THE DISTRIBUTION AND PREVALENCE OF THE ALFALFA BLOTCH LEAFMINER (DIPTERA: AGROMYZIDAE) IN ILLINOIS

J. G. Lundgren[1,2], K. L. Steffey[3], and R. N. Wiedenmann[4]

ABSTRACT

Surveys were made in 2001 and 2002 to determine the distribution and prevalence of the alfalfa blotch leafminer, *Agromyza frontella* (Diptera: Agromyzidae), and its primary parasitoids, *Dacnusa dryas* and *Chrysocharis liriomyzae* (Hymenoptera: Braconidae and Eulophidae, respectively), in Illinois. We collected 239 samples from alfalfa fields in the alfalfa-producing regions of Illinois. Samples from each site consisted of 20 cut stems and 10 sets of 10 sweeps in 2001, and 40 stems and 10 sets of 20 sweeps in 2002. Each trifoliate was examined for mining and pinholing injury, and the number of adult *A. frontella*, *D. dryas*, and *C. liriomyzae* per 10 sweeps was calculated for each site. We found that 16.3% of the sites were infested with *A. frontella*, and all infested fields were north of 39.95º N latitude. Although up to 95% of stems were injured at some sites, mean injury per stem never exceeded 12% of trifoliates. Maximum adult abundance was 8.1 adults per 10 sweeps. We did not detect *D. dryas* or *C. liriomyzae* in any of the sweep samples. Because of consistently low populations and the relatively slow rate of *A. frontella's* spread in Illinois, we conclude that *A. frontella* is not a serious threat to alfalfa production in this state at this time.

The first North American detection of *Agromyza frontella* (Rondani) was in Massachusetts during 1968 (Miller and Jenson 1970). By 1983, *A. frontella* had been recorded in 15 states and Ontario, Quebec, and the maritime provinces of Canada (Bereza 1979, Hendrickson and Plummer 1983). By 1994, *A. frontella* had invaded the Midwest through Minnesota and Wisconsin (Hutchison et al. 1997); subsequent surveys detected pest populations in North Dakota and Illinois (Venette et al. 1999), and Manitoba (Lundgren et al. 1999). After the initial 1997 detection of *A. frontella* in McHenry County, IL, informal surveys failed to corroborate the presence of *A. frontella* in Illinois, and the distribution and sizes of pest populations in this state were unknown.

Intense infestations of *A. frontella* are associated with reduced digestible dry matter and protein content of alfalfa, *Medicago sativa* (Hendrickson and Day 1986). Attempts to relate plant injury to economic losses led to the establishment of action thresholds for *A. frontella* at 30 mines per stem (Hendrickson and Day 1986). In 1997, Minnesota populations of *A. frontella* mined 80% of stems with a peak of >40 mines per stem, and adult populations peaked at >275 adults per 10 sweeps (Venette et al. 1999). Wisconsin infestations during 1999 resulted in 100% of stems with mines and up to 20% of trifoliates with mines (Davis 2000). Management of *A. frontella* initially proved to be difficult; insecticide application is inefficient for suppressing *A. frontella* populations, and no alfalfa varieties are known to be resistant to *A. frontella* (Drolet and McNeil 1984, Hendrickson and Day 1986, Venette et al. 1999). A biological control program initiated in the

[1]Department of Entomology, University of Illinois, 320 Morrill Hall, 505 S. Goodwin Ave., Urbana, IL, 61801.

[2]Corresponding author. Address: Center for Ecological Entomology, INHS, 607 E. Peabody Dr., Champaign, IL; E-mail: jlundgre@uiuc.edu; Ph: 217-244-6867.

[3]Department of Crop Sciences, University of Illinois, S 322 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL, 61801.

[4]Center for Ecological Entomology, Illinois Natural History Survey, 607 E. Peabody Dr., Champaign, IL, 61820.

1970s has effectively suppressed *A. frontella* throughout much of its range (Drea and Hendrickson 1986). Of 14 parasitoids that were introduced, *Chrysocharis liriomyzae* (Delucchi) (Hymenoptera: Eulophidae) and *Dacnusa dryas* (Nixon) (Hymenoptera: Braconidae) were established. These two species have contributed to the suppression of *A. frontella* throughout its range (Drea and Hendrickson 1986, Heimpel and Meloche 2001), although multiple releases are required to control *A. frontella* where it has spread into new areas ahead of its natural enemies. The *A. frontella* invasion of the Midwest was unaccompanied by *D. dryas*, however the 1999 decline in Midwestern populations of *A. frontella* was attributed, in part, to high parasitism rates by *C. liriomyzae* in Wisconsin (Hutchison et al. 1997, Davis 2000). We were uncertain whether *D. dryas* or *C. liriomyzae* were established on *A. frontella* or native *Liriomyza* spp. in Illinois.

Concerns regarding the potential impact of *A. frontella* on Illinois alfalfa production and uncertainty about the presence of natural enemies prompted our surveys. More than 500,000 acres of alfalfa are harvested annually in Illinois (IASS 2002). Unnecessary insecticide applications for control of *A. frontella* might disrupt established biological control programs for the alfalfa weevil, *Hypera postica* (Gyllenhal), and pea aphid, *Acyrthosiphon pisum* (Harris).

A number of factors are involved in determining the distribution of an invading organism. The dispersion of food resources, climatic conditions, biotic resistance in the form of competition or predation, and many other factors influence the suitability of a particular habitat to invasion (Brown 1993, Williamson 1996). We hypothesized that *A. frontella* and its parasitoids had established in the major alfalfa-producing regions of Illinois; the goal of our research was to determine the distributions and sizes of *A. frontella*, *C. liriomyzae*, and *D. dryas* populations in Illinois.

MATERIALS AND METHODS

A sampling program was conducted by regional extension educators with University of Illinois Extension, and scientists from the departments of Entomology and Crop Sciences at the University of Illinois and the Illinois Natural History Survey. Samples were collected from sites within five days of the following dates: 10 May and 25 June 2001, and 13 June and 25 July 2002. The rate of degree-day accumulation was inversely proportional to latitude, making it difficult to target a specific life stage throughout the entire sample range. Consequently, sample dates were selected to represent periods when *A. frontella* is active in other portions of its geographic range, and several sampling methods were applied to assess the populations of multiple life stages of the pest. In 2001, 101 samples consisting of 20 stems and 10 sets of 10 sweeps were collected from sites in 37 counties. In 2002, 138 samples consisting of 40 stems and 20 sets of 10 sweeps were collected from sites in 40 counties; counties where *A. frontella* was detected in 2001 were not resampled in 2002. Efforts were made to represent the major alfalfa-producing regions of Illinois in the 239 samples (Fig. 1). For each sample site, latitude and longitude were recorded with a GPS unit, or latitude and longitude were later calculated from locations marked on a map (Illinois Atlas & Gazetteer, 3rd edition, DeLorme Publishers, Yarmouth, ME). Sample sites for a single date did not occur within 1.6 km of each other, and the alfalfa at selected sites was at least 0.3 m tall. In many cases the history of the site was unknown, and so we didn't distinguish fields treated with insecticides. Stem and sweep samples were mailed overnight to the University of Illinois in Champaign and stored at 5°C until they were processed.

The severity and incidence of injury and the densities of adult insect populations were estimated for each site. The total number of trifoliates, the number of trifoliates with *A. frontella* mines, and the number of trifoliates with pinholing injury were counted on each stem. Mining incidence, the proportion of stems displaying plant injury, and severity, the proportion of trifoliates per stem that

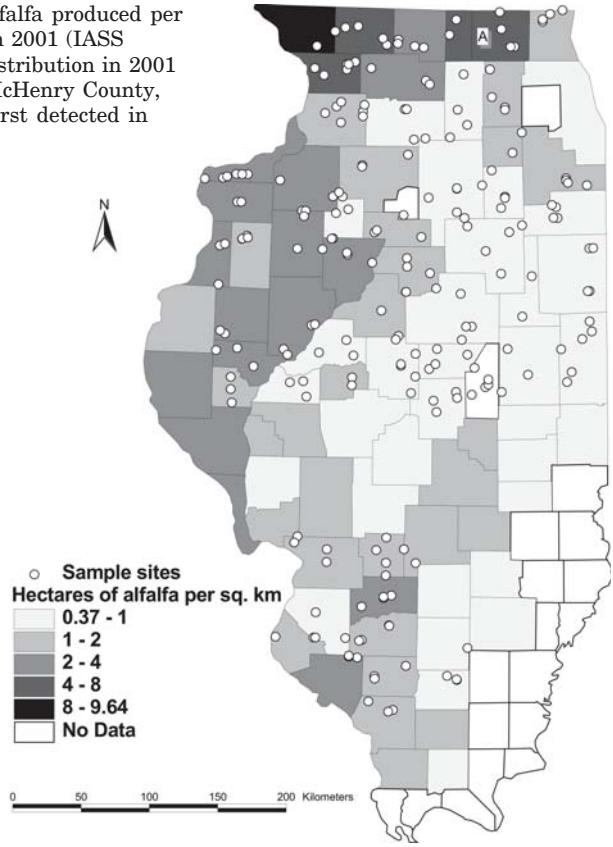

Figure 1. Hectares of alfalfa produced per km^2 in Illinois counties in 2001 (IASS 2002), and sample site distribution in 2001 and 2002. 'A' indicates McHenry County, where *A. frontella* was first detected in Illinois.

displayed injury, were calculated for each site. Sweep samples were examined under a microscope at 50x magnification for *A. frontella*, *C. liriomyzae*, and *D. dryas* adults. *Agromyza frontella* was identified using the description created by Steyskal (1972), and parasitoids were identified using the keys of Wharton et al. (1997) and Gibson et al. (1997). The mean number of *A. frontella* adults and parasitoids per 10 sweeps was calculated for each site. Voucher specimens of *A. frontella* were deposited in the arthropod collection at the Illinois Natural History Survey.

The number of *A. frontella* adults and degree of injury were entered into a database and imported into ArcView GIS 3.2 (Environmental Systems Research Institute [ESRI], Redlands, CA). The probability of infestation based on presence/absence data was interpolated for areas between sample sites with information from the nearest 10 sample sites using Spatial Analyst 2 (ESRI).

RESULTS

We detected *A. frontella* at 16.3% of the 239 sample sites. Most infestations (82%) occurred north of 41ºN latitude, and no infestations were detected south of 39.95ºN latitude (Table 1). The highest levels of injury and the largest adult population densities occurred in the northernmost counties (Boone, DeKalb,

Lake, Ogle, Stephenson, and Winnebago counties) (Tables 1 and 2). Adult flies were captured at 10.0% of sample sites, mines were collected at 3.8% of sites, and there were six infestations characterized only by pinholing injury. Although as many as 95% of stems displayed damage at some northern sites, the percentage of mined trifoliates on infested stems never exceeded 12% (Table 1). The majority of adult populations were detected north of 40.73º N latitude, and no sites exceeded 8.2 adults per 10 sweeps (Table 2). No adult *D. dryas* or *C. liriomyzae* were found in the sweep samples.

Agromyza frontella was detected a maximum of 280 km from the original 1997 infestation in McHenry County. Interpolation of all samples with Spatial Analyst yielded the estimated probability of infestation (Fig. 2). The GIS model produced estimates of the highest probability of infestation in northeastern Illinois within 130 km of McHenry County, and no infestation in the southwest half of the state (Fig. 2).

DISCUSSION

Although there is a high probability of infestation by *A. frontella* in much of northern Illinois (Fig. 2), we conclude that this exotic pest currently poses minimal risk to Illinois alfalfa producers. Hendrickson and Day (1986) set an economic threshold for *A. frontella* infestations at 30 third-instar mines per stem. The maximum mean (SEM) number of mines per stem in Illinois occurred in Boone County and was 5.25 (0.84) mines; most infested sites had much lower levels of mining (Table 1). Interestingly, neither the intensity of the infestation nor the predicted probability of infestations appear to be well correlated with alfalfa production (Figs. 1 and 2). Comparatively favorable conditions, at least six years of residency and a high number of degree-day accumulations in Illinois relative to other infested Midwestern regions, have not produced economically damaging populations of *A. frontella*. Thus, we believe that *A. frontella* is not a serious threat to alfalfa production in Illinois, although alfalfa producers should be sensitive to potential *A. frontella* outbreaks.

In addition to the low population levels, *A. frontella* range expansion is slower (47 km/yr) in Illinois than previously observed in the Midwest (Venette et al. 1999) or in New England (Hendrickson and Plummer 1983). Historically, spread of *A. frontella* has occurred at a rate of 80–93 km/yr; at that rate, Illinois should be infested at least 480–560 km south of McHenry County. Our surveys showed that *A. frontella* has not spread in Illinois at the rate observed throughout much of the pest's range, nor has it experienced the types of population growth rates that are characteristic of this species (Harcourt and Binns 1980, Venette et al. 1999). Interestingly, Hendrickson and Plummer (1983) alluded to *A. frontella* populations spreading at a rate similar to that observed in our study (48 km/yr) in Ohio, a state with a latitude, and perhaps climatic conditions, similar to that of Illinois.

Biotic and abiotic sources of mortality are potential explanations for the current distribution and abundance of *A. frontella* in Illinois (Brown 1993). Successful invasion by any pest depends, in part, on the climatic suitability of a region to the particular physiological requirements of a pest. Temperature, moisture, and prevailing wind direction and velocity are important abiotic factors affecting insect population dynamics and may be playing a role in slowing *A. frontella's* spread through Illinois. Climate also may increase the susceptibility of *A. frontella* to predation or parasitism by native or introduced parasitoids. The mortality inflicted on *A. frontella* populations by *C. liriomyzae* in Wisconsin (Davis 2000) leads us to believe that this parasitoid may be in Illinois, despite our inability to detect it with sweep samples. Collecting small parasitoids is difficult with sweep samples when they are at low densities. Collection of living *A. frontella* and native *Liriomyza* spp. larvae or pupae and rearing primary parasitoids is an important next step toward estimating the degree of mortality

Table 1. Leafmining injury by *Agromyza frontella* in Illinois alfalfa in 2001 and 2002.

County	Site information			Mining incidence[1]	Mining severity[2]
	Year	Latitude	Longitude		
Boone	2001	42.43	-88.85	0.95	0.118
Boone	2001	42.33	-88.91	0.65	0.094
Lake	2001	42.43	-88.08	0.65	0.030
Ogle	2001	42.02	-89.12	0.31	0.007
Mercer	2001	41.20	-90.72	0.15	0.005
Kane	2001	41.83	-88.42	0.10	0.008
Iroquois	2001	40.63	-87.68	0.05	0.003
Tazewell	2001	40.50	-89.48	0.05	0.001
Piatt	2002	39.97	-88.44	0.03	0.001

[1] Incidence is defined as the proportion of stems with at least one mined trifoliate.
[2] Severity is defined as the mean proportion of mined trifoliates on injured stems.

Table 2. Adult *Agromyza frontella* densities at infested sites in 2001 and 2002.

County	Site information[1]		Adults per 10 sweeps
	Latitude	Longitude	
Stephenson	42.30	-89.50	8.30
DeKalb	41.73	-88.75	4.90
Stephenson	42.37	-89.83	4.30
Winnebago	42.27	-89.37	2.30
McHenry	42.48	-88.47	1.40
Lee	41.83	-89.28	1.10
McHenry	42.37	-88.45	0.80
Will	41.35	-87.87	0.40
Grundy	41.43	-88.53	0.40
Will	41.33	-87.70	0.30
Boone	42.37	-88.83	0.30
Stephenson	42.26	-89.47	0.20
Ogle	42.00	-89.08	0.20
DeKalb	42.07	-88.78	0.20
Ten infested sites with 0.10 or fewer adults per 10 sweeps[2]			

[1] All injury reported in the table was discovered at designated sites in 2001.
[2] Samples infested with fewer than 0.1 adults per 10 sweeps were collected in Bureau, Carroll, JoDaviess, Kane, Kendall, Knox, Lake, Lee, and Woodford counties in 2001 and 2002.

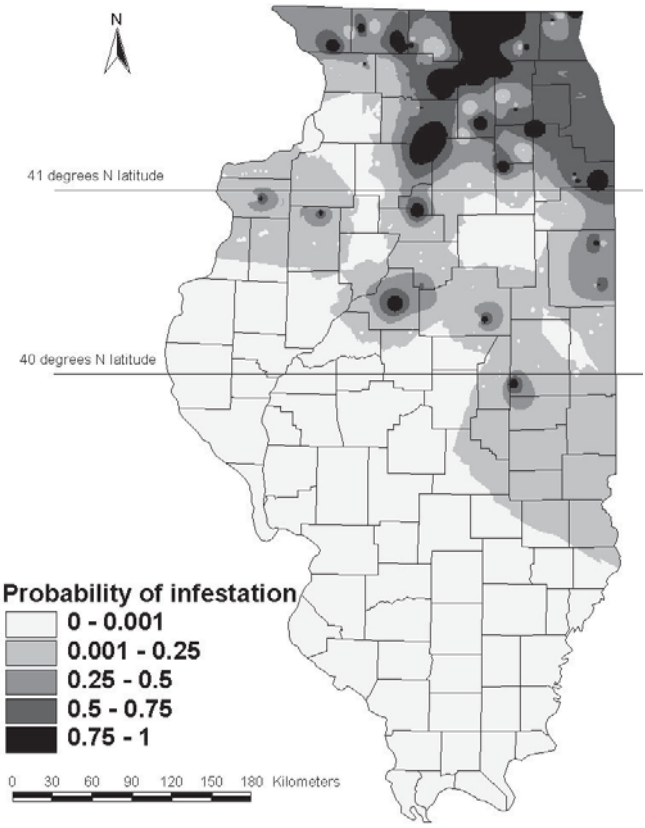

Figure 2. The probability of infestation by *Agromyza frontella* based on 239 samples collected throughout Illinois in 2001 and 2002 (see text for data analysis). A site was considered infested if *A. frontella* adults were collected or if mining/pinholing injury was detected.

that introduced biological control agents are inflicting on *A. frontella* populations in Illinois.

From our study, it is impossible to definitively determine what factors are restricting the range of *A. frontella* in Illinois, although the range is not restricted by alfalfa availability. Relating the physiological requirements of *A. frontella* to the climatic conditions of Illinois and determining the interactions among *A. frontella*, *Liriomyza* spp., and their natural enemies may allow us to explain the current distribution of *A. frontella* in Illinois more completely. Furthermore, these experiments will help us understand the potential risk posed by this pest to alfalfa production in this state.

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