The cups were covered with vaseline and changed daily. The trap was very sensitive to wind changes, thus allowing us to compare the numbers of thrips adhering on the windward and leeward sides of the cups.

Over the entire soybean growing season, most *F. tritici* were found on the leeward side, with far fewer on the windward side, whereas *S. variabilis* showed the opposite trend (Fig. 4). Most *S. variabilis* were found on the windward side, with far fewer taken on the leeward side.

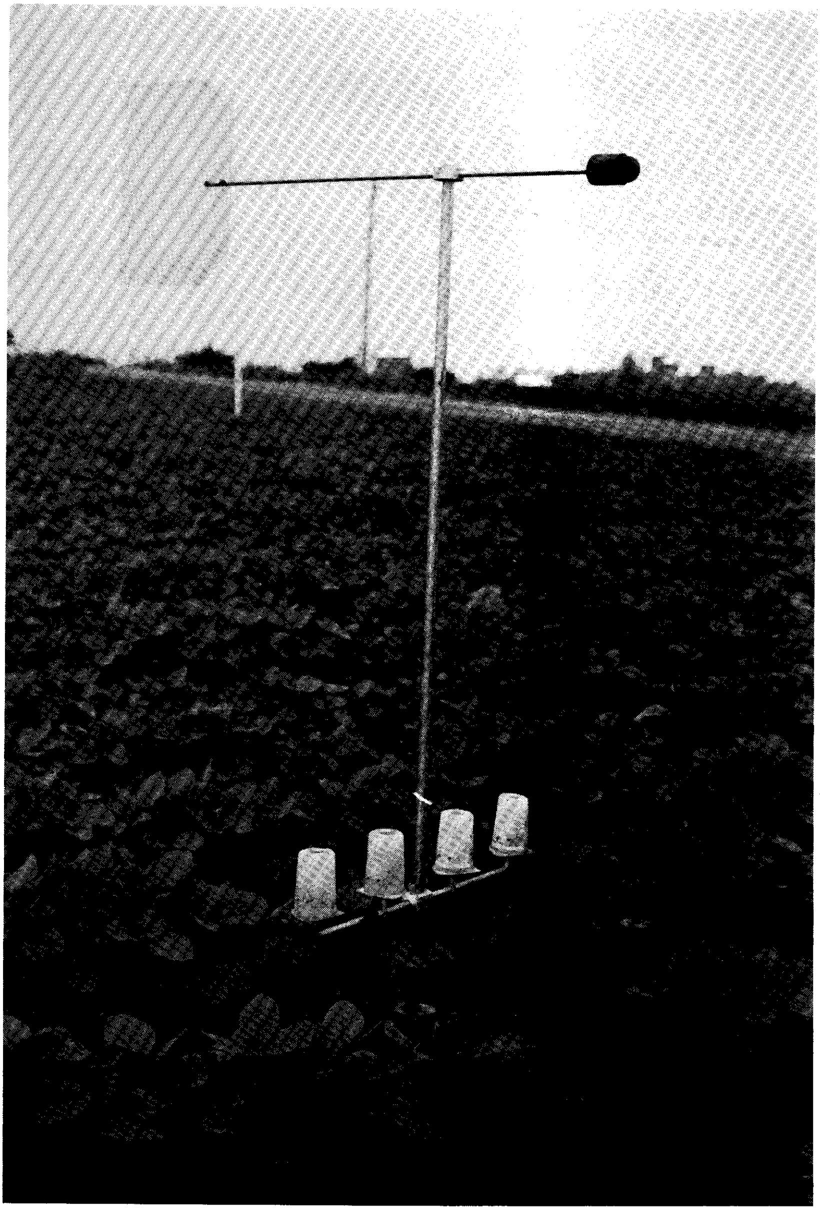

Figure 3. Modified wind-directed, vertically oriented trap for capturing small insects on windward and leeward sides of cylindrical, sticky-coated polyethylene cups.

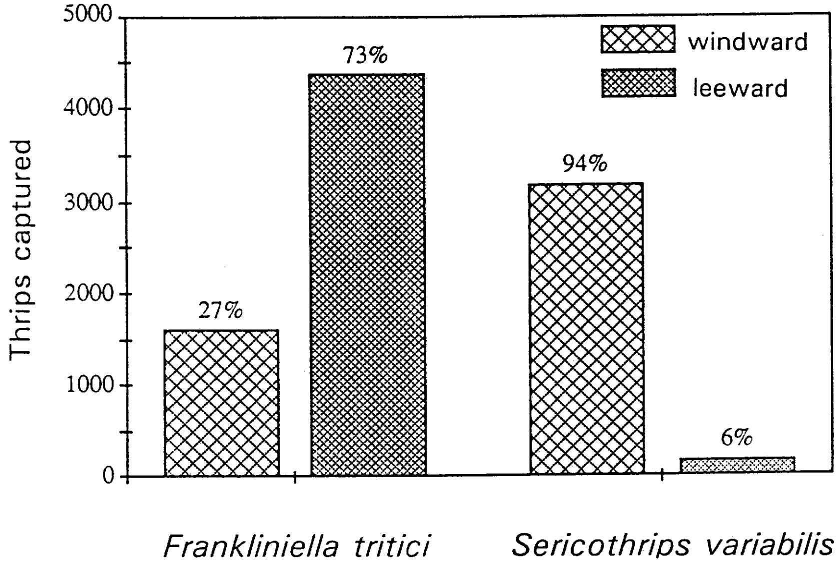

Figure 4. Proportion of two species of thrips captured on a vertically oriented cylindrical sticky trap in soybeans during the 1975 growing season, Urbana, Ill.

It seems most reasonable to postulate that those specimens collected on the windward side were being blown with the wind while those collected on the leeward side were flying against it. Because thrips are such weak flyers, those that were collected on the leeward side were probably flying at times when wind speeds were very low. This great difference in flight behavior between the two soybean-colonizing thrips species serves to point out the dangers in generalizing from one species to another.

Vertical Stratification in the Canopy

The within-canopy stratification of both soybean-inhabiting species of thrips was resolved so that a simplistic sampling plan could be devised that would best track the field population trends of these pests. To determine the stratification of each thrips species, the center leaflets of each main stem trifoliolate of ten plants from each plot were placed in a bottle containing a solution of water with a drop of detergent. The bottle was shaken thoroughly, the leaves were removed and rewashed, and the effluent was placed into the bottle. The bottles, four (one per plot) for each vertical node on the soybean plant, were taken to the laboratory where the liquid was put through a fine sieve, thereby concentrating the thrips, which were identified, sexed, counted, and tabulated.

The results of this set of experiments (Fig. 5), conducted over two soybean growing seasons, were quite interesting. *S. variabilis* adults were concentrated near the top of the soybean plant, at about the second leaf down from the terminal. Because adults oviposit there, by the time the first and second instars develop, they are concentrated on about the fifth and sixth leaves down from the top, particularly early in the season when soybean plants are putting out one to two new leaves per week. Therefore, to sample for *S. variabilis* adults, the second trifoliolate from the top is most appropriate, but to sample for first or second instars, the fifth or sixth trifoliolate from the top is most appropriate. When new nodes are no longer produced, this species begins to emigrate from the plant and from the field in large numbers.

The findings were quite different with *F. tritici* (Fig. 6). Adults and larvae of this species concentrate heavily in terminals (meristem tissue) prior to the formation of buds and flowers, but once buds and flowers appear, a large-scale shift occurs into them. When flowering ceases, a shift occurs back to the terminals. Therefore, to sample *F. tritici*, terminals and flowers must be monitored. The two soybean-inhabiting thrips species, thus, occupy very different parts of the plant. Experiments conducted concurrently demonstrate that specimens of neither species move very much during a 24 hour period.

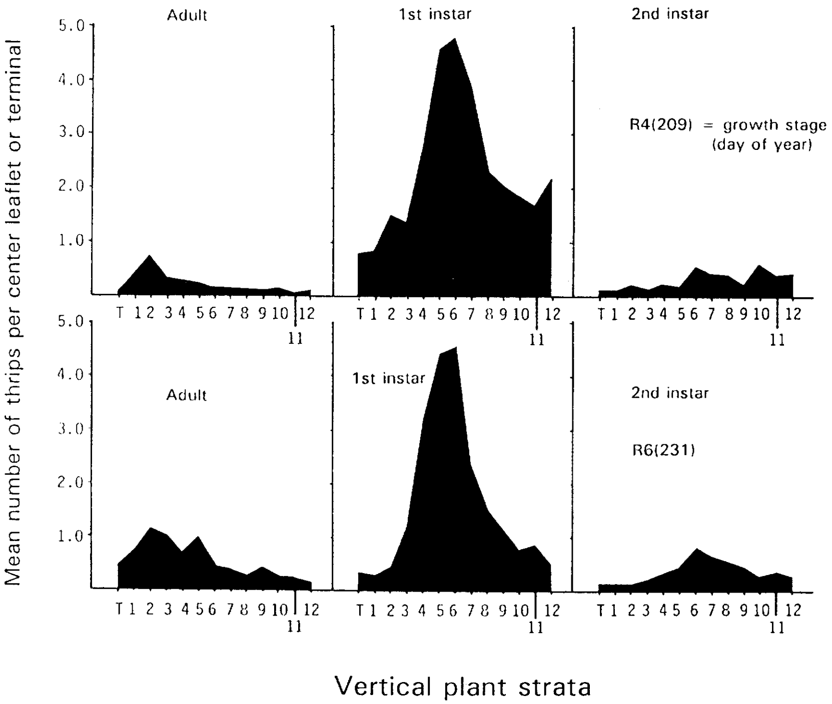

Figure 5. Within plant stratification of *Sericothrips variabilis* by life stage on soybean cv. Williams at growth stages R_4 (209 days post planting) and R_6 (321 days post planting), Urbana, Ill., 1976. T = terminal, 1-12 = center leaflets at nodes from uppermost expanded trifoliolate (1) downward on the main stem of the soybean plant.

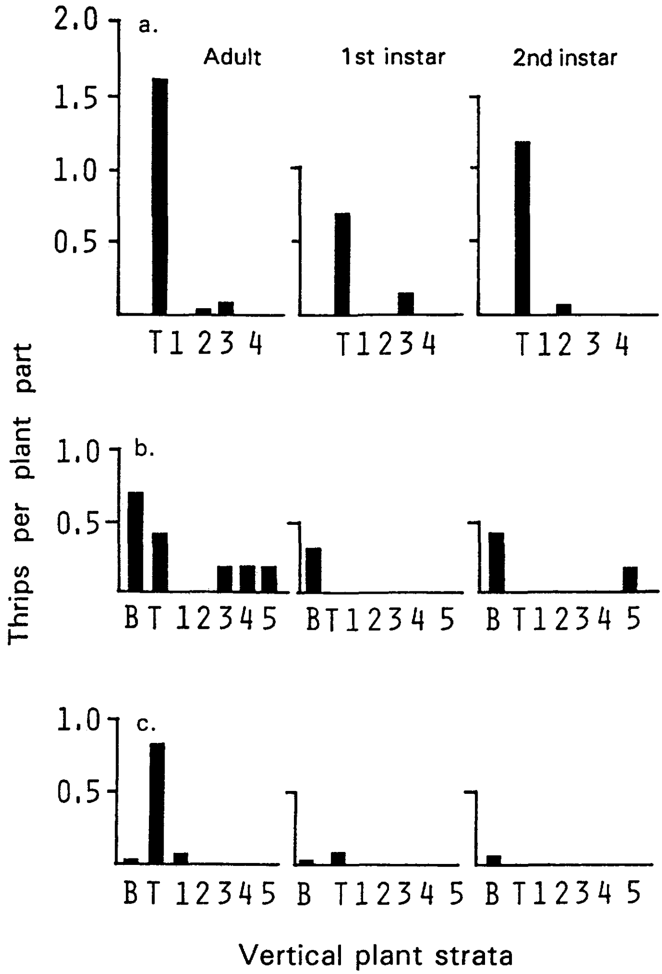

Figure 6. Within plant stratification of *Frankliniella tritici* by life stages on soybean cv. Williams at growth stages V_5 (a), R_2 (b), and R_5 (c), Urbana, Ill., 1976. B = blossoms, T = terminal, 1-12 = center leaflets at nodes from uppermost expanded trifoliate (1) downward on the main stem of the soybean plant.

Seasonal Phenologies: Within Canopy Abundance vs. Flight Activity

During the 1976 soybean growing season, thrips were monitored in Illinois for flight activity and for population density measurements. Flight activity was monitored with horizontal sticky green traps set just above the canopy and population density was assessed by leaf and terminal sampling (see previous section). Both sampling techniques resulted in very high catches of adult *S. variabilis* and *F. tritici* when compared with all other species. A comparison of these two methods illustrates the differences in the proportions of specimens of these two species sampled throughout the season. The leaf and terminal sample technique, used to determine the relative abundance of these two species within the canopy, showed that *S. variabilis* was four times more abundant overall. The sticky trap technique, however, indicated that *F. tritici* was twice as abundant overall (Fig. 7).

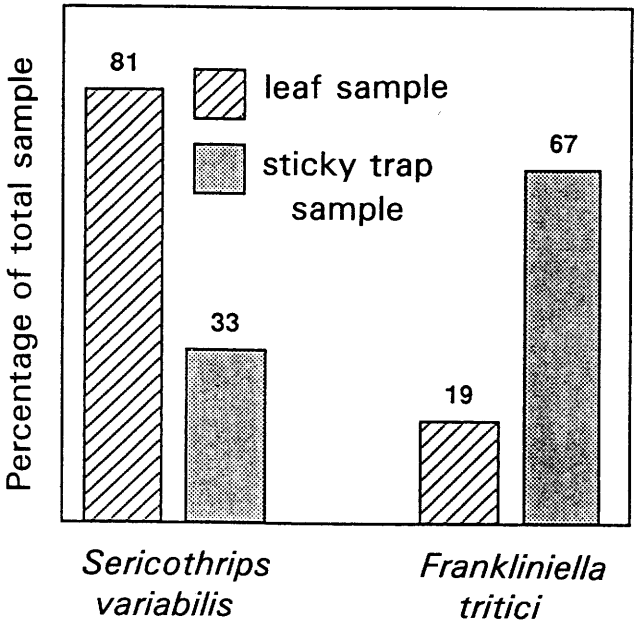

Figure 7. Proportional catches of the two most commonly collected thrips species in soybean cv. Williams, Tolono, Ill., 1976, using two methods: horizontal green sticky trap and plant part sampling.

This apparent paradox can be resolved. If the phenologies of adult thrips are plotted using the two sampling techniques, the picture becomes clearer (Fig. 8). For *F. tritici*, there are apparently two major peaks of flight activity, although from leaf samples there is but one population density peak in soybeans. The entire second peak of flight activity is most likely a product of population buildup on other host plants, thus accounting for a greater proportion of *F. tritici* in horizontal sticky traps than in terminal samples. The patterns of *S. variabilis* can also be explained. It is our contention that fewer adults immigrate, but these reproduce more successfully on soybean than *F. tritici*, and adults become active only late in the season as soybean plants begin to senesce. Thus, horizontal sticky trap samples suggest a flight peak of *S. variabilis* after the adult population within the soybean canopy begins to decline.

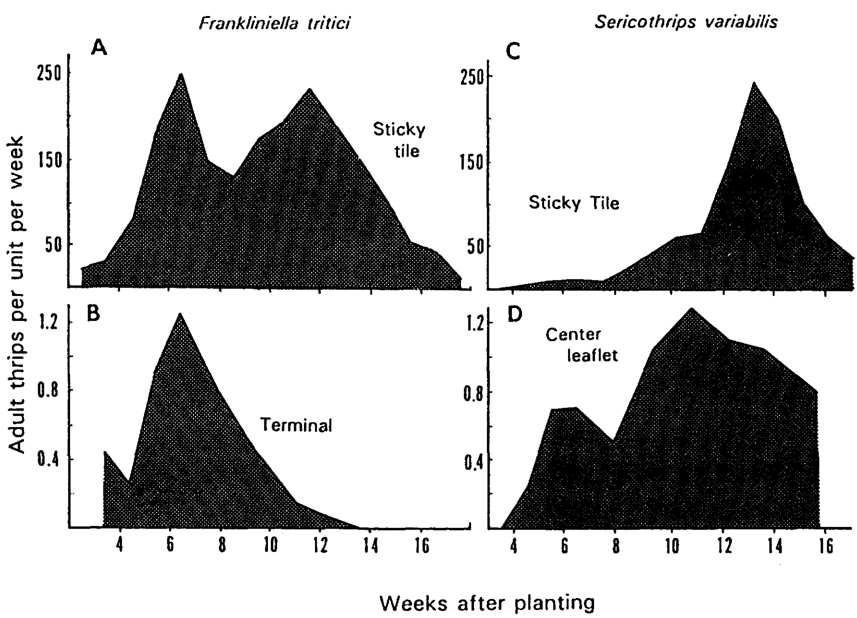

Figure 8. Seasonal phenologies of adult *Frankliniella tritici* (A, B) and *Sericothrips variabilis* (C, D), comparing abundances between flight activity patterns ("sticky tile," A, C) and population fluctuations within the soybean canopy ("terminal" and "center leaflet," B, D).

Conclusions

Thrips colonize and build up in a habitat in a very dynamic fashion. It is important to understand the factors that drive this process and therefore experimentation involving sampling strategies must be undertaken. From the study presented on the biological dynamics of two species of thrips in soybean, it is clear that if one lacked comparative data from horizontal sticky traps and plant part samples, it would be possible to wrongly conclude that *F. tritici* was the more abundant species in soybean and that it reached peak abundances in soybean twice during the season. I believe that this points to the dangers of using a sampling technique to accomplish an objective for which it was not designed.

I caution that sampling strategies for the pear thrips in sugar maple be tailored to the aspects of the biologies you wish to determine. It is far too easy to devise a sampling strategy that will provide bogus information, setting your program back by several seasons.

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