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Spring Dispersal of Some Leafhoppers and Aphids

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Spring Dispersal of Some Leafhoppers and Aphids[1]

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ABSTRACT — Two species of leafhoppers and four species of cereal aphids appear to be transported to Minnesota each spring on strong winds from the south or southwest. The aster leafhopper, *Macrosteles fascifrons* (Stal); the English grain aphid, *Macrosiphum avenae* (Fabr.); the apple grain aphid, *Rhopalosiphum fitchii* (Sand.); and the greenbug, *Schizaphis graminum* (Rond.), usually arrive in Minnesota during late April or early May. Weather conditions favorable for northward movement of these insects consist of a high pressure area over the eastern states, a low pressure area over the western plains, and the resulting strong, persistent, south wind which is often called a low-level jet. The potato leafhopper, *Empoasca fabae* (Harris), usually arrives in southern Minnesota about May 20 and in central Minnesota about May 25. By mid-June it has usually dispersed to the northern part of the state. The corn leaf aphid, *Rhopalosiphum maidis* (Fitch), usually arrives during early June.

For the past 16 years the authors have been interested in the northward dispersal of leafhoppers and aphids into Minnesota each spring. Two species of leafhoppers and four species of aphids are apparently transported to Minnesota on warm winds from the southern states. From 1954 to 1961 seasonal appearances of the potato leafhopper were observed in cooperation with North Central Regional Project NC-29 entitled "Causes of Outbreaks of the Potato Leafhopper, *Empoasca fabae* (Harris)."

Leafhoppers were collected by sweeping alfalfa and clover fields with a 15-inch insect net, by light traps, and by air socks which were located on the roof of 4-story Green Hall on the St. Paul Campus of the University of Minnesota and on the 14-story Mayo Memorial Hospital on the Minneapolis Campus. Each air sock was similar to a large insect net with an opening of 5 sq. ft. The frame was equipped with a wind vane to keep the mouth of the net directed into the wind. Appearances of the leafhoppers were related to weather patterns, and information gathered in all of the North Central States was coordinated through a regional committee.

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A similar north central regional project was initiated in 1961 to study the long distance dispersal of cereal aphids (NC-69 entitled "Migrations of Aphids and Noctuids"). First seasonal appearances of aphids were determined by yellow pan traps, field collections with a 15-inch insect net, an air sock on the roof of Green Hall, and a Johnson-Taylor suction trap, also on the roof of Green Hall. The suction trap has some advantages in that it runs continuously and is not dependent on wind for its operation. The air sock, on the other hand, depends on the wind for its effectiveness as a collecting device.

First appearances of the aster leafhopper. *Macrosteles fascifrons* (Stål), also were recorded each spring. These were based on field collections with an insect net and daily collections in the air sock and suction trap.

The Potato Leafhopper

The potato leafhopper, *Empoasca fabae* (Harris), is a toxicogenic insect which causes hopperburn on potatoes, yellowing and stunting of alfalfa and clovers, and severe injury to a number of ornamentals. It overwinters in southern Louisiana, southern Mississippi, and northern Florida (Medler, 1962; Decker and Cunningham, 1968). Numerous observations indicate that this species is not able to overwinter in the northern states (Poos, 1932; DeLong and Caldwell, 1935; DeLong, 1938; Medler, 1940). Decker and Cunningham (1967) found that adults survived less than 48 hours at 25° F. Decker and Cunningham (1968) conclude that overwintering of *E. fabae* is limited to areas which have frost-free periods of at least 260 to 270 days. Both adults and nymphs have been found in Minnesota as late as November, but they always disappear after temperatures have remained below 20° F. for several days. The adult stage is the first to appear in the spring, and nymphs do not occur until approximately 3 weeks later. Convincing evidence for northward movements of the potato leafhopper each spring has been summarized by Medler (1957) and Pienkowski and Medler (1964).

The first spring records for the potato leafhopper in Minnesota for the period 1952-60 are presented in

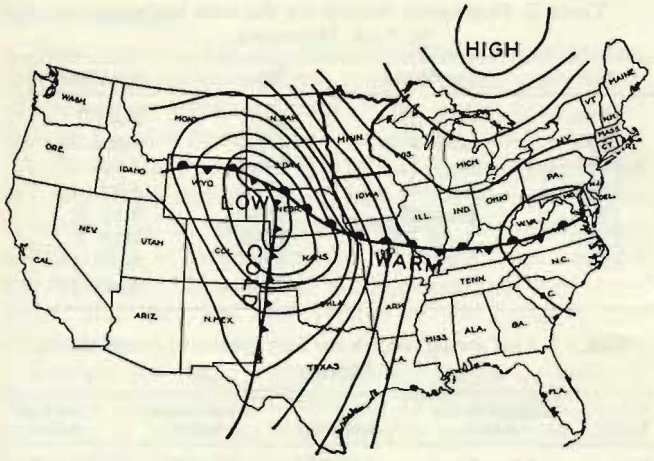

FIGURE 1. Weather map showing the northward advance of a warm front at 12:30 P.M. on May 20, 1957.

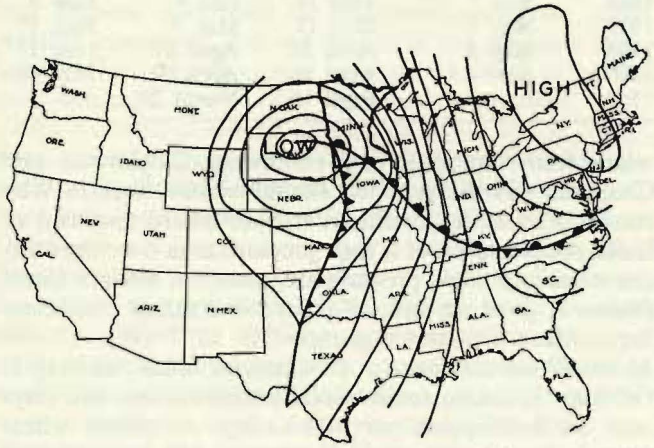

FIGURE 2. The warm front reaches southern Minnesota. 6:30 A.M., May 21, 1957.

Table 1. A comparison of the first collection dates for St. Paul with the phenological sequence of spring events as recorded by Hodson (1961) indicates that arrival of *E. fabae* in the St. Paul area each year is not related to the state of the season (Table 1). A close association was observed between the first arrival of the leafhoppers in Minnesota and the arrival of warm air masses from the southern United States. Similar observations have been published by Pienkowski and Medler (1964).

TABLE 1. First spring records for the potato leafhopper in Minnesota.

Year	So. Minn.	St. Paul	Stage of Spring St. Paul, May 25[1]	No. Minn.
1952	June 2	June 2	Early	June 11
1953	May 25	May 30	Late	June 16
1954	May 25	June 2	Late	July 1
1955	May 21	May 25	Early	June 7
1956	May 22	May 26	Late	June 10
1957	May 23	May 27	Average	June 23
1958	May 23	May 27	Early	June 16
1959	May 12	May 19	Average	June 10
1960	May 17	May 30	Late	June 28

[1] According to a 20-year record of spring events (Hodson, 1961)

The advance of a typical warm front is illustrated by some 1957 weather charts (Figs. 1-3). Note the high pressure area to the east and the low pressure area to the west. Strong, sustained south or southwest winds result from the clockwise movement of air around the high and the counter-clockwise movement of air around the low. Frequently a stationary front develops along the line where the warm air from the south meets the colder air from the north. As the cold air chills the warmer air, the leafhoppers tend to fall out. No potato leafhoppers were found in southern Minnesota during rather intensive collecting on May 16 and May 20, 1957. On May 21 a warm front arrived, and it was pushed across southern Minnesota by a cold front (Figs. 1-3). On May 23 *E. fabae* averaged 42 per 100 sweeps of an insect net in southeastern border counties and occurred in decreasing numbers as far north as Hader (Goodhue County) and as far west as Fairmont (Martin County). Subsequently, there appeared to be a gradual dispersal of the leafhoppers northward. They were first collected at St. Paul on May 27, Grand Rapids on June 10, and Stephen on June 23. They apparently did not reach Roseau on the Canadian border until some time after June 27. During May of this same year, Glick (1960) col-

FIGURE 3. A cold front has pushed the warm front across southern Minnesota. 6:30 P.M., May 21, 1957.

FIGURE 4. Weather map showing favorable conditions for the dispersal of the aster leafhopper and cereal aphids to Minnesota. 6:30 A.M., May 7, 1957.

lected *E. fabae* by airplane at altitudes of 200 to 4,000 feet over Louisiana, Mississippi, Arkansas, Indiana, and Illinois.

In 1958, the first appearance of *E. fabae* in southern Minnesota border counties was associated with a warm front which approached southern Minnesota on May 22 and was quickly driven eastward across the state by a cold front. After arrival of a second warm front on May 26, leafhoppers were distributed over a broad area in south central Minnesota including the Twin Cities.

The following year a warm front reached southern Minnesota on May 10, and potato leafhoppers occurred 1 per 100 sweeps in the southern counties on May 12. A few leafhoppers were probably carried as far north as St. Paul, because one was caught in a light trap on May 19. A second front passed over central Minnesota on May 26. Near St. Paul an alfalfa field was negative for leafhoppers on May 24 of that year, then on May 27, *E. fabae* averaged 23 per 100 sweeps along the protected southern and western portions of this field and 4 per 100 sweeps in the less protected northern and eastern portions of the field.

Again in 1960 it was observed that leafhoppers became distributed first in southern Minnesota and later in central Minnesota following northward movement of successive warm fronts. In some years there was evidence for additional dispersals of leafhoppers northward to Minnesota during June and even during early July. It was not possible to associate the arrival of leafhoppers in the northern half of the state with regional weather patterns, and it may be presumed that distribution over the northern area results from more local movements of leafhoppers.

Although the first appearance of the potato leafhopper in Minnesota can be predicted by studying weather maps, this alone does not necessarily help in the prediction of outbreaks. A combination of a reasonably large initial population of leafhoppers, warm weather during June and early July, and the presence of succulent host plants appears to be necessary for the increase of *E. fabae* to economically dangerous levels.

The Aster Leafhopper

The aster leafhopper, *Macrosteles fascifrons* (Stal), has been found to disperse northward from the winter grain areas in Texas, Oklahoma, Kansas, Louisiana, and Arkansas to the northern states and Canada each spring (Drake and Chapman, 1965; Chiykowski and Chapman, 1965). This leafhopper in its egg stage can overwinter in Minnesota in stems of grasses such as rye, bromegrass, quackgrass, crabgrass, and timothy (Meade and Peterson, 1964). But the adults from the south arrive 3 to 4 weeks before the overwintering eggs hatch. Some of the adults are already infective with the aster yellows virus upon their arrival in Minnesota. This virus affects production of lettuce, celery, and carrots, and in 1957 and 1966 caused extensive losses to potatoes and flax.

The dates for first collections of the aster leafhopper in Minnesota for 1954-67 are shown in Table 2. Their first arrival has been associated with strong, sustained winds from the south and southwest. Chiykowski and Chapman (1965) reported similar observations in Wisconsin. Favorable conditions for northward dispersal of leafhoppers consist of a high pressure area over the eastern states and a low pressure area over the western Great Plains. A good example of favorable weather conditions for northward dispersal occurred in 1957 (Fig. 4). No *M. fascifrons* was found at Rosemount, Minn., on May 1. On May 7, strong south winds prevailed, and two days later 90 leafhoppers per 100 sweeps on winter wheat were collected. This seemed to mark the beginning of the severe infestation. It should be pointed out that the extensive crop losses experienced in 1957 resulted from a combination of circumstances. There were large numbers of aster leafhoppers, and an unusually large proportion of these leafhoppers was infective with the aster yellows virus.

TABLE 2. First spring records for the aster leafhopper at St. Paul, Minnesota.

Year	First Record	Year	First Record
1954	May 13	1961	May 7
1955	May 4	1962	April 26
1956	May 11	1963	April 17
1957	May 9	1964	April 16
1958	May 15	1965	May 4
1959	April 26	1966	May 5
1960	May 2	1967	April 14
		1968	April 15

TABLE 3. First spring records for four species of cereal aphids in Minnesota.

Year	English Grain Aphid	Greenbug	Apple Grain Aphid	Corn Leaf Aphid
1961	May 28	May 31	June 9	June 4
1962	May 26	May 5	June 7	June 7
1963	May 3	May 24	May 3	June 3
1964	May 7	May 18	July 8	June 9
1965	May 3	May 11	May 7	June 17
1966	May 3	April 28	April 27	June 13
1967	April 15	April 16	April 19	May 30
1968	April 16	April 16	March 29	

The aster leafhopper was reported to be a serious pest on barley in Oklahoma during late March and early April, 1963. Insecticides were applied to some grain fields to control the insect (U.S.D.A. Cooperative Economic Insect Report 13:316, 392, 429). Strong southwest winds occurred in Minnesota on April 16, and on April 17 the first *M. fascifrons* of the season were found. There was another strong south wind on May 7, and the next day 1,500 aster leafhoppers were gathered per 100 sweeps on winter wheat at St. Paul. There was fear of an outbreak of aster yellows similar to that of 1957, but, relatively few of these leafhoppers were infective with the aster yellows virus, and no such outbreak occurred.

As concluded by Meade and Peterson (1967), outbreaks of the aster leafhopper appear to depend on the numbers of leafhoppers, on warm weather during May and June, on the presence of succulent host plants, and also on the incidence of virus in the leafhopper population.

Cereal Aphids

Four species are of concern here: the greenbug, *Schizaphis graminum* (Rond.); the English grain aphid, *Macrosiphum avenae* (Fabr.); the apple grain aphid, *Rhopalosiphum fitchii* (Sand.); and the corn leaf aphid, *Rhopalosiphum maidis* (Fitch). The English grain aphid, the greenbug, and the corn leaf aphid are not known to overwinter in Minnesota; however, the apple grain aphid is able to overwinter here in the egg stage on apple and hawthorn. These aphids are important pests of cereal crops, and they are also vectors of the barley yellow dwarf virus.

Records for the cereal aphids are shown in Table 3. Wadley (1931) believed that the 1926 outbreak of the greenbug in Minnesota was probably initiated by windborne aphids from Oklahoma.

Observations during the past 7 years indicate that the English grain aphid, the apple grain aphid, and the greenbug disperse northward to Minnesota under the same weather conditions that are favorable for the aster leafhopper (Fig. 4); all appear after strong south or southwest winds of 1 to 3 days duration. Hodson and Cook (1960) described similar conditions under which greenbugs and harlequin bugs were transported into Minnesota in considerable numbers during early May of 1959 after large populations of those insects were reported in Oklahoma and Texas. According to Wallin, Peters, and Johnson (1967), the development of a low-level jet wind from south to north is associated with the same weather picture in which a high pressure area exists over the eastern states, a low pressure area occurs over the western plains, and a stationary front extends from southwest to northeast in the northern states. The latter authors associate the first arrival of the greenbug at Ames, Iowa, on May 3, 1965, with a low-level jet wind, and the date corresponds closely to records of the first English grain aphid in Minnesota on May 3 and the aster leafhopper on May 4.

Discussion

Definite proof for long distance dispersal of leafhoppers and aphids such as might be provided by marked individuals is lacking, however, the evidence seems convincing. Early collections each spring are negative. Then adult insects appear suddenly, and their appearance is associated with warm air masses moving northward from the southern states. The first adults usually appear much too early to have developed from overwintering eggs. In 1968, for example, collections from the suction trap included a winged adult of the apple grain aphid on March 29 and 3 more on April 1.

Finally, numbers of insects arriving in Minnesota seem to be related to numbers of insects in the overwintering areas southward.

During the past few years, the aster leafhopper, the apple grain aphid, the English grain aphid, and the greenbug arrived in Minnesota during April or early May. The potato leafhopper arrived quite regularly in late May, while the corn leaf aphid did not appear until early June. As Medler (1962) suggested, the potato leafhopper has farther to come than the aster leafhopper or the cereal aphids, so the potato leafhopper can be expected to arrive at a later date.

Hodson and Cook (1960) point out that outbreaks of greenbugs in Minnesota might be predicted by knowing the relative abundance of the aphid in the overwintering area and by watching weather maps to determine when conditions become favorable for long distance transport of the greenbugs. The same is true for the English grain aphid, the apple grain aphid, and both species of leafhoppers. However, more needs to be known about conditions which favor a rapid increase of these insects after they reach Minnesota, since all 6 species seem to be transported northward to this state every year. Moreover. there may be several periods each year which are favorable for long distance dispersal.

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ENTOMOLOGY

Distribution and Emergence Patterns of Mayflies Ephemera simulans *(Ephemeroptera: Ephemeridae)*

CALVIN R. FREMLING * and GERRIT P. KLOEK **

ABSTRACT — Analyses of collections made during the years 1961-1964 reveal that *Ephemera simulans* is widely distributed in the lake regions of Minnesota and Wisconsin. The period of maximum emergence in central Minnesota and northern Wisconsin occurs during the last three weeks in June, the peak in extreme northern Minnesota about two weeks later.

Collections of Mayflies in the lake regions of Minnesota and Wisconsin during the years 1961-1964 revealed three species, *Hexagenia bilineata* (Say), *Hexagenia limbata* (Serville), and *Ephemera simulans* (Walker) were predominant. One or more of these species is usually present when shoreline residents and motorists experience nuisance problems with Mayflies in the areas studied. All three species are large and tend to emerge *en masse*.

H. bilineata was collected only from the Mississippi River and its tributaries. *H. limbata* was collected from lakes, rivers, and streams. *E. simulans* was collected from lakes and rivers. *H. limbata* was usually found in association with *E. simulans*.

A comprehensive review of the biology of *E. simulans* has been presented by Britt (1962). The effects of respiration and substrate upon distribution have been reported by Ericksen (1964). *E. simulans* has been previously reported from Minnesota by Needham, Traver, and Hsu (1935) and by Daggy (1941). The species has been reported from Wisconsin by Baker (1924).

For this study specimens were recorded according to the state, county and respective latitude of places where gathered, proceeding from south to north. Locations of the collecting points are presented in Figure 1.

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** GERRIT P. KLOEK received the B.S. degree at Winona State College and is presently completing work for the Ph.D. degree in zoology at Southern Illinois University.

Minnesota Locations

RUM R., Anoka Co., 7-VI-63. GREEN L., Kandiyohi Co., 11-VI-62, 12-VI-62. MISSISSIPPI R., Stearns Co., 9-VI-63, 8-VI-64. GRINDSTONE L., Pine Co., 14-VI-63, 10-VI-64. MILLE LACS L., Mille Lacs Co., 4-VI-61, 9-VI-61, 20-VI-61, 26-VI-62, 4-VII-63, 7-VII-63, 10-VII-63, 11-VII-63, 22-VII-63, 12-VI-64, 23-VI-64, 21-VII-64. BATTLE L., Otter Tail Co., 30-VI-62, 19-VI-63, 9-VII-63, 27-VI-64. WHITE SAND L., Crow Wing Co., 5-VI-61, 6-VI-61. OTTER TAIL L.,

FIGURE 1. — Emergence records of *Ephemera simulans* in Minnesota and Wisconsin in 1961-1964. Each dot indicates a body of water from which one or more collections was made.