A SURVEY FOR POSSIBLE VIRUS DISEASE VECTORS OCCURRING ON THE CULTIVATED BLUEBERRY *VACCINIUM CORYMBOSUM* LINNAEUS

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ABSTRACT

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by Thomas Lee Burger

During the spring and summer of 1964 a survey of possible virus disease vectors occurring on cultivated blueberry, Vaccinium corymbosum Linnaeus, was conducted in southwestern Michigan. Objectives of the survey were to correlate differences occurring between counties and between farms in the counties as to species of Arthropods present and virus disease incidence. Observations on other Arthropods were also made.

Survey sites were chosen on the bases of acreage and disease incidence appearing in areas under intensive cultivation of the high-bush blueberry.

At the conclusion of the study the results indicate that:

1. Scaphytopius magdalensis (Prov.), a leafhopper known to be a vector of stunt disease in New Jersey, is present in Michigan.

2. Separation of Scaphytopius magdalensis (Prov.) from other species of the same genus occurring in Michigan, has been accomplished on the bases of anatomical characteristics and color variation.

3. There are a number of insect species present in Michigans' cultivated blueberry fields, capable of transmitting virus diseases.

4. Virus disease incidence is increasing annually in Michigans' cultivated blueberry fields.

5. Shoestring, a virus disease of highbush blueberries, has remained at a low incidence level in Berrien County, Michigan which may be due to the absence of Myzus scammelli, an aphid.

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INTRODUCTION

Background History

Vaccinium corymbosum Linnaeus, the cultivated highbush blueberry, has been an economic asset to the agriculture of Michigan, contributing over $5,000,000 annually to the State's economy. The acreage of cultivated blueberries has been restricted to certain areas of southwestern Michigan where climatic and soil conditions favorable for growing highbush blueberries are present. In general, blueberries require a temperate climate, a soil with low pH, and a high water table. These agronomic characters are present only in the southwestern section of the State near Lake Michigan.

While great advances have been made in agriculture pertaining to blueberry production, there are some factors which cause a reduction in potential production that need investigation. One such area of lower production includes fungus, bacterial and virus diseases of blueberries.

In the last 10 to 15 years, there has been an increase of not only numbers of diseased bushes but also an increase of new blueberry diseases. The diseases of the highbush blueberry are not restricted to Michigan alone, but may be found in other blueberry-growing areas of the United States including New Jersey, which competes with Michigan as a major producer of cultivated blueberries.

Research entomologists and plant pathologists in New Jersey have

investigated the spread of diseases, particularly virus diseases. One virus disease, commonly known as blueberry stunt, which has seriously threatened the blueberry industry in New Jersey, has been the object of research efforts the past 15 to 20 years. The disease, first observed in 1928, was described and named by Wilcox (1942) when its virus nature was demonstrated by budding techniques. Further investigations have been conducted since 1943 by research personnel employed by the New Jersey Agricultural Experiment Station. They have determined that an insect vector known as Scaphytopius magdalensis (Prov.) is responsible for the transmission of blueberry stunt disease; this vector belongs to the family Cicadellidae in the class Insecta. Determination of this species of leafhopper as the insect vector was not accomplished without extensive investigation and elimination of many of the other possible disease vectors found in the insect class.

Insects are not the only biological agents suspected of the transmission of the different virus diseases. Investigations involving nematode, mechanical and root grafting transmission are currently being conducted.

In 1963, the Michigan Blueberry Growers' Association proposed that a research project should be initiated to determine how virus diseases are being spread in commercial plantations in Michigan. Before detailed investigations could be initiated, it was necessary to determine the possible virus disease vectors present in commercial plantings. The preliminary survey program was divided into two parts: the first to determine by survey techniques the nematode species present in the fields, and the second to survey and determine possible insect vectors present in the blueberry fields.

During the 1964 growing season, a survey of the insect fauna was taken. The objectives were to obtain a cross-section of the insect fauna present in the fields throughout the growing season, which is the most probable time for disease transmissions. Another objective of the survey was to eliminate and reduce the number of species of insects that would be required for further tests on transmission of blueberry virus diseases, such as stunt, red ringspot, shoestring, mosaic, and necrotic ringspot.

Distribution and Economic Importance

The highbush blueberry is native from northern Florida to southern Maine and westward to southern Michigan. Michigan and New Jersey lead in the production of cultivated blueberries, with other areas such as Indiana, North Carolina and Washington having sizeable acreage under cultivation. Smaller areas under cultivation can be found in New York, Pennsylvania, Ohio, several New England states and Oregon as reviewed by Dorr (1965).

In Michigan, there is a distinct demarcation between areas where cultivated highbush blueberries and native lowbush blueberries are found (Plate 1). The line runs from Bay City southwest across the state to a point just north of Grand Rapids, then northwest along the isothermal line to the shore of Lake Michigan. The northerly projection on the west side of the state is due to the moderating influence of Lake Michigan.

The areas under the highest cultivation of highbush blueberries are confined to five counties: Berrien, Van Buren, Allegan, Ottawa and Muskegon (Plate 1). The 1964 census of the Michigan Blueberry

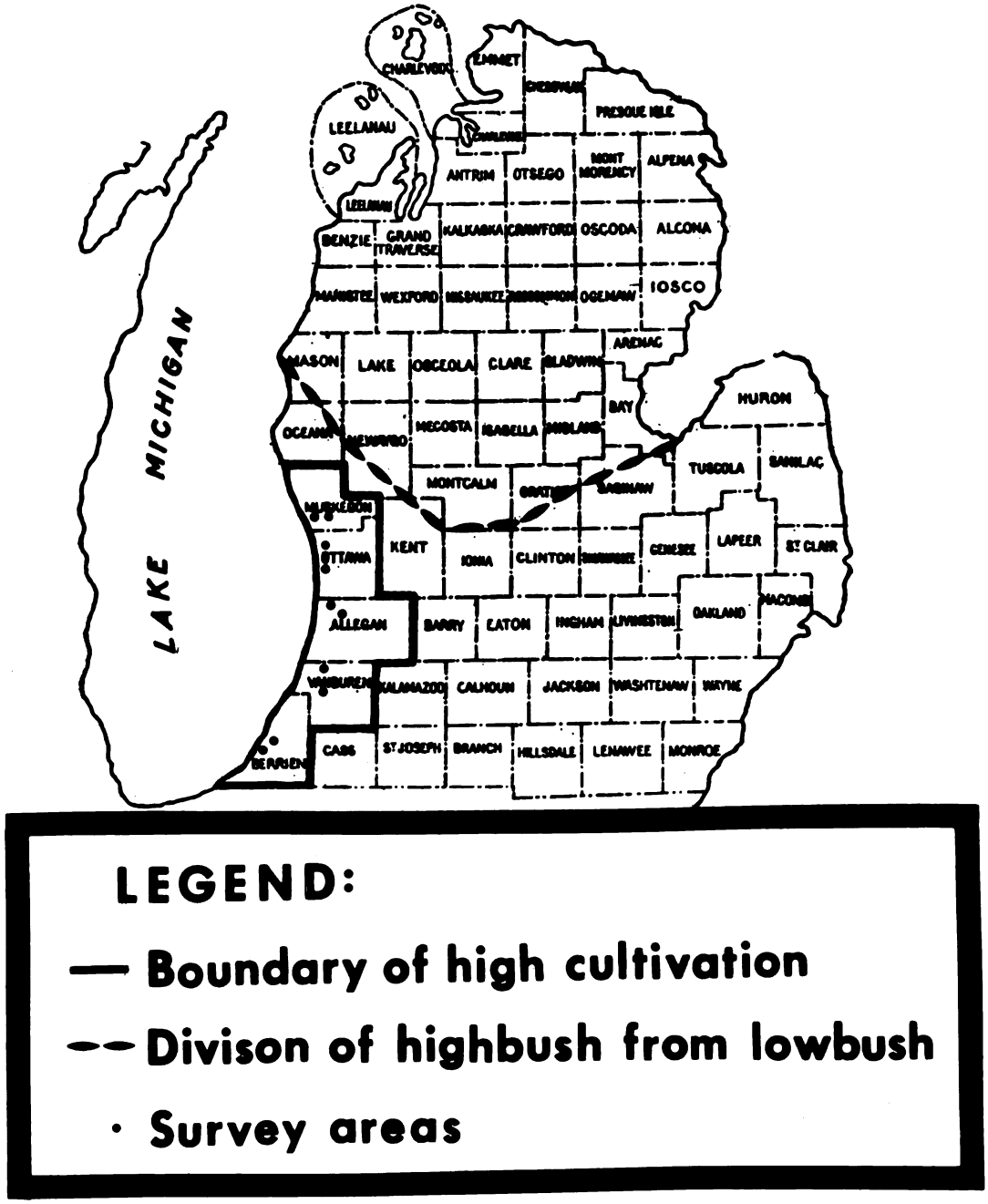

Plate 1.--Map of Michigan showing blueberry areas.

Growers' Association shows that 9,000 acres of land in these five counties are under cultivation of the highbush blueberry.

Total acreage of highbush blueberries is increasing annually in Michigan, but due to the requirements needed for growing, the increase is small. In 1965, the cultivated blueberry industry was valued at over five million dollars (Hobein, 1965, personal interview).

Nature of the Problem

Members of the Michigan Blueberry Growers' Association and the Departments of Botany and Plant Pathology and Entomology hypothesized that production of the highbush blueberry crop could be increased by improved disease control, particularly in the area of insect-transmitted viruses. In order to provide information on this problem, a program was initiated to survey the insect fauna present in cultivated blueberry fields, and more specifically, to determine the presence of possible virus disease vectors.

Since 1942, when Wilcox (1942) first discovered and isolated the stunt disease of highbush blueberries in New Jersey, several research workers have carried on a continuous search for insect vectors of blueberry virus diseases. Tomlinson, Marucci and Doelhert (1950) reported transmission of blueberry stunt by a complex of Scaphytopius magdalensis (Prov.) and S. verecundus (Van Duz.). One of the principal reasons the survey was undertaken was to determine whether these insect vectors were present in Michigan.

The last insect survey of Michigan's highbush blueberries was taken by Tuttle (1947), the main collecting method being a sweep net. Since then, many new and more advanced collecting techniques have

been introduced.

The research project was designed to determine: (1) possible new pests that have entered into the blueberry insect problems; (2) possible disease vectors present; and (3) distribution of possible vectors of blueberry diseases. This survey was conducted on two farms in each of the five counties that contain the highest acreage of cultivated blueberries in Michigan (Plate 1).

LITERATURE REVIEW

Blueberry Viruses and Vectors

Virus diseases have become a serious problem to the cultivated highbush blueberry industry, not only in Michigan, but also in New Jersey, where most of the diseases were first noticed.

One such disease, called stunt, was first observed in 1928 and was later described and named by Wilcox (1942) when its virus nature was demonstrated by transmission through budding. Wilcox also explained that the general effect of the stunt diseases is a reduction in length and vigor of new growth, a moderate stimulation of branching, and the production of small, unmarketable fruit. At that time, Wilcox had no proof as to the means of dissemination of the disease, but suspected that some insect was the vector. L. O. Kunkel (Tomlinson et al 1951) of the Rockefeller Institute confirmed, by means of graft and dodder transmissions, the conclusion reached by Wilcox that stunt is caused by a virus.

Johnston et al (1945) stated that, while stunt disease is present in a number of Michigan blueberry fields, it has spread very slowly. Johnston further stated that a quarantine had been enacted, which prohibited the shipment of nursery stock into the state from any outside point, or from point to point within the state, except under, or in compliance with, the quarantine regulations. From this quarantine stemmed the annual inspection of fields in Michigan by inspectors from

the State Department of Agriculture as insurance against the rapid spread of stunt disease in Michigan.

A search for insect vectors was initiated by the New Jersey Agricultural Experiment Station in 1943. Tomlinson (1947) initiated a general insect control experiment in relation to stunt disease in hopes of limiting the spread of stunt in fields by controlling the insect vector or vectors, but his efforts were of little avail. Marucci (1947) published results of a Cicadellidae survey in blueberry fields and Tuttle (1947) of a survey of insects in Michigan blueberry fields. The two surveys differed greatly as to the species and number of species of Cicadellidae found in blueberry fields.

In 1944, C. A. Doehlert, in a preliminary experiment with leafhoppers, successfully transmitted stunt from a diseased blueberry bush to healthy plants, as reported by Marucci et al (1947). This led to subsequent studies by Marucci et al until Tomlinson et al (1951) reported that a complex of Scaphytopius magdalensis (Prov.) and S. verecundus (Van Duz.) was responsible for the transmission of blueberry stunt disease in New Jersey. Later research revealed that it was S. magdalensis that was a vector of stunt and not S. verecundus (Hutchinson 1955 and Maramorosch 1955).

Goheen (1953) reported that stunt, a virus disease of the yellows type, is prevalent in New Jersey and North Carolina and that entire fields may become so badly diseased that little or no crop is produced. Goheen also stated that the disease occurs in Massachusetts, New York, Michigan, Maryland, and eastern Canada and could be spread from bush to bush by dodder, a parasitic seed plant found in some blueberry fields.

Hutchinson et al (1954) was apparently the first to investigate

a disease locally known as "ringspot." They report that symptoms are suggestive of other described ringspot diseases caused by viruses. They are most apparent in the fall when infected leaves may show red rings or jagged patterns of the oak-leaf type associated with the veins or both. In the spring, small red circles and dots may be seen on the leaves. In grafting experiments, small chlorotic dots were the first symptoms of ringspot. These later changed to red dots, after which red rings and the oak-leaf patterns appeared. Hutchinson further states that ringspot was transmitted to 10 of 13 two-year-old Cabot plants whip-grafted in April, 1952. Clear virus symptoms were evident within five months. The presence of red ringspot in wild blueberry in New Jersey may mean that it has spread from the wild to commercial plantings (Stretch, 1965). Red ringspot has not been reported in the other blueberry-growing areas, except Michigan, where red ringspot was found in plants whose origin could be traced to New Jersey. No reports of red ringspot in wild or in most commercial plantings in Michigan, North Carolina, Massachusetts, Washington and Oregon may mean that the vector is not present in those areas.

Varney (1957) was the first to report the occurrence of mosaic and shoestring, two virus diseases of cultivated blueberry in New Jersey. Shoestring had been assumed to be a virus and mosaic a genetic disorder, but Varney presented evidence that both are of virus origin. Shoestring virus symptoms appear on both twigs and leaves. Red streaks appear first on new twigs in the spring but may become masked later in the summer. Severely infected leaves are narrow and pointed or strap-like; moderately affected leaves are wavy and distorted. Varney inoculated two Jersey and two Burlington varieties of blueberry bushes

in the spring of 1953 by chipbuds from Cabot plants showing typical shoestring symptoms. No symptoms appeared the first year, but the following spring red streaks, red veinbanding and leaf distortion appeared on the inoculated bushes.

Mosaic disease symptoms on blueberry, as reported by Varney (1957), are shown by the leaves of affected bushes which are strikingly mottled with yellow and yellow-green areas. The degree of mottling varies with leaf position and blueberry variety. Varney inoculated healthy bushes at budbreak in the greenhouse by means of chipbuds from a Stanley bush showing symptoms typical of mosaic. Twelve out of 13 inoculated bushes showed symptoms in two to three weeks after inoculation.

Necrotic ringspot, a virus disease of cultivated blueberries, reported occurring in New Jersey by Varney et al (1960) and in Michigan, causes eventual death to the bush. Symptoms of the disease are expressed by reduction in size of leaves which have chlorotic areas appearing as rings or lines. The chlorotic areas may drop-out of the leaves, leaving a tattered, shot hole, appearance. In transmission tests conducted by Griffin et al (1963), a nematode, Xiphinema americanum (Cobb), transmitted the disease from infected blueberry bushes to cucumber plants in greenhouse experiments. Transmission of the disease from one bush to another by X. americanum has not been demonstrated.

Le Clug (1964) estimated the average annual loss from potential blueberry production, due to fungus, bacteria and virus diseases, at nearly two million dollars.

Insect Survey Equipment

The use of the vacuum-sweeping technique for surveying for possible disease vectors was demonstrated by Maki (1965). Vacuum-sweeping is a superior method, as compared to the sweep net, for collecting Cicadellidae, Aphididae, Cercopidae and many other families of insects that could be possible vectors of blueberry virus diseases.

MATERIALS AND METHODS

The survey program for possible virus vectors was carried out in the five counties with highest acreage of cultivated highbush blueberries in Michigan: Berrien, Van Buren, Allegan, Ottawa and Muskegon (Plate 1). Two farms in each of the counties were selected as sampling sites. They were selected on the basis of disease incidence in the field, one field of low disease incidence and the other of high, to determine the difference in species and population size of insects between the two fields.

Ten bushes were sampled in each field and were picked on the basis of different types of conditions that existed in that particular field, such as low, wet areas; high, dryer areas; and areas of vigorous growth, to obtain a representative cross-section of the insect fauna. Jersey, the major variety of highbush blueberries, in Michigan, made up the bulk of the bushes sampled.

The D-Vac Model 12 sampler, a vacuum sweeper-like machine, was employed for sampling the bushes for Arthropods. The D-Vac (Plate 2) consists of a power source, a blower, and a fiberglass housing for holding the sample bags. A 1.26 cubic inch, three-quarter horsepower, two-cycle gasoline engine supplies the power. A fine mesh nylon net, capable of holding mites, was fastened to the fiberglass housing, the open end of which measures 0.929 square feet. The entire device weighs only 15-1/2 pounds.

Samples were taken by directing the open end of the device

Plate 2.--D-Vac Model 12 Sampler used in survey for collecting taxon found in cultivated blueberry fields.

toward the bush and sweeping from bottom to top and repeating until the entire bush was covered (Plate 3). This sampling method not only enabled the outside of the bush to be sampled easily, but also the center, where the younger and more succulent canes are found. Each bush took approximately one minute to sample, varying a little as to size of bush.

After 10 bushes in the field had been sampled, the machine was kept running and the larger debris was checked and thrown out. The remaining material in the net was then emptied into pint jars partially filled with K-A-A-D, a fixative consisting of 1 part Kerosene, 7 parts 95% ethyl alcohol, 2 parts glacial acetic acid and 1 part diopane, and then labeled as to date, locality and farm. K-A-A-D was used to keep the soft-bodied insects from becoming deformed so that subsequent identification could be handled more easily. After remaining in K-A-A-D from six to eight hours, the material was washed and stored in 80% ethyl alcohol. The two farms in each county were sampled on the same day; all ten farms were sampled within three consecutive days. The sampling periods, which varied between 15 and 20 days, ran from May 7 through September 12, 1964. This gave assurance of not missing the appearance and disappearance of some particular species of Arthropod in the field.

The first problem encountered was the separation of the insects from the debris, which consisted of leaves, twigs, and blossoms, on which and in which the smaller insects would be caught. It was also found that the samples were too large, which meant more time and work would be required for separation. To solve these problems, a sub-sampling technique was employed.

Plate 3.--Collecting sample from cultivated blueberry bush showing ease by which center of the bush can be sampled.

To determine the size of the subsample needed for accurate determination of the Arthropods present, each of the seventy samples was graded with respect to size. It was determined that the largest sample would fit inside a petri dish which had a radius of 2.75 in. and a total area of 23.77 in. The petri dish was divided into eight equal parts and the number of each species was counted in each section.

Through a comparison of the individual section counts with total counts, it was demonstrated that 95% accuracy of total insect species present in the sample could be obtained by counting only one section of the plate. Each subsample was removed from the entire sample by placing a wedge-shaped cup over the subsample that was randomly chosen. The rest of the sample was then washed back into the pint jar and the subsample into a smaller petri dish for easier sorting. The figures resulting from the tally were then multiplied by 8 to give an estimate of the total number in the entire sample. All 70 samples were subsampled in the above manner. Each subsample was sorted and separated into the different classes and orders of Arthropods and stored in vials of 80% ethyl alcohol for further taxonomic classification. Subsamples were examined under a binocular scope to assure complete removal of such specimens as mites, thrips, aphid nymphs, etc., from the petri dish.

Identification of Arthropods in the samples was done by the author with the exception of the Aphididae, Coleoptera, Lepidoptera, Hymenoptera and Acarina. The other Arthropods presented in this thesis were submitted to persons in the Entomology Department at Michigan State University for final confirmation.

The insect survey data were analyzed for information that might

answer the following questions: (1) What possible virus disease vectors are present in the fields, and (2) What difference is there, if any, between high and low virus disease incidence fields as far as species of insects are concerned? A discussion of the results of these analyses are presented in the following sections of the thesis.

RESULTS AND DISCUSSION

General Arthropod Survey

The author has found, as did Maki (1965), that the vacuum-sweep method of surveying is ideal for collecting such taxa as Cercopidae, Cicadellidae, Aphididae, acalypterate Diptera and Acarina as indicated by the taxon collected (Appendix II). The fluctuation in population of each taxon represented could be due to such factors as insecticide application, weather, and predators or parasites. The application of insecticides is probably the most critical factor, since greater numbers of individual taxon were collected in the spring before dusting was initiated, and in the fall after dusting had been terminated.

Tables in Appendix II list the taxa present in the samples. Totals are given for each farm sampled, with each table comparing the two farms sampled in the county.

Possible Virus Disease Vectors - Aphids

In the survey for possible insect virus disease vectors, emphasis was placed on collecting two major families of insects: Cicadellidae and Aphididae. The latter are discussed in this section. After the 1964 survey, it was apparent that only 2 species, Masonaphis pepperi (MacGillivray) and Myzus scammelli (Mason), colonized on high-bush blueberry in Michigan. The other aphids, which were collected during their transient activity on blueberry, can not be disregarded

as possible virus vectors. This study was restricted to the 2 species closely associated with cultivated blueberries as a point for research embarkation. The transient aphid collections have not been identified but have been retained for future use should efforts with M. scammelli and M. pepperi as vectors of blueberry viruses prove futile.

Masonaphus pepperi was the predominate species found colonizing on highbush blueberry. Each county and farm surveyed contained M. pepperi (Table 1). The largest number of specimens was collected in the two counties with the highest virus disease incidence as shown in Table 3. Myzus scammelli, on the other hand, was not found in every county or on every farm surveyed, as shown in Table 2, and was not found as numerous as M. pepperi. To verify the findings that M. scammelli was not present in Berrien County, a follow-up survey was conducted on 10 additional farms in Berrien County during the summer of 1965. The results of that survey were also negative as to the presence of M. scammelli. Along with this follow-up survey a few farms in La Porte County, Indiana, which adjoins Berrien County at the Indiana-Michigan border, were surveyed and found to be free of this species. A comparison of Tables 1 and 2 with Table 3 indicates a marked difference between the presence of the two species of aphids and the disease incidence of all viruses in each of the five counties. There is good correlation between the absence of M. scammelli and the low incidence of shoestring virus in Berrien County. Survey results from La Porte County compare with Berrien County in this respect. Comparisons of Tables 2 and 3 show that the presence of M. scammelli and the spread of shoestring to be quite closely correlated by the fact that, where M. scammelli is found, shoestring incidence is also

TABLE 1.--Comparison of counties and farms showing differences in numbers of Masonaphis pepperi (MacGillivray) collected

Masonaphis pepperi							
Farm	Sampling Dates						
Berrien County, Mich., 1964							
	5/8	5/27	6/15	7/6	7/27	8/18	9/10
Chikaming	-	24	-	-	16	-	-
Hutchinson	-	-	72	104	40	24	-
Van Buren County, Mich., 1964							
	5/7	5/25	6/16	7/8	7/28	8/19	9/11
Hartman	-	-	-	24	16	-	-
Wakeman	-	-	40	-	72	110	24
Allegan County, Mich., 1964							
	5/10	5/25	6/16	7/8	7/29	8/19	9/11
Wadsworth	8	32	96	384	216	848	192
Double A	-	-	-	144	40	16	8
Ottawa County, Mich., 1964							
	5/11	5/26	6/17	7/9	7/29	8/20	9/12
De Pree	-	-	16	384	496	352	-
Boo Hoot	-	-	112	16	-	48	16
Muskegon County, Mich., 1964							
	5/11	5/26	6/18	7/9	7/29	8/20	9/12
Derkse	-	8	-	-	-	-	-
Pauls	8	-	-	16	16	16	8

TABLE 2.--Comparison of counties and farms showing differences in numbers of Myzus scammelli (Mason) collected

Myzus scammelli							
Farm	Sampling Dates						
Berrien County, Mich., 1964							
	5/8	5/27	6/15	7/6	7/25	8/18	9/10
Chikaming	-	-	-	-	-	-	-
Hutchinson	-	-	-	-	-	-	-
Van Buren County, Mich., 1964							
	5/7	5/25	6/16	7/8	7/28	8/19	9/11
Wakeman	-	-	-	16	-	8	8
Hartman	-	-	-	-	-	-	-
Allegan County, Mich., 1964							
	5/10	5/25	6/16	7/8	7/29	8/19	9/11
Wadsworth	-	8	16	-	-	-	-
Double A	-	-	-	8	40	-	-
Ottawa County, Mich., 1964							
	5/11	5/26	6/17	7/9	7/29	8/20	9/12
De Pree	-	-	24	-	-	-	8
Boo Hoot	24	16	16	-	-	-	-
Muskegon County, Mich., 1964							
	5/11	5/26	6/18	7/9	7/29	8/20	9/12
Derkse	-	-	16	16	-	-	-
Pauls	-	8	16	24	-	-	-

TABLE 3. The comparison of virus disease incidence in five counties (1959-1965)
Data was obtained from Division of Plant Industry Records

County	Acres Surveyed	Virus Diseases Surveyed[a]							
		Stunt		Shoestring		N.R.S.V.		Mosaic	
		DB	DB/A	DB	DB/A	DB	DB/A	DB	DB/A
				1959					
Berrien	132	13	0.10	-	0.00	28	0.21	4	0.03
Van Buren	518	130	0.25	26	0.05	30	0.06	46	0.09
Allegan	360	108	0.30	14	0.04	32	0.09	25	0.07
Ottawa	618	455	0.74	565	0.92	87	0.14	243	0.39
Muskegon	377	221	0.58	6	0.02	2	0.01	63	0.17
Total	2005	927	0.46[b]	611	0.31[b]	179	0.09[b]	381	0.19[b]
				1960					
Berrien	112	16	0.14	3	0.03	32	0.29	4	0.04
Van Buren	528	107	0.20	169	0.32	59	0.11	108	0.20
Allegan	330	42	0.13	8	0.02	39	0.12	52	0.16
Ottawa	806	253	0.31	806	1.00	21	0.03	231	0.29
Muskegon	288	181	0.63	16	0.06	-	0.00	132	0.46
Total	2064	599	0.29[b]	1002	0.49[b]	151	0.07[b]	527	0.26[b]
				1961					
Berrien	68	89	1.31	-	0.00	5	0.07	-	0.00
Van Buren	500	95	0.19	86	0.17	44	0.09	54	0.11
Allegan	385	88	0.23	20	0.05	20	0.05	93	0.24
Ottawa	876	990	1.13	661	0.76	28	0.03	201	0.23
Muskegon	321	735	2.29	4	0.01	28	0.09	75	0.23
Total	2150	1997	0.93[b]	771	0.36[b]	125	0.06[b]	423	0.20[b]

TABLE 3.--Continued

County	Acres Surveyed	Virus Diseases Surveyed[a]							
		Stunt		Shoestring		N.R.S.V.		Mosaic	
		DB	DB/A	DB	DB/A	DB	DB/A	DB	DB/A
				1962					
Berrien	116	26	0.22	-	0.00	7	0.06	-	0.00
Van Buren	563	171	0.30	24	0.04	52	0.09	88	0.16
Allegan	359	90	0.25	25	0.07	9	0.03	47	0.13
Ottawa	719	894	1.24	676	0.94	15	0.02	185	0.26
Muskegon	275	199	0.72	-	0.00	1	0.00	17	0.06
Total	2032	1380	0.68[b]	725	0.36[b]	84	0.04[b]	337	0.17[b]
				1963					
Berrien	29	23	0.79	2	0.07	6	0.21	3	0.10
Van Buren	322	126	0.39	69	0.21	4	0.01	4	0.01
Allegan	272	69	0.25	21	0.08	3	0.01	8	0.03
Ottawa	639	411	0.64	323	0.51	19	0.03	178	0.29
Muskegon	245	316	1.29	1	0.00	1	0.00	38	0.16
Total	1507	945	0.63[b]	416	0.28[b]	33	0.03[b]	231	0.15[b]
				1964					
Berrien	56	63	1.13	1	0.02	1	0.02	9	0.16
Van Buren	429	161	0.38	7	0.02	31	0.07	42	0.10
Allegan	342	197	0.58	21	0.06	24	0.07	87	0.25
Ottawa	590	832	0.65	597	1.01	19	0.03	224	0.38
Muskegon	245	386	1.59	5	0.02	-	0.00	99	0.40
Total	1662	1189	0.72[b]	631	0.38[b]	75	0.05[b]	461	0.28[b]

TABLE 3.--Continued

County	Acres Surveyed	Virus Diseases Surveyed[a]							
		Stunt		Shoestring		N.R.S.V.		Mosaic	
		DB	DB/A	DB	DB/A	DB	DB/A	DB	DB/A
				1965					
Berrien	53	238	4.50	3	0.06	13	0.25	4	0.08
Van Buren	515	260	0.50	27	0.05	26	0.05	95	0.18
Allegan	325	195	0.60	62	0.19	40	0.12	30	0.09
Ottawa	542	1262	2.33	1328	2.45	43	0.08	264	0.49
Muskegon	247	596	2.41	20	0.08	-	0.00	53	0.22
Total	1682	2551	1.52[b]	1420	0.84[b]	122	0.07[b]	446	0.27[b]

[a]DB - Diseased Bushes
DB/A - Diseased Bushes Per Acre
N.R.S.V. - Necrotic Ringspot Virus

[b]Five county average for DB/A

the greatest. Shoestring has remained in low incidence through the years where M. scammelli has not been found. The fact that the disease is present in Berrien and La Porte counties, but not in large proportions, could be explained by the movement of symptomless diseased nursery stock in to the counties which later developed diseased symptoms from previous infection.

Possible Virus Disease Vectors - Leafhoppers

The second family of possible virus disease vectors covered in the survey are the cicadellids, or more commonly known as the leafhoppers. Much emphasis has been placed on this family in the thesis, since it is known to contain the vector of stunt disease of blueberries in New Jersey. This survey uncovered a greater number of genera and species (Table 4) than Tuttle obtained in 1947, a phenomenon which could be based on the superiority of the D-Vac collecting method over the sweep net method which was employed by Tuttle. Scaphytopius magdalensis (Prov.), the vector of stunt disease in New Jersey, also appears in Table 4, but was not collected during the author's original survey. Out of the 25 species of leafhoppers (Table 4), only about a dozen appear to be possible leads for further transmission tests. This conclusion is based on the relationships of the various species to virus disease incidence. If a species of leafhopper is not present on more than one farm and in more than one county its potential as being a vector is lessened due to the fact that virus diseases are widespread in at least 4 counties.

TABLE 4.--Leafhopper species, with total number of each species, found in the five-county survey

Genera and Species	Counties					
	Berrien	Van Buren	Allegan	Ottawa	Muskegon	Total
Aceratagallia sanguinolenta (Prov.)	-	-	24	16	8	48
Agalliopsis peneoculata (Oman)	8	-	-	-	-	8
Amblysellus curtisii (Fitch)	-	-	56	-	-	56
Balclutha impicta (V.D.)	-	-	-	8	8	16
Bandara inflata (Knull)	-	-	16[a]	48[a]	16[a]	80
Deltocephalus flavicostus (Sta.)	-	8	-	-	-	8
Draeculacephala antic (Walker)	16	16	8	16	8	64
Empoasca fabae (Harris)	336[a]	248[a]	612[a]	840[a]	448[a]	2,484
Endria inimica (Say)	32[a]	88[a]	104[a]	56[a]	48[a]	328
Erythroneura obliqua (Say)	8	-	-	-	-	8
Erythroneura ziczac (Walsh)	8	-	-	-	-	8
Exitianus exitiosus (Vhl.)	-	-	16	88[a]	24[a]	128
Forcipata loca (Del.)	48[a]	8	24	16	24[a]	120
Graminella nigrifrons (Forbes)	8	8	8	-	-	24
Graphocephala coccinea (Forst)	-	-	8	8	-	16

TABLE 4.--Continued

Genera and Species	Counties					
	Berrien	Van Buren	Allegan	Ottawa	Muskegon	Total
Gyponana arcta (Del.)	16	8	8	16	-	48
Macrosteles fascifrons (Stal.)	64[a]	104[a]	136[a]	80[a]	40	424
Norvellina seminuda (Say)	-	8	-	-	-	8
Osbornellus auronitens (Prov.)	16	8	8	-	-	32
Paraphlepsius irroratus (Say)	-	-	-	88[a]	-	88
Scaphytopius acutas (Say)	-	8	-	-	-	8
Scaphytopius frontalis (V.D.)	8	-	-	-	-	8
Scaphytopius magdalensis[b] (Prov.)						
Tylozygus bifidus (Say)	-	8	-	-	-	8
Xestocephalus pulicarius (V.D.)	-	-	-	8	-	8

[a]Found on both farms in county.

[b]Found appearing in large numbers in late fall of 1965 after survey had terminated.

Rearing Experiments with Leafhoppers

In the summer of 1965, with the aid of the D-Vac, specimens of leafhoppers were collected from cultivated blueberry fields for feeding and rearing studies. The specimens collected were transferred to caged 2 year old blueberry plants of the Jersey variety. The cages were then transferred to a plant-growth room (Temperature: 72^{o} F $\pm$ 2^{o}; RH: 50-70%). From these collections, 2 species--Scaphytopius magdalensis (Prov.) and Graphocephala coccinea (Forst.)--became established. The former species was not recorded from the 1964 samples when collecting terminated on September 12. Scaphytopius magdalensis was identified from a collection on October 9, 1965. This species in New Jersey has 2 generations per year, one which occurs in the spring the other in the fall (Hutchinson 1955). This indicated that the species had either been missed in the field during the regular survey program, or the species did not appear until late fall after the regular survey program had been terminated.

As found by Hutchinson (1955) and corroborated herein, accurate determination of S. magdalensis adult males requires examination of the genitalia. The separation of species of Scaphytopius found in Michigan to date can be accomplished by general appearances. The adult male of S. magdalensis is dark brown to brownish-black and the female lighter brown (Plate 4). Both sexes lack an acutely pointed vertex as possessed by males and females of S. acutus (Say), and are also lacking a bright yellow face which S. frontalis (V.D.) males and females possess. Hutchinson (1955) states that in New Jersey, six distinct color-variants of S. magdalensis nymphs occur and, on the

basis of these color-variants, can be readily separated from other nymphs of the same genus. Some of these color-variants are shown in Plates 5 and 6. Plate 6 illustrates not only some of the common color-variants, but, in addition, shows another color-variant found in Michigan and not mentioned by Hutchinson as occurring in New Jersey. The color variation is apparent in the first instar and appears as a black band with white markings across the dorsal thoracic region of the nymph.

Scaphytopius magdalensis females seem to be impartial as to site for oviposition on the blueberry bush. Oviposition has been found occurring on the edge of the leaves, just under the cuticle (Plate 7), in the midrib of the leaf, and in the new tip growth of canes.

According to Delong (1948) the other species, G. coccinea, usually occurs in abundance upon Rubus and is frequently found in all stages upon certain species of ornamental shrubs such as Forsythia and often occurs in sufficient numbers to cause economic injury to ornamental plants. It is distributed throughout the eastern United States and occurs as far west as Texas and Oklahoma. Plate 8 shows an adult male of the species feeding on a blueberry leaf. Females with the same color pattern but larger in size have been observed feeding and ovipositing on blueberry bushes in the field and in the laboratory. The nymphs of G. coccinea are pale green in color until the fifth instar, at which time red bars edged with broken white appear on the wing pads and pronotum as shown in Plate 9.

The feeding injury to the growing tips of the canes caused by this particular species could be causing some of what is commonly

called "winter injury" to the new wood. In culture where three to four of the nymphs have been observed feeding on the same tip, a gradual die-back of the tip has been noticed.

Additional experimentation is now appropriate to determine if other leafhoppers will rear on blueberry. Transmission studies with the 2 reared-species will be initiated in the near future; trials with other species will be made as they become successfully established in laboratory colonies.

Plate 4.--Copulation between male (right) and female (left) of Scaphytopius magdalensis (Prov.). Note the slight color variation between male and female.

Plate 5.--Nymphs of Scaphytopius magdalensis (Prov.) showing second instar nymph with black markings and third instar nymph with red.

Plate 6.--Nymphs of Scaphytopius magdalinsis (Prov.) showing black banded first instar nymph, red banded second and third instar nymphs and sand stone colored fifth instar nymph. The first instar nymph is a color variant not mentioned by Hutchinson (1955) as occurring in New Jersey.

Plate 7.--Female of Scaphytopius magdalensis (Prov.) showing feeding and ovipositing on cultivated blueberry, Vaccinium corymbosum Linnaeus.

Plate 8.--Male of Graphocephala coccinea (Forst.) showing coloration and feeding on cultivated blueberry, Vaccinium corymbosum Linnaeus.

Plate 9.--Nymph of Graphocephala coccinea (Forst.) showing coloration in fifth instar.

SUMMARY AND CONCLUSIONS

A survey for possible virus disease vectors of stunt, shoestring, necrotic ringspot, and mosaic, which are virus diseases of the cultivated blueberry, Vaccinium corymbosum Linnaeus, was carried out in a five-county area in Michigan (Plate 1). During the spring and summer of 1964, two farms in each of the five counties were surveyed. All the farms and counties were compared with regard to virus disease incidence and Arthropods present.

Collection of the Arthropods present in the survey areas was completed with the aid of a vacuum-sweeper like machine called a D-Vac Model 12 Sampler. The results of this survey led to the following conclusions:

1. There is a definite correlation between virus disease incidence and Arthropod species present between counties, but not between farms in a county.

2. Scaphytopius magdalensis (Prov.), found for the first time in Michigan by the author, is the vector of stunt in cultivated blueberries in New Jersey. Therefore, it is concluded that S. magdalensis is the probable vector of stunt in cultivated blueberries in Michigan.

3. There are two generations, spring and fall, of S. magdalensis in New Jersey, but only a fall generation has been found in Michigan. The fact may indicate that the insect control program for cultivated blueberries now being followed in Michigan is adequate for controlling the spring generation.

4. A number of species of insects found by this survey show potential as being possible vectors of blueberry viruses.

5. Virus disease incidence is increasing annually in Michigan.

6. Shoestring, a virus disease of cultivated blueberries, has remained in low incidence in Berrien County. The absence of Myzus scammelli Mason, a species of aphid, in Berrien may be the controlling factor.

7. A fall survey should be conducted to determine if S. magdalensis is present in the five counties previously surveyed. Since stunt incidence is high in all the counties. A more precise picture of Arthropod fauna present at this time could also be obtained.

8. A pre-bloom, dormant and post-harvest experimental insecticide program should be initiated. The fact that some pests appear or reach greater proportions at these times, as shown in Appendix II, will test this hypothesis.

9. Stunt disease incidence in the cultivated blueberry fields could possibly be reduced if a post-harvest insect control program were initiated.

10. Scaphytopius magdalensis (Prov.) and Graphocephala coccinea (Forst.) can be reared on cultivated blueberry, Vaccinium corymbosum Linnaeus.

11. Male and female adults of Scaphytopius magdalensis (Prov.) can be separated by anatomical characteristics or color variation from other species of Scaphytopius that are found in Michigan.

12. Nymphs of Scaphytopius magdalensis (Prov.) could possibly be separated out from other leafhopper nymphs on the basis of color patterns.

13. Extensive testing of virus transmission in cultivated blueberries can now be shortened with the aid of the author's findings.

LITERATURE CITED

Delong, D. M.

1948. Leafhoppers or Cicadellidae of Illinois. Illinois Natural History Survey Bulletin, 24(2):1-376.

Dorr, J. E.

1965. Pollination studies on the cultivated blueberry Vaccinium corymbosum (Linnaeus). M.S. Thesis, Mich. State Univ., East Lansing, pp. 1-59.

Goheen, A. C.

1953. The cultivated highbush blueberry, pp. 784-789. In Plant Diseases, U.S. Dept. Agr. Yrbk. Agr.

Griffin, G. D., J. E. Huguelet, and J. W. Nelson

1963. Xiphinema americanum as a vector of necrotic ringspot virus of blueberry. Plant Disease Reptr., 47(8):703-704.

Holbein, Peter

1965. Personal interview concerning the economic importance of the cultivated blueberry industry in Michigan.

Hutchinson, M. T. and E. H. Varney

1954. Ringspot--a virus disease of cultivated blueberry. Plant Disease Reptr., 38:260-262.

Hutchinson, M. T.

1955. An ecological study of the leafhopper vectors of blueberry-stunt. J. of Econ. Entomol., 48(1):1-8.

Johnston, S., D. Cation and C. A. Boyer

1945. Blueberry stunt disease. Mich. Agr. Expt. Quarterly Bul., 27:409-412.

LeClug, E. L.

1964. Crop losses due to plant diseases in the United States. Phytopathology, 54(11):1305-1319.

Maki, J. R.

1965. A comparison of sampling methods used in field pesticide side effects studies. M.S. Thesis, Mich. State Univ., East Lansing, pp. 1-54.

Maramorosch, K.

1955. Transmission of blueberry-stunt virus by Scaphytopius magdalensis. J. Econ. Entomol., 48:106.

Marucci, P. E.
1947. A leafhopper survey in blueberry fields, pp. 2-4. In Proceedings of the 16th Annual Blueberry Open House. New Jersey Agr. Exp. Stat., Rutgers.

Marucci, P. E., W. E. Tomlinson, Jr., and C. A. Doehlert
1947. Cage tests for possible carriers of blueberry stunt disease, pp. 9-11. In Proceedings of the 16th Annual Blueberry Open House. New Jersey Agr. Exp. Stat., Rutgers.

Michigan Dept. of Agriculture, Division of Plant Industry Records
1965. Number of virus diseased blueberry plants tagged per county for seven years. (Unpublished)

Stretch, A. W.
1965. Ringspot virus of cultivated blueberries, pp. 3-4. In Proceedings of the 33rd Annual Blueberry Open House. New Jersey Agr. Exp. Stat., Rutgers.

Tomlinson, W. E., Jr.
1947. The blueberry fruit fly and other pests of 1947, pp. 15. In Proceedings of the 16th Annual Blueberry Open House. New Jersey Agr. Exp. Stat., Rutgers.

Tomlinson, W. E., Jr., P. E. Marucci, and C. A. Doehlert
1951. Leafhopper transmission of blueberry stunt disease. J. of Econ. Entomol., 43(5):658.

Tuttle, D. M.
1947. A study of the insect fauna of the cultivated blueberry, Vaccinium corymbosum Linnaeus. M.S. Thesis, Mich. State Univ., East Lansing, pp. 1-85.

Varney, E. H.
1957. Mosaic and shoestring virus diseases of cultivated blueberry in New Jersey. Phytopathology, 47:307-309.

Varney, E. H. and L. C. Raniere
1960. Necrotic ringspot, a new virus disease of cultivated blueberry. Phytopathology, 50:241.

Wilcox, R. B.
1942. Blueberry stunt, a virus disease. Plant Disease Reptr., 26(9):211-213.

APPENDIX I

Farms Surveyed in Michigan

The specific location of each farm surveyed is listed.

APPENDIX I

Farms Surveyed in Michigan

Berrien County, Michigan

Hutchinson's - W 1/4, Sec. 2, T. 7S., R. 20 W.
Chikaming Gardens - S 1/4, Sec. 3, T. 75, R. 20 W.

Van Buren County, Michigan

Hartman's - Found to be just over the line into Allegan County, SE 1/4, Sec. 36, T. 1N, R. 16 W.
Wakeman's - S 1/4, Sec. 6, T. 2S., R. 15 W.

Allegan County, Michigan

Wadsworth's - S 1/4, Sec. 31, T. 3N, R. 15 W.
Double A - N 1/4, Sec. 30, T. 4N., R. 15 W.

Ottawa County, Michigan

DePree's - W 1/4, Sec. 13, T. 5N., R. 16W.
Boo Hoot's - E 1/4, Sec. 2, T. 5N., R. 16W.

Muskegon County, Michigan

Paul's - W 1/4, Sec. 15, T. 9N., R. 16 W.
Derkse's - E 1/4, Sec. 30, T. 9N., R. 15 W.

APPENDIX II

Summary of Arthropods Collected

The total numbers and taxa of arthropods collected during the spring and summer of 1964 are presented in this appendix. The appendix is subdivided according to county, farms, time sample was taken, and approximate dusting dates.

Berrien County, 1964

Taxon	Hutchinson							Chikaming						
	Sampling Dates							Sampling Dates						
	*5/8	**5/27	*6/15	**7/6	**7/27	*8/18	9/10	5/8	5/27*	**6/15	**7/6	**7/27	*8/18	9/10
Acarina														
Mesostigmata	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Sarcoptiformes	8	-	-	-	-	-	-	-	-	-	-	8	24	-
Trombidiformes	-	8	-	-	-	-	-	-	8	8	-	-	-	-
Coleoptera														
Anthicidae														
Tomoderus sp.	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Chrysomelidae														
Glyptina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Psylliodes sp.	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Coccinellidae														
Ceratomegilla maculata	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Hippodamia quinquesignata	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Collembola														
Entomobryidae	-	-	-	-	-	-	-	-	112	56	-	-	-	-
Sminthuridae	8	8	-	-	-	-	-	-	-	-	-	-	-	-
Diptera														
Agromyzidae	-	-	-	-	8	-	-	-	-	32	-	-	-	-
Borboridae	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Cecidomyidae	-	-	-	-	168	96	48	-	-	24	-	56	160	16
Ceratopogonidae	-	-	-	-	-	-	-	-	8	40	-	-	-	-
Chironomidae	-	-	24	-	304	-	24	-	8	248	56	120	32	16
Chloropidae	-	8	16	32	8	16	16	40	168	72	136	16	24	40
Dolichopodidae	-	-	-	8	-	-	-	8	8	-	40	-	-	-
Drosophilidae	-	-	-	-	-	-	-	-	-	64	32	-	-	16
Lonchopteridae	-	-	8	8	-	-	-	-	-	-	-	-	-	-
Lycoriidae	8	16	-	-	-	16	-	-	96	-	-	-	-	-
Muscidae	-	8	8	-	-	-	16	8	152	8	-	-	-	-

Berrien County, 1964--Continued

Taxon	Hutchinson							Chikaming						
	Sampling Dates							Sampling Dates						
	*5/8	**5/27	*6/15	*7/6	*7/27	*8/18	9/10	5/8	5/27*	*6/15	*7/6	*7/27	*8/18	9/10
Mycetophilidae	120	-	-	-	-	-	-	16	-	-	72	-	-	-
Ochthiphilidae	32	-	-	-	-	-	-	8	-	-	-	-	-	-
Phoridae	-	-	-	-	-	-	-	8	-	-	-	-	8	-
Psilidae	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Syrphidae	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Tetanoceridae	-	-	-	-	-	-	-	-	-	24	-	-	-	-
Tipulidae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Trypetidae	-	-	-	-	-	-	-	-	-	8	8	-	-	-
Hemiptera														
Lygaeidae														
Ischnorrhynchus resedae	-	-	-	8	-	-	8	-	-	-	8	8	-	8
Lygaeus kalmii	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Miridae														
Capsus ater	-	-	-	8	-	8	-	8	-	-	-	-	16	-
Orthotylus chlorionis	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Trigonotylus ruficornis	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Nabidae														
Nabis limbutus	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Neididae														
Jalysus spinosus	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Tingididae														
Corythaica bellula	-	-	-	-	-	-	-	-	-	-	-	8	-	-
Homoptera														
Aphididae														
Masonaphis pepperi	-	-	72	104	32	24	-	-	24	-	-	16	-	-
Aleyrodidae														
Aleurochiton forbesii	-	32	8	16	8	-	-	-	32	8	-	8	-	16

Berrien County, 1964--Continued

Taxon	Hutchinson							Chikaming						
	Sampling Dates							Sampling Dates						
	*5/8	**5/27	*6/15	**7/6	**7/27	*8/18	9/10	5/8	5/27*	**6/15	**7/6	**7/27	*8/18	9/10
Cercopidae														
Philarnus spumarius	-	-	8	24	-	-	16	-	-	-	48	16	-	-
Chermidae														
Livia vernalis	-	-	16	-	-	-	-	-	-	-	-	-	-	-
Psyllia albogena	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Cicadellidae														
Agalliopsis peneoculata	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Draeculacephala antic	-	-	-	-	8	-	8	-	-	-	-	-	-	-
Empoasca fabae	-	8	8	8	16	16	32	-	16	80	56	8	24	72
Endria inimica	-	-	-	-	8	8	-	-	-	-	-	-	-	8
Erythroneura obliqua	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Erythroneura ziczac	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Forcipata loca	-	16	-	-	-	-	-	-	8	-	-	-	-	24
Graminella nigrifrons	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Gyponana arcta	-	-	-	-	-	-	-	-	-	-	16	-	-	-
Macrosteles fascifrons	-	8	-	-	16	8	16	-	8	-	-	8	-	-
Osbornellus auronitens	-	-	-	-	-	-	-	-	-	-	-	-	8	16
Scaphytopius frontalis	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Hymenoptera														
Apidae														
Bombus impatiens	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Dialictus sp.	-	-	-	-	8	-	-	-	-	-	-	-	8	-
Braconidae	-	-	8	-	-	8	24	-	-	8	8	-	-	16
Chalcidoidea	8	16	8	-	16	32	96	-	64	-	96	40	40	40
Cynipidae	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Formicidae	8	-	64	8	8	24	-	-	-	8	-	-	-	-
Ichneumonidae	-	-	-	-	-	-	8	-	-	8	-	-	-	-
Tenthredinidae	-	-	-	-	-	-	-	-	16	-	-	-	-	-

Berrien County, 1964--Continued

Taxon	Hutchinson							Chikaming						
	Sampling Dates							Sampling Dates						
	*5/8	**5/27	*6/15	*7/6	*7/27	*8/18	9/10	5/8	5/27*	*6/15	*7/6	*7/27	*8/18	9/10
Trichogrammatidae	-	8	-	-	-	-	-	-	8	-	-	-	-	-
Lepidoptera														
Arctiidae	-	-	8	-	-	8	-	-	-	-	-	-	-	-
Liparidae	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Neuroptera														
Chrysopidae	-	16	16	-	8	-	16	-	-	16	8	16	16	-
Hemerobiidae	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Thysanoptera														
Aeolothripidae	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Thripidae	48	16	-	-	-	-	-	24	40	8	-	-	-	-
Immatures	-	277	-	-	-	-	-	-	101	8	-	-	-	-

*Approximate dusting dates.

Van Buren County, 1964

Taxon	Hartman							Wakeman						
	Sampling Dates							Sampling Dates						
	5/7	5/25**	6/16**	7/8**	7/28	8/19	9/11	*5/7*	5/25**	6/16*	*7/8	*7/28	8/19	9/11
Acarina														
Mesostigmata	-	-	-	-	-	-	-	-	-	-	-	-	-	16
Sarcoptiformes	8	-	-	-	-	-	-	-	-	-	-	-	-	24
Trombidiformes	16	-	-	24	-	24	8	-	8	-	-	-	-	-
Coleoptera														
Chrysomelidae														
Agalyptus sp.	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Glyptina sp.	-	-	-	8	8	-	-	-	-	-	-	8	8	-
Longitarsus sp.	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Curculionidae														
Baris scolopacea	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Brachyrhinus rugifrons	-	-	-	16	-	-	-	-	-	-	-	-	-	-
Staphylinidae														
Osorius sp.	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Collembola														
Sminthuridae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Diptera														
Bombyliidae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Cecidomyidae	48	-	8	24	-	-	8	-	-	16	-	-	-	16
Chironomidae	8	8	-	-	-	-	-	128	16	-	-	-	56	56
Chloropidae	-	-	48	56	-	72	24	-	-	-	40	24	48	48
Culicidae	-	-	-	-	-	-	16	-	-	8	-	-	-	8
Dolicopodidae	-	-	-	24	-	16	16	-	8	8	24	-	16	-
Drosophilidae	-	8	-	-	-	0	-	-	40	-	-	-	624	752
Lonchopteridae	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Lycorridae	16	-	24	24	-	8	-	192	56	8	-	-	48	-
Muscidae	-	-	-	-	8	8	-	-	16	-	-	8	-	8
Mycetophilidae	240	88	40	8	-	-	-	-	136	32	-	-	-	-

Van Buren County, 1964--Continued

Taxon	Hartman							Wakeman						
	Sampling Dates							Sampling Dates						
	5/7	5/25**	6/16**	7/8**	7/28	8/19	9/11	*5/7*	5/25**	6/16*	7/8	*7/28	8/19	9/11
Ochthiphilidae	-	40	8	-	-	-	-	-	-	16	-	-	-	-
Phoridae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Psychodidae	-	-	-	-	-	-	-	-	-	-	32	-	-	-
Sciaridae	-	-	24	-	-	-	-	-	-	-	-	-	-	-
Syrphidae	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Telanoceridae	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Trypetidae	-	-	-	-	-	16	-	-	-	-	-	-	-	-
Hemiptera														
Anthocoridae														
Orius insidiosus	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Lygaeidae														
Ischnorrhynchus residae	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Ischnorrhynchus championi	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Miridae														
Capsus ater	16	-	8	-	-	-	-	-	8	-	-	-	-	-
Trigonolylus ruficornis	-	-	-	8	-	-	-	-	-	-	-	-	-	-
Piesmidae														
Piesma cinerca	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Tingididae														
Corythaica beldula	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Homoptera														
Aleyrodidae														
Aleurochiton forbesii	-	-	-	8	-	16	-	-	-	-	-	-	-	8
Aphididae														
Masonaphis pepperi	-	-	-	24	16	-	-	-	-	40	-	72	112	24
Myzus scammelli	-	-	-	-	-	-	-	-	-	-	16	-	8	8
Cercopidae														
Philaenus spumarius	-	-	8	24	8	-	8	-	-	-	8	8	-	-

Van Buren County, 1964--Continued

Taxon	Hartman							Wakeman						
	Sampling Dates							Sampling Dates						
	5/7	5/25**	6/16**	7/8**	7/28	8/19	9/11	*5/7*	5/25**	6/16*	7/8*	7/28	8/19	9/11
Chermidae														
Phylloplecta diaspyri	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Psyllia annulata	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Cicadellidae														
Deltocephalus flavicostus	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Draeculacephala antic	-	-	-	-	-	-	-	-	-	-	-	8	-	8
Empoasca fabae	-	-	24	8	8	16	-	-	32	40	24	16	40	40
Endria inimica	-	-	-	8	-	16	-	-	8	-	-	-	-	48
Forcipata loca	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Graminella nigrifrons	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Gyponana arcta	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Macrosteles fascifrons	-	-	-	-	16	-	8	-	-	32	-	-	16	32
Norvellina seminuda	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Osbornellus auronitens	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scaphytopins acutas	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Tylozygus bifidus	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Fulgoridae														
Cixius misellus	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Delphacodes nigridorsum	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Liburnilla ornata	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Hymenoptera														
Apidae														
Apis mellifera	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Bombus vagans	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Braconidae	-	8	-	8	-	24	-	-	-	-	-	-	8	16
Chalcidoidea	8	-	16	48	8	312	24	8	16	8	56	-	56	160
Cynipidae	-	16	-	8	-	24	-	-	16	-	-	-	16	-

Van Buren County, 1964--Continued

Taxon	Hartman							Wakeman						
	Sampling Dates							Sampling Dates						
	5/7	5/25**	6/16**	7/8**	7/28	8/19	9/11	*5/7*	5/25**	6/16*	*7/8	*7/28	8/19	9/11
Formicidae	-	-	-	-	-	-	-	-	-	8	24	-	-	-
Ichneumonidae	-	-	-	-	-	-	-	-	-	16	-	-	16	16
Platygasteridae	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Trichogrammatidae	-	-	-	-	-	-	16	-	-	-	-	8	16	40
Lepidoptera														
Geometridae	-	-	-	-	-	8	8	-	-	-	-	-	-	-
Gracilariidae	-	16	-	16	-	-	-	-	-	-	-	-	-	-
Pieridae														
Pieris sp.	8	16	-	-	-	-	-	-	-	-	-	-	-	-
Pyralidae														
Crambus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Neuroptera														
Chrysopidae	-	8	-	8	-	8	-	-	8	-	8	-	-	8
Hemerobiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	16
Psocoptera														
Pseudocaecilliidae														
Lachesilla pedicularia	-	8	-	-	-	-	-	-	-	-	-	-	-	8
Thysanoptera														
Phloeothripidae	-	-	-	-	-	-	-	-	-	-	-	-	16	-
Thripidae	-	24	-	-	-	8	8	-	56	-	8	-	-	-
Immatures	-	8	-	-	-	-	-	-	-	-	-	-	-	-

Allegan County, 1964

Taxon	Wadsworth							Double A						
	Sampling Dates							Sampling Dates						
	5/10	5/25*	6/16*	7/8**	7/29	8/19	9/11	5/10	5/25*	6/16*	7/8*	7/29*	8/19	9/11
Acarina														
Mesostigmata	-	16	-	-	-	-	-	16	8	-	16	-	-	-
Sarcoptiformes	8	-	16	16	80	256	112	-	-	-	-	-	-	-
Trombidiformes	32	88	8	32	-	8	8	-	-	-	-	-	-	-
Coleoptera														
Carabidae														
Lebia sp.	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Chrysomelidae														
Glyptina sp.	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Longitarsus sp.	-	-	-	-	-	8	-	-	-	-	-	-	-	8
Cisidae														
Cerais sp.	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Coccinellidae														
Ceratomegilla maculata	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Curculionidae														
Acalyptus sp.	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Lathridiidae														
Corticaria sp.	-	-	-	8	-	-	-	-	-	-	-	-	-	-
Nitidulidae														
Carpophilus sp.	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Orthoperidae														
Corylophodes sp.	-	-	-	8	-	-	-	-	-	-	-	-	-	-
Phalacridae														
Phalacrus sp.	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Collembola														
Entomobryidae	-	-	-	16	-	-	-	-	-	-	-	-	-	-
Sminthuridae	-	-	-	-	-	-	-	40	-	-	-	-	-	-

Allegan County, 1964--Continued

Taxon	Wadsworth							Double A						
	Sampling Dates							Sampling Dates						
	5/10	5/25*	6/16*	7/8**	7/29	8/19	9/11	5/10	5/25*	6/16*	7/8*	7/29*	8/19	9/11
Diptera														
Anthomyiidae	-	-	-	24	-	-	-	-	-	-	-	-	8	-
Bombyliidae	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Cecidomyidae	-	-	-	8	-	16	24	-	-	24	-	-	40	72
Ceratopoganidae	-	-	-	-	-	-	-	-	8	-	-	8	-	-
Chironomidae	8	168	-	32	8	32	40	8	-	-	16	-	88	8
Chloropidae	32	104	72	32	136	48	96	-	136	-	24	16	56	32
Culicidae	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Dolicopodidae	-	-	-	16	32	24	-	-	-	-	-	-	-	-
Drosophilidae	-	-	168	56	32	184	88	-	-	-	-	-	-	24
Empididae	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Ephydridae	-	-	24	-	-	-	40	-	-	-	-	24	-	8
Lonchopteridae	16	72	-	-	-	-	-	-	16	-	-	-	-	-
Lycorridae	32	24	-	-	-	-	-	24	-	16	8	16	-	8
Muscidae	-	-	16	-	8	-	-	-	-	-	24	-	-	-
Mycetophilidae	232	146	24	-	-	-	16	88	32	-	-	-	-	-
Ochthiphilidae	-	-	-	-	-	-	-	-	72	-	-	-	-	-
Phoridae	-	-	16	8	-	-	-	-	-	-	-	-	16	-
Pipunculidae	-	-	-	-	8	-	16	-	-	-	-	-	-	-
Sarophagidae	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Sciaridae	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Tebanoceridae	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipulidae	-	-	-	-	-	-	8	-	-	8	-	8	-	-
Trypetidae	-	-	-	-	-	-	-	-	-	-	-	8	-	-
Hemiptera														
Anthocoridae														
Orius insidiosus	-	8	-	-	-	-	-	-	-	-	-	-	16	8

Allegan County, 1964--Continued

Taxon	Wadsworth							Double A						
	Sampling Dates							Sampling Dates						
	5/10	5/25*	6/16*	7/8**	7/29	8/19	9/11	5/10	5/25*	6/16*	7/8*	7/29*	8/19	9/11
Lygaeidae														
Ischnorrhynchus residae	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Miridae														
Capsus ater	8	-	-	8	-	16	8	-	8	-	-	16	-	24
Nabidae														
Nabis limbutus	-	-	-	8	8	-	-	-	-	-	-	-	-	-
Reduvidae	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Homoptera														
Aleyrodidae														
Aleurochiton forbesii	-	-	-	-	8	-	-	-	-	-	8	-	-	-
Aphididae														
Masonaphis pepperi	8	32	96	384	216	848	192	-	-	-	144	40	16	8
Myzus scammelli	-	8	16	-	-	-	-	-	-	-	8	40	-	-
Cercopidae														
Philaenus spumarius	-	-	24	32	56	24	-	-	-	8	24	-	8	-
Chermidae														
Aphalara persicaria	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Cicadellidae														
Aceratagallia sanguinolenta	-	-	-	-	-	-	-	-	-	-	16	8	-	-
Amblysellus curtisii	-	-	-	-	-	8	48	-	-	-	-	-	-	-
Bandara inflata	-	-	-	-	-	-	8	-	-	-	-	-	-	8
Draeculacephala antic	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Empoasca fabae	-	16	16	32	16	56	272	-	16	64	24	24	52	56
Endria inimica	-	-	-	-	-	16	-	-	-	-	8	-	-	24
Exitianus exitiosus	-	-	-	-	-	-	56	-	-	-	-	-	8	8
Forcipata loca	8	8	-	-	-	8	8	-	-	-	-	-	-	-
Graminella nigrifrons	-	-	-	-	-	-	-	-	-	-	-	-	8	-

Allegan County, 1964--Continued

Taxon	Wadsworth							Double A						
	Sampling Dates							Sampling Dates						
	5/10	5/25*	6/16*	7/8**	7/29	8/19	9/11	5/10	5/25*	6/16*	7/8*	7/29*	8/19	9/11
Lygaeidae														
Ischnorrhynchus residae	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Miridae														
Capsus ater	8	-	-	8	-	16	8	-	8	-	-	16	-	24
Nabidae														
Nabis limbutus	-	-	-	8	8	-	-	-	-	-	-	-	-	-
Reduvidae	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Homoptera														
Aleyrodidae														
Aleurochiton forbesii	-	-	-	-	8	-	-	-	-	-	8	-	-	-
Aphididae														
Masonaphis pepperi	8	32	96	384	216	848	192	-	-	-	144	40	16	8
Myzus scammelli	-	8	16	-	-	-	-	-	-	-	8	40	-	-
Cercopidae														
Philaenus spumarius	-	-	24	32	56	24	-	-	-	8	24	-	8	-
Chermidae														
Aphalara persicaria	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Cicadellidae														
Aceratagallia sanguinolenta	-	-	-	-	-	-	-	-	-	-	16	8	-	-
Amblysellus curtisii	-	-	-	-	-	8	48	-	-	-	-	-	-	-
Bandara inflata	-	-	-	-	-	-	8	-	-	-	-	-	-	8
Draeculacephala antic	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Empoasca fabae	-	16	16	32	16	56	272	-	16	64	24	24	52	56
Endria inimica	-	-	-	-	-	16	-	-	-	-	8	-	-	24
Exitianus exitiosus	-	-	-	-	-	-	56	-	-	-	-	-	8	8
Forcipata loca	8	8	-	-	-	8	8	-	-	-	-	-	-	-
Graminella nigrifrons	-	-	-	-	-	-	-	-	-	-	-	-	8	-

Allegan County, 1964--Continued

Taxon	Wadsworth							Double A						
	Sampling Dates							Sampling Dates						
	5/10	5/25*	6/16*	7/8**	7/29	8/19	9/11	5/10	5/25*	6/16*	7/8*	7/29*	8/19	9/11
Graphocephala coccinea	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Gyponana arcta	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Macrosteles fascifrons	-	-	8	-	-	16	8	-	-	16	-	24	16	48
Osbornellus auronitens	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Fulgoridae														
Cixius misellus	-	-	-	-	-	-	8	-	-	-	-	-	8	-
Delphacodes campestris	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Fitchiella robertsoni	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Kelisia crocea	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Liburnilla ornata	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Pentagramma vittatifrons	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Hymenoptera														
Apidae														
Apis mellifera	-	-	-	-	-	-	-	-	24	-	-	-	-	-
Bombus fervious	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Bombus Neuadensis aueicamus	-	-	-	-	-	-	-	8	8	-	-	-	-	-
Xylocopa virginica	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Braconidae	-	-	-	-	24	16	40	-	-	-	8	16	8	8
Chalcidoidea	56	8	24	80	120	200	464	8	8	8	64	48	232	96
Cynipidae	16	-	-	16	-	-	-	-	-	-	-	-	32	8
Formicidae	-	8	-	-	-	-	-	-	-	8	-	-	16	-
Ichneumonidae	40	-	16	24	-	8	96	-	-	-	-	-	8	8
Trichogrammatidae	8	-	16	-	-	8	24	32	-	-	8	8	-	8
Lepidoptera														
Geometridae	-	-	-	-	-	-	-	8	8	-	-	-	-	-
Gracilaridae	-	-	-	-	8	32	24	-	-	-	-	-	-	-
Micro-Lepidoptera	-	-	-	-	48	-	-	-	-	-	8	-	-	16

Allegan County, 1964--Continued

Taxon	Wadsworth							Double A						
	Sampling Dates							Sampling Dates						
	5/10	5/25*	6/16*	7/8**	7/29	8/19	9/11	5/10	5/25*	6/16*	7/8*	7/29*	8/19	9/11
Phalaenidae	16	-	-	-	-	-	-	-	-	-	-	-	-	-
Neuroptera														
Chrysopidae	-	-	-	8	-	-	40	-	-	-	8	16	16	24
Hemerobiidae	-	-	-	-	-	-	8	-	-	-	-	-	8	-
Thysanoptera														
Phloeothripidae	-	-	-	-	-	-	8	-	8	-	-	-	-	-
Thripidae	-	32	-	-	-	-	8	24	72	-	56	24	48	8

Ottawa County, 1964

Taxon	De Pree							Boo Hoot						
	Sampling Dates							Sampling Dates						
	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12
Acarina														
Mesostigmata	-	32	-	-	-	-	-	16	-	-	-	-	-	8
Sarcoptiformes	-	-	-	56	8	8	56	-	-	-	-	-	-	-
Trombidiformes	-	-	8	56	-	8	24	-	-	-	32	-	-	-
Coleoptera														
Anthicidae														
Tomaderus sp.	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Chrysomelidae														
Glyptina sp.	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Longitarsus sp.	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Pachybrachis sp.	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Coccinellidae														
Ceratomegilla maculata	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Lathridiidae														
Corticaria sp.	-	-	-	-	-	-	8	-	-	-	8	-	-	-
Mordellidae														
Glipa hilaris	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Phalacridae														
Phalacrus sp.	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Scarabacidae														
Macrodactylus sp.	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Staphylinidae														
Osorius sp.	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Collembola														
Entomobryidae	-	-	-	16	-	-	-	-	-	-	-	-	-	-
Sminthuridae	8	48	-	-	-	-	-	8	-	-	-	-	-	-
Diptera														
Asilidae	-	-	-	-	8	-	-	-	-	-	-	-	-	-

Ottawa County, 1964--Continued

Taxon	De Pree							Boo Hoot						
	Sampling Dates							Sampling Dates						
	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12
Borboridae	56	-	-	-	8	-	-	-	-	-	-	-	-	-
Cecidomydiae	-	-	-	8	16	-	24	-	-	-	-	8	24	48
Chironomidae	-	24	-	16	-	24	8	8	-	16	-	16	64	16
Chloropidae	-	248	32	32	88	32	64	-	48	48	104	32	72	48
Culicidae	-	-	-	8	-	-	-	-	-	-	-	-	8	-
Dolicopodidae	-	-	32	-	16	16	-	-	-	-	-	8	-	-
Drosphilidae	-	-	8	-	-	16	-	-	-	24	-	-	32	48
Empididae	-	-	-	24	-	-	-	-	-	-	-	-	-	-
Ephydridae	-	-	-	-	-	-	24	-	-	-	-	-	-	-
Lycorridae	16	-	-	24	32	16	32	8	-	-	48	-	-	-
Muscidae	8	-	-	8	-	-	-	-	-	-	-	-	-	-
Mycetophilidae	344	184	8	-	-	-	-	64	8	16	24	-	-	-
Ochthiphilidae	168	136	-	-	-	-	-	-	24	-	16	-	-	-
Otitidae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Phoridae	-	-	-	8	-	-	-	-	-	-	-	-	-	-
Sciaridae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Syrphidae	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Tipulidae	-	-	-	8	-	8	-	-	-	-	-	-	-	8
Trypetidae	-	-	-	-	8	8	-	-	-	-	-	8	-	-
Hemiptera														
Anthocoridae														
Oruis insidiosus	-	-	-	-	-	16	-	-	-	-	-	-	8	8
Lygaeidae														
Ischnorrhynchus championi	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Ischnorrhynchus residae	-	-	-	-	-	-	-	-	-	-	-	-	-	80
Miridae														
Capsus ater	-	8	-	-	-	-	8	-	-	8	8	-	-	8
Trigonotylus ruficornis	-	-	-	-	-	8	-	-	-	-	-	8	-	-

Ottawa County, 1964--Continued

Taxon	De Pree							Boo Hoot						
	Sampling Dates							Sampling Dates						
	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12
Nabidae														
Nabis limbutus	-	-	-	8	8	16	-	-	-	-	-	-	-	-
Neididae														
Jalysus spinosus	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Pentatomidae														
Podisus maculiventsis	-	-	-	-	-	8	-	-	-	-	-	-	-	-
Homoptera														
Aleyrodidae														
Aleurochiton forbesii	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Aphididae														
Masonaphis pepperi	-	-	16	384	496	352	-	-	-	112	16	-	48	16
Myzus scammelli	-	-	24	-	-	-	8	24	16	16	-	-	-	-
Cercopidae														
Philaenus spumarius	-	-	8	24	-	8	-	-	-	8	24	32	-	8
Chermidae														
Phylloplecta salicis	8	-	-	-	-	-	-	8	-	-	-	-	-	-
Cicadellidae														
Aceratagallia sanguinolenta	16	-	-	-	-	-	-	-	-	-	-	-	-	-
Balclutha impicta	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Bandara inflata	-	-	-	-	-	-	24	-	-	-	-	-	-	24
Draeculacephala antic	-	-	-	-	-	-	-	-	-	-	-	-	-	16
Empoasca fabae	-	48	-	16	64	56	152	-	24	32	56	88	160	144
Endria inimica	-	-	-	8	-	-	8	-	-	-	8	-	-	32
Exitianus exitiosus	-	-	-	-	-	-	16	-	-	-	8	-	24	40
Forcipata loca	-	-	-	16	-	-	-	-	-	-	-	-	-	-
Graphocephala coccinea	-	-	-	8	-	-	-	-	-	-	-	-	-	-
Gyponana arcta	-	-	-	-	-	16	-	-	-	-	-	-	-	-

Ottawa County, 1964--Continued

Taxon	De Pree							Boo Hoot						
	Sampling Dates							Sampling Dates						
	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12	5/11	5/26*	6/17*	7/9*	7/29*	8/20	9/12
Macrosteles fascifrons	-	8	-	-	8	-	8	-	8	16	16	-	8	-
Paraphlepsius irroratus	-	-	16	8	-	8	8	-	8	16	16	-	8	-
Xestocephalus pulicarius	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Fulgoridae														
Cixius misellus	-	-	-	-	-	-	-	-	-	-	-	-	-	16
Liburnilla ornata	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Hymenoptera														
Bethylidae	-	-	-	-	-	-	-	-	-	-	-	8	-	-
Braconidae	8	8	-	8	-	8	8	-	-	-	-	16	8	-
Chalcidoidea	32	32	-	32	72	64	184	16	16	160	24	80	196	196
Cynipidae	32	16	-	-	-	8	-	16	-	-	-	-	16	-
Diapriidae	-	-	-	-	-	-	-	-	-	-	8	-	-	-
Formicidae	24	-	-	8	-	8	-	-	-	-	8	-	-	-
Ichneumonidae	16	-	-	24	-	16	-	8	-	-	-	-	-	8
Trichogrammatidae	-	8	-	-	8	16	8	-	-	8	-	8	8	8
Lepidoptera														
Geometridae	16	-	-	-	-	-	-	8	-	-	-	-	-	-
Gracilariidae	-	-	-	-	-	-	-	-	-	-	16	-	-	-
Micro-Lepidoptera	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Phalaenidae	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Neuroptera														
Chrysopidae	-	32	-	8	8	-	32	-	24	8	-	8	32	40
Hemerobiidae	-	-	-	-	8	16	8	-	-	-	-	-	-	-
Thysanoptera														
Acolothripidae	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Thripidae	16	8	-	-	-	-	-	-	24	16	-	-	-	-
Immatures	-	40	-	-	-	16	-	8	24	-	-	-	-	-

Muskegon County, 1964

Taxon	Pauls							Derkse						
	Sampling Dates							Sampling Dates						
	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12
Acarina														
Mesostigmata	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Sarcoptiformes	-	-	-	16	-	-	-	-	-	8	48	40	152	32
Coleoptera														
Anthicidae														
Tomoderus sp.	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Chrysomelidae														
Diabrotica undecimpunctata	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Glyptina sp.	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Longitarsus sp.	-	-	-	-	-	8	-	-	-	-	-	-	-	8
Coccinellidae														
Ceratomegilla maculata	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Hippodamia quinquesignata	-	-	-	-	-	-	16	-	-	-	-	-	-	-
Lathridiidae														
Corticaria sp.	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Nitidulidae														
Carpophilus sp.	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Phalacridae														
Phalaesus sp.	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Scarabaeidae														
Hoplia sp.	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Diptera														
Agromyzidae	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Asilidae	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Borboridae	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Cecidomyidae	-	-	-	-	-	16	-	-	8	24	-	-	-	32
Chloropidae	-	96	8	32	32	24	-	-	96	24	16	8	24	32

Muskegon County, 1964--Continued

Taxon	Pauls							Derkse						
	Sampling Dates							Sampling Dates						
	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12
Dolicopodidae	-	-	-	8	8	-	-	-	-	-	-	8	-	-
Drosphilidae	8	-	-	-	-	8	-	-	-	-	-	-	88	8
Empididae	16	-	-	-	-	-	-	-	-	-	-	-	-	-
Lonchopteridae	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Lycorridae	-	-	-	-	8	-	-	-	-	24	-	24	-	24
Muscidae	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Mycetophilidae	48	16	-	-	-	-	-	56	80	-	-	-	-	-
Ochthiphilidae	16	24	8	-	-	-	-	24	160	-	-	-	-	-
Phoridae	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Sarcophagidae	-	-	8	-	-	-	-	-	-	-	-	-	-	-
Syrphidae	-	-	-	-	-	-	8	-	-	-	8	-	8	-
Tipulidae	-	-	-	-	-	-	-	-	-	-	-	-	-	16
Trypetidae	-	-	-	8	-	-	-	-	-	-	16	-	-	-
Hemiptera														
Miridae														
Capsus ater	-	-	-	8	-	-	-	-	-	16	8	-	8	-
Trigonotylus ruficornis	-	-	-	-	-	-	-	-	-	-	16	-	-	8
Nabidae														
Nabis limbutus	-	-	-	-	-	8	-	-	-	-	-	-	-	8
Homoptera														
Aleyrodidae														
Aleurochiton forbesii	-	-	8	-	8	-	-	8	8	-	-	-	-	-
Aphididae														
Masonaphis pepperi	8	-	-	16	16	16	8	-	8	-	-	-	-	-
Myzus scammelli	-	8	16	24	-	-	-	-	-	-	16	-	-	-
Cercopidae														
Philaenus spumarius	-	-	-	-	16	-	-	-	-	16	40	8	-	-

Muskegon County, 1964--Continued

Taxon	Pauls							Derkse						
	Sampling Dates							Sampling Dates						
	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12
Cicadellidae														
Aceratagallia sanguinolenta	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Balclutha impicta	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Bandara inflata	-	-	-	-	-	-	8	-	-	-	-	-	-	8
Draeculacephala antic	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Empoasca fabae	-	-	16	32	16	16	32	-	16	64	56	48	48	104
Endria inimica	-	-	8	-	-	-	8	-	-	-	8	8	-	16
Exitianus exitiosus	-	-	-	-	-	-	16	-	-	-	-	-	-	8
Forcipata loca	-	-	-	-	-	8	-	-	-	8	-	8	-	-
Macrosteles fascifrons	-	-	-	-	-	-	-	-	8	8	-	-	-	24
Hymenoptera														
Apidae														
Apis mellifera	-	8	-	-	-	-	-	-	8	-	-	-	-	-
Braconidae	-	-	-	-	32	-	-	-	-	8	-	8	-	24
Chalcidoidea	16	8	16	144	56	88	40	24	32	24	112	16	112	88
Cynipidae	-	-	-	16	-	-	-	-	-	-	8	8	24	-
Formicidae	-	-	-	-	8	8	-	-	-	-	-	-	-	8
Ichneumonidae	16	-	8	8	-	16	-	-	-	-	-	-	-	8
Trichogrammatidae	-	-	-	-	16	-	-	-	-	16	40	-	8	-
Lepidoptera														
Geometridae (Immatures)	24	-	-	-	-	-	-	16	48	8	-	-	-	-
Gracilariidae	-	-	-	-	-	-	-	-	-	16	-	-	-	-
Micro-Lepidoptera	-	-	-	-	-	8	8	-	-	-	-	-	-	-
Pyralidae	-	-	-	-	-	-	-	-	-	-	16	-	8	-
Neuroptera														
Chrysopidae	-	24	8	24	-	16	16	-	8	8	-	-	-	8
Hemerobiidae	-	-	-	8	-	-	-	-	-	-	-	-	8	-

Muskegon County, 1964--Continued

Taxon	Pauls							Derkse						
	Sampling Dates							Sampling Dates						
	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12	5/11	5/26***	6/18	7/9**	7/29	8/20*	9/12
Thysanoptera														
Phloeothripidae	-	-	-	-	-	-	-	-	8	-	-	-	-	-
Thripidae	16	16	16	-	-	8	8	16	56	8	-	-	-	-
Immatures	-	8	24	-	-	-	-	-	8	8	-	-	-	-