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TB52: Seasonal Population Trends and Productiveness of the Potato Aphid on Swamp Rose in Northeastern Maine

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COVER PHOTO

A patch of swamp rose, *Rosa palustris* Marsh., in full flower. This widespread rose is the most important primary (overwintering) breeding host of the potato aphid, *Macrosiphum euphorbiae* (Thomas), in Maine. It occurs in many, varied environments, including pastures, hedge rows, along rock walls, and in the edge of woods. The spring migration of the potato aphid from roses to fields of potatoes and to other secondary, summer host plants is near the peak about the time the roses are in full flower.

CONTENTS

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SEASONAL POPULATION TRENDS AND PRODUCTIVENESS OF THE POTATO APHID ON SWAMP ROSE IN NORTHEASTERN MAINE[1]

W. A. Shands[2], Geddes W. Simpson[3] and H. E. Wave[4]

SUMMARY AND CONCLUSIONS

Studies were conducted in northeastern Maine to determine seasonal population trends and productiveness of the potato aphid on swamp rose. The results presented and discussed concern chiefly chronological and phenological aspects of the utilization of swamp rose as a primary host of the aphid; time-temperature developmental requirements of the aphid in spring; productiveness of the aphid in caged colonies on swamp rose in spring; population trends of the aphid on naturally occurring, undisturbed swamp rose in spring and in fall; populations of aphid eggs on swamp rose in November and again in mid April of the following year; and a comprehensive assessment of the probable usefulness of results from surveys of abundance of the aphids or aphid eggs on swamp rose in making advanced estimates of abundance of the potato aphid on potatoes.

Overwintered potato aphid eggs on swamp rose began hatching after mid April. Under field conditions the second generation produced some alate and most of the third generation matured as alatae. However, when the stem mother and her descendents developed on potato foliage in the greenhouse, the percentages of alatae in the second to sixth generations were 4, 16, 24, 17 and 50, respectively.

On potatoes in the greenhouse, an average of 8.4 days or 536 day-degrees F was required for nymphal development of specimens destined to be apterous adults in the second to sixth generations, and 8.6 days, or 578 day-degrees F. were required for those becoming alate adults.

The time of beginning and duration of the spring migration were influenced largely by the time the eggs hatched and the rate of aphid development. During 27 years the date of the beginning of the spring migration varied from about May 25 to about June 15 to 20. There was less variation among years in the beginning of the fall migration; it varied from about August 20 to about September 1.

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On caged branches of swamp rose, during an 11-year period, June 4 was the average date that the spring migrants began maturing. The average date of the peak of maturation of spring migrants was June 24. In one year, alate forms continued to mature until September 20 to 24—nearly one month after the start of the fall migration—and the apterous forms continued to be present until September 24.

The numbers of spring migrants per stem mother maturing in caged colonies on swamp rose ranged from 1 to 808. While the average number of alatae per stem mother each year varied from 94 to 186, the average for the 11 years was 117. The range in duration of maturation of alatae in the caged colonies during these years was 36 to 103 days; the average was 59 days.

The rate of growth and size of the potato aphid population on undisturbed stands of swamp rose increased rather steadily from the time second generation adults began to mature until the spring peak was reached about June 20, or about the time that roses began to flower. The spring migrants matured over an average of 28 days, ranging from as early as May 16 to as late as July 18; spring breeding of apterae occurred until late in July in some years. The overall abundance of potato aphids developing on swamp rose in spring, including spring migrants, was influenced largely by biotic factors (arthropod parasites and predators and entomogenous fungi) and weather conditions. There was an 8-fold difference among the 11 years in size of population at the spring peak.

Peak abundance of the potato aphid on swamp rose in autumn occurred shortly before mid September. The year-to-year average number of potato aphids at the peak ranged from 13.20 to 0.04 apterae per leaf. Population size then gradually decreased until late in October. Not all of the nymphs matured before the onset of winter. Overall size of the population in autumn appeared to be influenced by entomogenous fungi, spiders and by internal parasites.

During an 18-year period the average numbers of aphid eggs per 100 buds, 100 limb crotches or 100 inches of trunk in November were 8.1, 9.5 and 11.4, respectively; in mid April of the following year the comparable averages were 5.7, 7.2 and 6.1, respectively. Percentages of shriveled eggs in the same sample units in November were 15.1, 11.4 and 8.1, respectively, while in mid April of the following year, the comparable percentages were 32.7, 28.6 and 20.2, respectively. There was less shriveling and less over-winter loss of eggs on the lower than on upper parts of rose plants; this was due probably to the presence of undergrowing vegetation, snow cover and protection from feeding by birds afforded by snow cover in spring.

There were significant positive correlations between abundance of aphid eggs on swamp rose in November and peak abundance earlier in the fall of potato aphids only; a similar relationship was also observed between abundance of aphid eggs in mid April and in November of the preceding year. However, only in one year out of five was abundance of aphid eggs in mid April correlated significantly with potato aphid abundance at the fall peak in the preceding year.

Potato aphid abundance at the summer peak on untreated potatoes was correlated with that on swamp rose at the fall peak of the preceding year, but not with abundance of the aphid at the spring peak on swamp rose in the same year or with that of aphid eggs on swamp rose in mid April. Abundance of the potato aphid on potatoes might have exhibited a greater dependence upon that of aphids or aphid eggs on swamp rose had the geographical distribution of the sample potato fields been the same as that of the swamp rose stations, and if the aphid counts on potatoes could have been made each year just prior to or at the start of activity of entomogenous fungi in the potato fields.

INTRODUCTION

The potato aphid, *Macrosiphum euphorbiae* (Thomas), is one of the four species of aphids commonly infesting field-growing potatoes, *Solanum tuberosum* L., in Maine (Figure 1). This aphid occurs widely throughout the United States and elsewhere in the world; it utilizes many wild plants as summer hosts (Patch, 1938) and it may infest other commercially-grown plants in addition to potatoes. The other three species of potato-infesting aphids in northeastern Maine are the buckthorn aphid, *Aphis nasturtii* Kaltenbach, the green peach aphid, *Myzus persicae* (Sulzer), and the foxglove aphid, *Acyrthosiphon solani* (Kaltenbach).

These four species are important pests of potatoes from two standpoints. When their numbers become sufficiently large, unless controlled, their feeding damage to the foliage (Figure 2) can cause reduced yield of tubers (Shands *et al.*, 1950; Simpson and Shands, 1954). In addition, the aphids are vectors of several plant viruses as they feed on and move from diseased to healthy potato plants within and between fields. The virus diseases reduce yield and quality of tubers to varying degrees depending upon variety, the time when the plants become infected, and upon other factors, including field fertilization and storage conditions.

The potato aphid serves as a vector of several of the viruses that may infect potato plants. It is an important vector of the virus *Marmor solani* Holmes (Schultz *et al.*, 1919; Folsom, 1920) which, when introduced into a potato plant containing virus X (*Annulus dubius* (Holmes)),

FIG. 1-A

FIGURE 1. Potato aphids feeding on *A*, a young potato stalk, *B*, on potato flowers, and *C*, on a potato flower stalk after the flowers have died prematurely from aphid feeding.

FIG. 1-B

results in the potato disease known as mild mosaic. Results of a study by McKinnon (1969) provided conclusive evidence that the potato aphid is also a vector of the potato leaf roll virus, *Corium solanum* Holmes. Unpublished results of our recent studies as well as published results of Robert (1971) confirm this, but indicate that the aphid probably is of no great importance as a vector of leaf roll virus under field conditions.

Studies by Patch (1914, 1915, 1919, 1938) disclosed that many plants can serve as hosts for the potato aphid, including the "Japanese

FIG. 1-C

rose," *Rosa* sp. Her studies (Patch, 1925) showed that rose is a plant on which the potato aphid overwinters and breeds abundantly in spring before it infests potatoes and other plants. In early studies, several species of wild and escaped roses were recognized to serve as overwintering hosts of the potato aphid in northeastern Maine and to be rather generally distributed throughout the potato-growing districts of that section of the State (Simpson, 1940).

More intensive observations in 1941 and 1942 revealed that swamp rose, *Rosa palustris* Marsh., was the most abundant and widely dis-

FIGURE 2. Typical damage to foliage of field-growing potatoes from feeding by the potato aphid. The cupped, crinkled leaves resulted from feeding by large numbers of the potato aphid.

tributed species of the wild roses occurring in northeastern Maine; it was also found that it was an important primary or overwintering host of the potato aphid throughout the area. Some species of wild or escaped roses, including *Rosa carolina* L., *Rosa rugosa* Thunb., and *Rosa multiflora* Thunb., occasionally supported substantially larger populations of the potato aphid than did *R. palustris*. However, because of their more limited abundance and distribution, these plants were considered to be far less important than was *R. palustris* as a source of potato aphids for infesting potatoes over the area as a whole.

From 1941 to 1959, inclusive, a long-range study was conducted to gain more understanding of the role of swamp rose as a host of the potato aphid and its relationship to populations of the potato aphid on potatoes in northeastern Maine.

SEASONAL HISTORY AND DEVELOPMENT OF THE POTATO APHID ON SWAMP ROSE

In northeastern Maine, eggs of the potato aphid overwintering on swamp rose begin hatching usually in late April. The nymphs hatching from these eggs mature as apterous stem mothers (fundatrices). The stem mothers and their spring descendents feed on the tender, succulent, new growth arising from buds at any place on the plant; however, early in spring new growth near the base of the plants is more likely to be infested than that in the more exposed, upper parts of the plant.

All descendents of the stem mothers until late summer are females. Alate spring migrants mature on swamp rose in late spring and move to many species of summer or secondary hosts including potatoes. The calendar dates of the start and the duration of the spring migration were rather variable among years (Tables 3, 4).

Spring migrants of the potato aphid developed in the second to sixth generations on potato foliage in the greenhouse (Table 1). However, our field observations confirmed those of Patch (1925) that most potato aphids of the third generation on roses mature as spring migrants although the data in Table 1 do not support this observation. (Use of potato plants, instead of swamp rose, as the host for stem mothers and their progeny in our study may have altered the percentages of alatae developing in successive generations of the stem mother descendents.) On swamp rose the number of spring migrants of the potato aphid maturing in the second generation is small because of the small size and low density of the potato aphid population at that time. However, the percentage of second generation adults maturing as alatae on swamp rose was much larger than the percentage shown in Table 1 for potatoes. In some of our studies, instances were observed where all, or nearly all, of the nymphs deposited by some stem mothers on swamp rose matured as alatae.

The time of occurrence and duration of the spring migration of the potato aphid are influenced largely by temperature, which determines the time that the eggs hatch and the rate of aphid development. Table 2 shows the developmental time of potato aphids on potatoes in the greenhouse at several different mean daily temperatures in spring. From 7.7 to 8.9 days were required for nymphal development of 203 specimens destined to be apterous adults at mean temperatures of 64.6°F to 63.3°F, respectively; the mean time was 8.36 days at a mean temperature of 64.1°F, or 536 day-degrees. The corresponding mean time for development of 39 nymphs destined to be alate adults was 8.63 days at a mean temperature of 67.0°F, or 578 day-degrees; these developmental times and number of day-degrees are somewhat less, but probably not significantly ($P = 0.05$) less, than those found by MacGillivray and Anderson (1958); their times for development on potato foliage at a mean temperature of 71.2°F were 8.1 days, or 577 day-degrees, for nymphs

Table 1

The percent of progeny from hatching eggs of the potato aphid, from swamp rose, that matured as alatae on greenhouse-growing potato plants in spring.

Generation	Percent alate[1]
1 (stem mother, or fundatrix)	0
2 (first agamic generation)	4
3	16
4	24
5	17
6	50

[1] See footnote 1, Table 2 for number of specimens.

Table 2

Development time in relation to temperature of most of the alate and apterous agamic specimens on which Table 1 was based[1].

Mean daily	Days of Development Time	
Temperature (F⁰)	Apterae	Alatae
63.3	8.9	
64.0	8.3	
64.3	7.7	
64.6	7.8	
65.8		8.0
65.9		8.8
68.2		8.5
Wt. avg.		
64.1 (apterae)	8.36	
67.0 (alatae)		8.63

[1] 39 alate and 203 apterous forms out of a total of 250.

destined to be apterous adults, and 8.6 days, or 612 day-degrees, for those to become alate adults.

The differences between the two studies in time-temperature developmental requirements may have been due chiefly to differences in the aphid lineage—host plant relations of the experimental materials used for each. The results in Table 2 were for the specimens of generations 2 to 6 in Table 1; they were the descendents of stem mothers that were confined continuously on potato plants, rather than on roses, from the time the stem mother nymphs hatched. The specimens in the tests of MacGillivray and Anderson (1958) were bred on potato foliage, also, but the mother aphids depositing the nymphs were transferred to the potato foliage used in their tests from potatoes on which that strain of the aphid had been maintained asexually for many generations. The strain used in their study was undoubtedly conditioned to the plant used as the host whereas the rate of development in our study may have been influenced by the lineage of the specimens, since at that time of year they normally would have been using swamp rose as the host.

Table 3

Approximate starting dates of the spring and fall migrations of the potato aphid in central Aroostook County.

Year	Spring Migration	Fall Migration
1942	Before June 8	August 27
1943	June 19	August 31
1944	June 1	[1]
1945	[1]	August 20
1946	June 5	[1]
1947	June 11 to 17	Before August 20
1948	June 2 to 7	August 23
1949	June 3 to 6	August 24
1950	May 29 to June 2	August 21
1952	June 6	August 21
1953	June 5	August 21
1954	June 8	August 27
1955	June 3 to 5	August 26
1956	June 12	August 27
1957	May 31 to June 3	August 25
1958	June 2 to 6	September 1 to 2
1959	June 2	August 21
1960	[1]	August 21
1961	June 15 to 20	August 23
1962	June 6 to 7	August 24
1963	June 5	About September 1
1964	June 5	August 23
1965	Before June 12	August 23
1966	June 8 to 9	[1]
1967	About June 15	[1]
1968	May 25	[1]
1969	About June 6 to 7	[1]

[1] Observations were inadequate for establishing a definite date (no observations were made in 1951).

The suitability of the secondary host, *per se,* may have influenced developmental times of the potato aphid (Smith, 1919) as has been reported for the green peach aphid (Weed, 1927; Sylvester, 1954). Smith (1919) reported that developmental times of the nymphal stages of asexuales of the potato aphid were 16.7 days, 22.0 days, or 25.0 days when the host plants were potato, egg plant (*Solanum melongena* L.) and spinach, or only spinach, respectively. He did not indicate the temperature or time of year when the determinations were made. At a mean temperature of about 75°F, the nymphal stages of the green peach aphid required 6.5 days when spinach, *Spinacia oleraceae* L., was the host (Weed, 1927), and 5 to 8 days were required when *Brassica juncea* (L.) Coss. was the host (Sylvester, 1954).

Developmental time of the nymphal stages of a few stem-mother progeny of the potato aphid on Canada plum, *Prunus nigra* Ait., was determined in the greenhouse at Presque Isle. For three specimens destined to become alate adults, the average was 12.3 days at a mean temp-

Table 4

Productiveness of spring migrants of the potato aphid on new growth of singly caged branches of swamp rose near Presque Isle, Maine.

		Approximate times of maturation				Number days of maturation		Number of alatae maturing per colony		
	Number	Stem mothers	Spring migrants							
Year	of caged colonies	First	First[1]	Peak	Last[1]	Total	Appreciable[2]	Maximum	Minimum	Average
1946	—	May 12-15	June 5	June 15	—	—	—	—	—	—
1947	19	June 1	June 11-12	June 30	August 21-24	103	17	429	1	85.6
1948	19	May 16	June 2- 3	June 28	July 27-29	56	21	619	36	232.6
1949	24	May 9	June 3- 6	June 17	July 16-20	49	16	580	1	135.1
1950	17	May 18	May 29-30	June 23	August 13-16	77	29	808	18	186.1
1952	20	May 20	June 3- 4	June 24	August 24-27	83	16	308	6	128.6
1953	16	May 10	June 6- 7	June 20	July 11-13	36	16	254	19	123.1
1954	19	May 14	June 8- 9	June 23	July 27-Aug. 2	52	11	312	18	89.8
1955	17	May 16	June 5- 6	June 20	July 13-23	43	16	90	15	55.9
1956	18	May 28	June 10-11	July 3	August 17-21	70	17	381	4	93.5
1957	9	May 9-10	May 31-June 1	June 18	July 4- 6	36	13	187	31	103.9
1958	17	May 18	June 2-3	June 27	July 23-25	52	9	210	7	47.8
Averages (1947-1958)		May 17	June 4	June 24	August 2	59	16	380	14	116.5

[1] Last observation before or after alatae were found, respectively.

[2] The number of days during which 2 alatae per day per colony matured in the cages.

erature of 59.4°F, or 731 day-degrees, and for one specimen maturing as an apterous adult it was 13.0 days at 60.9°F, or 792 day-degrees.

Alate females maturing on secondary hosts during summer are called summer dispersal forms. The first maturation of summer dispersal forms of the potato aphid on potatoes at Presque Isle, almost without exception during a 25-year period, occurred from July 18 to 22. The aphid populations on potatoes, including the potato aphid, usually were small at that time of year. From then until about mid August or later, ordinarily the summer dispersal forms increased in abundance.

Toward the end of August, some of the alate forms of the potato aphid maturing on secondary hosts are fall migrant forms (Patch, 1921). These fly to many species of roses, to Canada plum and to other plants and deposit nymphs on the foliage. These nymphs, when matured, are apterous, true females (oviparae). Alate males maturing on secondary hosts fly to the primary hosts and fertilize the oviparae which deposit the overwintering eggs. The eggs are green when laid but turn shiny black after undergoing partial development (Patch, 1915).

There was much more regularity from one year to another in the time of the beginning of the fall migration than in that of the spring migration. The beginning of the fall migration ranged from about August 20 to September 1. (Table 3). These dates are based on observations made between 1942 and 1969, inclusive. During six of these years the observations were inadequate or the numbers of fall migrants were too few to establish a firm date. The beginning of the spring migration from swamp rose during the 27-year period ranged from about May 25 to about June 15 to 20.

PRODUCTIVENESS OF SPRING MIGRANTS OF THE POTATO APHID ON SWAMP ROSE

PROCEDURE

A cage study was conducted during the period 1947 to 1958 to ascertain the importance of swamp rose as a breeding host for spring migrants of the potato aphid. Naturally occurring, single specimens or small colonies of the aphid were caged in spring each year on new growth of swamp rose in naturally occurring patches of the plant near Presque Isle. Usually, one immature stem mother was caged on the branch where she was first found. Rarely, the newly matured adult stem mother alone, or with her few newly deposited progeny was caged on the branch where found. Transferring a few of these stem mothers to another branch on the same plant or on another nearby plant that was more accessible for caging, facilitated observations on colony development. The transfers were accomplished by allowing the aphids to crawl from the infested to the uninfested foliage to be caged. Drawstring cages, 6 inches in diameter, 12 to 16 inches long and made of scrim (26 threads per inch) enclosed all of the new growth on the terminal 6 to 10 inches of the infested stem or branch terminal. Each cage contained the progeny or descendents of a single stem mother.

The caged colonies were observed at infrequent intervals until adults of the second generation began to mature. Thereafter, the colonies were examined three times each week, at intervals of two or three days, until the colonies ceased to exist. At each examination all alate forms were removed with an aspirator and preserved for subsequent identification and counts. Notes were made at the time of each observation concerning size and vigor of the aphid colony and the amount and condition of the caged foliage.

RESULTS

Figures 3 and 4 show the seasonal variation in production of spring migrants of the potato aphid on caged branches of swamp rose having new growth. The averages in Figure 4 and in Table 4 for the period 1947 to 1958 were derived by giving equal weight to all yearly averages irrespective of the number of cages involved each year.

The date of first maturation of stem mothers varied from May 9 in 1949 and 1957 to June 1 in 1947 (Table 4). The average date was May 17.

The beginning of maturation of spring migrants ranged from about May 29 in 1950 to about June 12 in 1947; the average date was June 4. The peak of maturation ranged from June 15 in 1946 to July 3 in 1956; the average date was June 24. The date of the last maturation of spring migrants ranged from about July 5 in 1957 to about September 22 in 1947. Apterous forms of the aphid continued to live on the caged branches as late as September 24 in 1947, which was over one month after the start of the fall migration (Table 4).

The total period during which alatae matured on the caged branches varied from about 103 days in 1947 to as few as 36 days in 1957 (Table 4); the average was 59 days. The length of the period during which appreciable maturation of alatae occurred ranged from 29 days in 1969 to only 9 days in 1958; the average was 16 days.

The minimum number of alatae to mature per cage varied from 1 in 1947 and in 1949 to 36 in 1948 (Table 4). The maximum number of alatae per colony ranged from as low as 90 in 1955 to 808 in 1950. The average number of alatae per colony for the 11 years was 117.

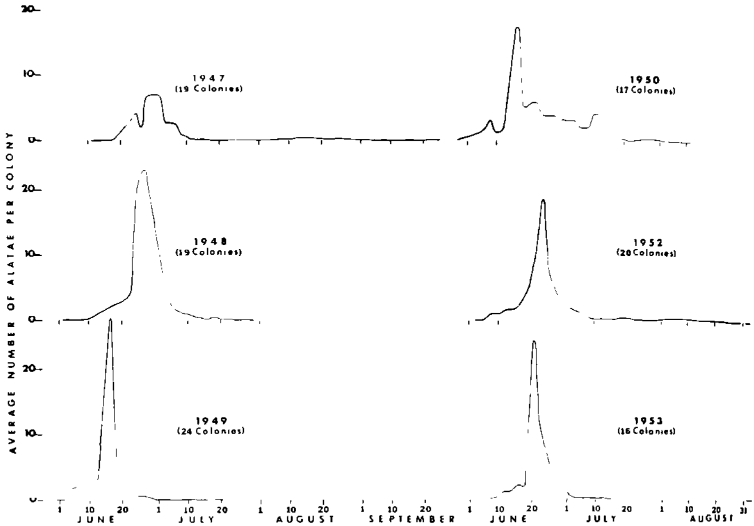

FIGURE 3. Production of alatae (spring migrants) of the potato aphid at Presque Isle on new growth of caged branch terminals of swamp rose, 1947 to 1953, inclusive. The colony in each cage was initiated by one stem mother.

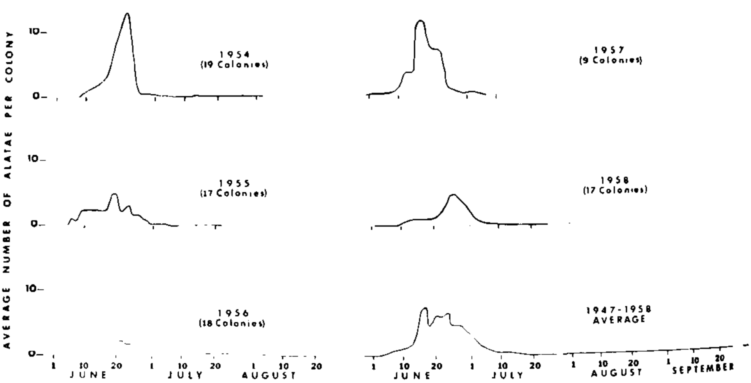

FIGURE 4. Production of alatae (spring migrants) of the potato aphid at Presque Isle on new growth of caged branch terminals of swamp rose, 1954 to 1958, inclusive, and the average for the period 1947 to 1958, inclusive.

DISCUSSION OF RESULTS

Several factors affected the yearly variations in colony productiveness. These included the skills and techniques of the observers, the amount and condition of foliage developing in the cages, the proportion of second and third generation adults maturing as alatae, the action of certain biological agents and, likely, the most important of all was weather conditions.

In most instances, we were unable to cage branches of the same length or with the same number of buds per branch. There was considerable variability both within and among years in the number of caged buds which grew, the amount and condition of new growth per bud, the total length of new growth per cage, and the length of time that the foliage remained suitable for aphid feeding. The amount of new growth per cage depended upon the number of buds producing new growth and the average length of new growth per bud. This, in turn, was influenced by soil moisture and position of the caged branch on the swamp rose bush. Ordinarily, caged branches in the upper, outer periphery of the plants produced more buds, but less foliage per bud, than those in the lower, inner parts of the bushes. Based on the measurements made in 1958 when the observations in each cage were discontinued, the number of buds per cage having new growth ranged from 2 to 8 with an average of 4.7. Comparable figures for total length of new growth per cage at that time were 6 in. to 30 in. and 14.3 in., respectively.

The length of time that new growth remained sufficiently tender and succulent for aphid feeding was influenced largely by soil moisture, size of the aphid population in the cages, and location of the caged branch. Ordinarily, in dry seasons the aphid colonies persisted longer on caged branches near the base of the plants than on those in the upper, outer periphery of the plants. Downy mildew was more prevalent and injurious to the caged foliage in wet seasons than in dry ones. The mildew decreased the suitability of the foliage for aphid feeding and frequently caused early loss of leaves.

Colony productiveness of spring migrants was influenced largely by the size of the third-generation population which in turn, was determined by the proportion of the second generation (stem-mother progeny) destined to become alatae.

Smaller numbers of aphids developed in the third generation when the proportion of stem mother progeny (second generation) maturing as spring migrants was large. In that case, the foliage became unsuitable as food before large numbers of aphids could develop in subsequent generations. On the other hand, when none or few of the second generation adults were alate, the numbers of aphids in the third generation frequently were large enough to shorten materially the length of time that the foliage remained suitable for breeding of the potato aphid. The caged branches produced new growth suitable for aphid breeding for a longer period when aphid populations were of moderate size than when they were either large or small.

During several years of this 11-year study, the action of entomogenous fungi reduced the number of potato aphids that developed on the caged branches. There was a substantial reduction in number of spring migrants from this cause in 1957. The causative organism was *Entomophthora aphidis* (Hoffman)[5]. The dead, diseased aphids were most abundant in the cages in mid June in 1957 or shortly before the usual time of the peak of maturation of the spring migrants (Table 4).

Insect parasites were of some importance during two years. Small numbers of the progeny of the stem mothers were attacked by aphidiids, which substantially reduced the potential size of the potato aphid population in the third generation. Apparently, parasites on the outside of the cages were able to deposit their eggs in aphids on rose foliage that touched the cage wall or in aphids that were crawling on the inside walls of the cages. The action of the external parasite mites, *Erythraeus* sp. (Acarina:Erythraeidae) and *Anystis* sp. (Acarina:Anystidae) was not a factor in these cages but at times they were observed infesting stem mother potato aphids nearby on swamp rose outside the cages. The immature stages of these arachnids are ectoparasites of several species of aphids in northeastern Maine.

The number of aphids developing in caged colonies was not limited by predators in this study.

Occasionally, foliage in a few of the cages became contaminated during June or July with *Capitophorus potentillae* (Walker) or *Capitophorus tetrarhodus* (Walker) which were on the wing and settled on the exposed rose foliage while the observer removed alate potato aphids from the temporarily uncaged branches. Noticeable decreases in numbers of the potato aphids developing occurred soon thereafter in such contaminated cages. Apparently, the competition from relatively small populations of *Capitophorus* spp. quickly reduced the rate of population growth of the potato aphid on swamp rose.

Based on our general observations during these cage studies, and counts to determine spring population trends of the potato aphid on swamp rose, the average number of spring migrants to develop from a stem mother is probably not less than the average of 117 observed (Table 4).

[5] Diagnosis was made by C. G. Thompson, Forest Science Laboratory, U. S. Forest Service, USDA, P. O. Box B887, Corvallis, Oregon 97330; formerly Research Entomologist, Entomology Research Division, ARS, USDA.

SEASONAL POPULATION TRENDS OF THE POTATO APHID ON SWAMP ROSE

PROCEDURE

Counts of aphids (by species) were made on swamp rose in spring and fall from 1948 to 1959 at 12 sampling stations to determine seasonal variability in size and trend of their populations infesting this primary host, including the potato aphid. The stations were widely distributed over central and southern Aroostook County. Usually, the counts in spring were made at weekly intervals from about the time the overwintered aphid eggs began to hatch in mid April to early in May, until about July 10 to 20 when spring breeding and the spring migration of the potato aphid were complete or nearly so. The fall counts usually were begun soon after the start of the potato aphid's fall migration to primary hosts from the secondary, summer hosts, and were repeated at intervals of about 10 days until most oviparous forms of the potato aphid were mature or until all or most of the rose foliage had fallen. The date for the discontinuance of the aphid counts varied from late in September until late in October depending upon conditions at each sampling station.

The units of plant samples used in making the aphid counts depended upon the time of year and stage of foliage development (Shands and Simpson, 1954; Shands *et al.*, 1954). The quantitative expression of aphid abundance varied likewise. The whole compound leaf was the unit of sample for the fall counts. A sample at each station consisted of 100 randomly located leaves on the plants. Aphid abundance was expressed as average number per 100 leaves and the percent of leaves infested. After loss of leaves began, estimates were made of the percentages of leaves still attached. These measures of abundance were inadequate after the oviparae began to mature because the mature oviparae appeared to utilize most of the time in ovipositional activities, moving over the limbs, branches or trunks of the rose plants.

Two units of plant sample were employed in the spring counts. Both were located at variable heights above ground on the terminals of limbs, branches or stems of the plants. Until the young leaves began to unfold, the unit examined was all new growth of all buds on the terminal 6 inches at these places. Thereafter, it was all new growth of enough buds at branch or stem terminals to make a total of 6 inches of new growth at each terminal. A sample consisted of 100 randomly located units. Depending upon the early-season rate of plant growth, the first of these two units of sample usually was employed for the first two counts. When aphid counts were made using the early-season sample unit, records were made also of the number of buds and the estimated total length of new growth of all buds on each unit, as well as of the number of aphids on the new growth of each bud. Records of sampling from the unit used later included the number of "buds" required to make a total of 6 inches of new growth and the number of aphids on the new growth from each of these buds. The expressions of aphid abundance were the number of aphids per inch of new growth or per bud and the percentage of buds and sample units that were infested.

SPRING POPULATION TRENDS

Ordinarily, most spring breeding by the potato aphid on swamp rose occurred during 3 generations. The stem mother nymphs hatched over a period of several weeks, depending considerably upon the temperature and how rapidly the snow level receded and exposed the eggs. During the first generation the numbers of apterae were small and their rate of increase was slow. The size and rate of increase of the apterous population were substantially larger during the second generation because of gradually rising temperatures. The most rapid rate of increase occurred during the third generation. In most years the duration and demarcation of each of these three generations were fairly evident when the numbers of apterae per unit length of new growth were plotted against time (Figures 5, 6).

Our observations during the spring counts of the potato aphid on swamp rose showed that small numbers of spring migrants of this aphid appeared first among the progeny of the stem mothers (second generation). However, most of the spring migrants developed in the third generation, when a very large percentage of the developing aphids matured as alatae. The percentages maturing as alatae by generations on swamp rose growing out-of-doors differed sharply from those on potatoes in the greenhouse (Table 1). This difference was probably due to the length of time the two kinds of plants continued to be suitable as breeding hosts. Ordinarily, under field conditions, the new growth of swamp rose became unsuitable in late June for continued feeding and multiplication of the aphid, whereas the potato plants in the greenhouse continued to be acceptable as a breeding host for a much longer time. Furthermore, spring migrants maturing on swamp rose ordinarily left the plants without depositing nymphs.

Large variations among years occurred in the rate of development and in the time and size of potato aphid populations at the spring peak on swamp rose; also in the initiation, rate of increase, and the maximum length of new growth of buds. The spring peak of apterous potato aphids occurred just before or about the time when swamp rose began to flower.

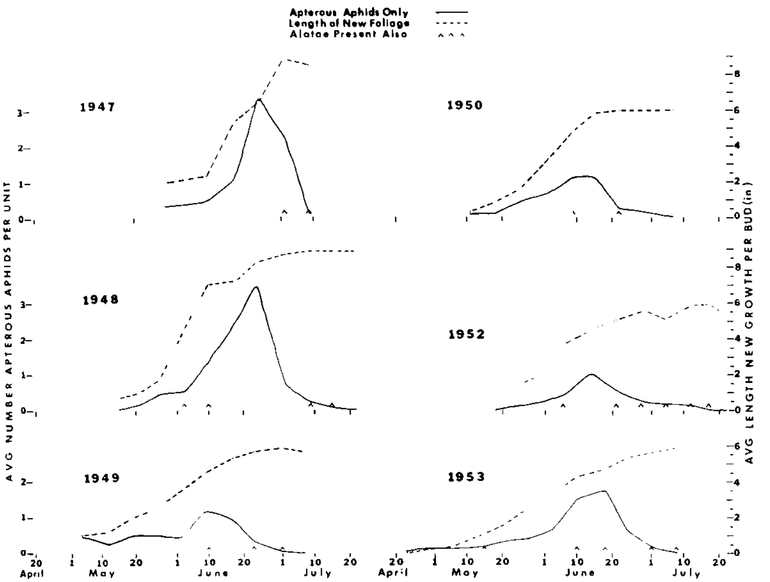

FIGURE 5. Spring populations of the potato aphid on swamp rose, and the new growth per bud at 12 locations in central and southern Aroostook County, Maine, 1947 to 1953, inclusive.

Among years, there was an 8-fold difference in size of apterous potato aphid population on swamp rose at the seasonal peak; it varied from 0.4 in 1945 to 3.5 per inch of new growth in 1948 (Figures 5, 6).

The period during which spring migrants matured varied from 13 days in 1950 to 45 days in 1948 (Figures 5, 6); the average was 28 days. The range in time of first appearance of alatae of the potato aphid on swamp rose was from May 16 in 1953 to June 18 in 1958; that for the last observed alata was June 22 in 1950 to July 18 in 1948. The peak of maturing of the spring migrants was concurrent with or soon after that of the apterae, which ranged from about May 30 in 1947 to about June 28 in 1956. The end of spring breeding on swamp rose varied from late June in 1957 to late July in 1958.

The rate of growth and amount of new growth per bud of swamp rose are of interest and of importance as well. Ordinarily, the length of new growth per bud increased rather steadily from mid May until about July 1 (Figures 5, 6). However, rate of increase was abnormally high when the new growth was delayed by a late spring as in 1947 and 1948, or interrupted by cold weather, as in 1950. The maximum length of new growth per bud ranged from about 4 inches to over 8 inches, depending upon the temperature and the distribution and amount of precipitation,

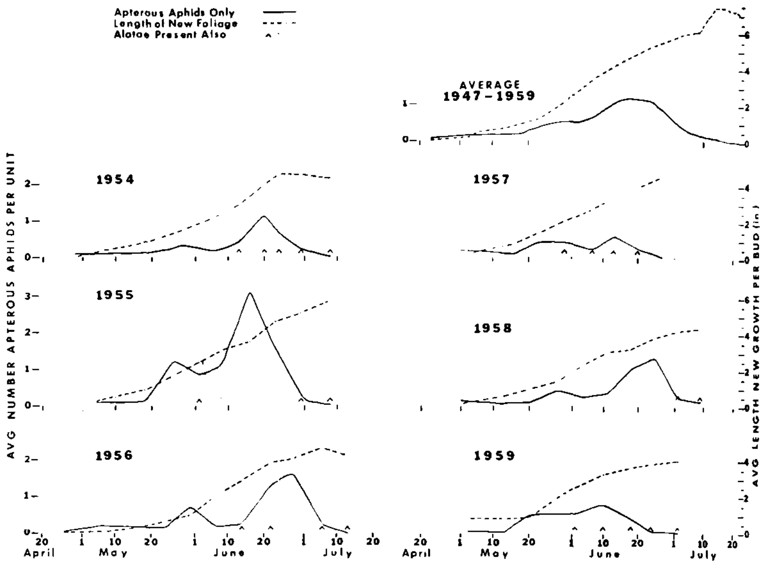

FIGURE 6. Spring population trends of the potato aphid, and new growth per bud at 12 locations in central and southern Aroostook County, Maine, 1954 to 1959, and the average for the period 1947 to 1959, inclusive.

or soil moisture. Maximum growth occurred when the amount of precipitation from March to June, inclusive, was normal or above. The season's growth, usually attained about mid July, was completed earlier than usual in years when temperatures during April and May were substantially above normal (Figures 5, 6).

The timing and seasonal sequence of several phenomena observed during the spring population studies doubtless were influenced by weather factors. However, abundance of the potato aphid on swamp rose in some years was limited or influenced very substantially by arthropod parasites and predators and to some extent, especially in 1957, by the action of entomogenous fungi.

In some years, at some sampling stations, rather large percentages of the developing stem mothers and second generation nymphs of the potato aphid were killed by parasites. The earliest appearing and most abundant of the internal, primary parasites was *Aphidius nigripes* Ashmead (Hymenoptera:Braconidae) (Shands *et al.*, 1955, 1965). Immature stages of the external mite parasites *Erythraeus* sp. and *Anystis* sp. were the most common ectoparasites; they were numerous in some years.

Several species of spiders and coccinellids (Coleoptera:Coccinellidae) were very important as predators of the potato aphid, especially during the first and second generations. On occasion and in some places, larvae of syrphids (Diptera:Syrphidae) and chrysopids (Neuroptera: Chrysopidae) were of some importance in the third generation.

The action of entomogenous fungi appeared to be confined largely to the third generation of potato aphids on swamp rose. Dead, diseased potato aphids were observed during June and early July in several years. In June 1957, pathogenic fungi substantially reduced the potential size of the spring migrant population of potato aphids maturing on swamp rose. *Entomophthora aphidis* was the only species diagnosed.

FALL POPULATION TRENDS

There was sharp contrast between fall and spring in the parts of swamp rose plants best suited for breeding of the potato aphid, as well as in their locations on the plants. The fall migrants sought and deposited their nymphs chiefly on the mature, yellowing leaves. At the time of the fall migration, in late August and September, the few leaves of this kind were situated largely on the lower half of the plants. However, yellowing leaves gradually became more abundant over the whole plant as autumn advanced. Nymphs of the potato aphid fed almost entirely on the maturing or matured leaves until the leaves were shed. When mature, the adult oviparae moved from the leaves but later appeared to feed to some extent on buds of the plant.

The time of the fall peak of abundance of apterae of the potato aphid on swamp rose was about September 15 (Figure 7). At the peak, the average number of apterae per leaf during the period 1948 to 1959, inclusive, ranged from a maximum of 13.2 in 1950 to a minimum of 0.05 in 1959. Usually after September 15 the number of apterae gradually declined. Some of this reduction in numbers during September was due to aphid mortality caused by pathogenic fungi; however, a substantial part of this apparent reduction was due to the movement of the oviparous adults over the stems, trunks and branches of the rose plants while engaged in ovipositional activities.

Not all of the potato aphid nymphs matured before the onset of winter, neither had the rose plants lost all of their leaves by late October

The size of the potato aphid population on swamp rose in fall was influenced by the number of fall migrants reaching the roses from potatoes and other secondary host plants and by the action of natural agents of aphid control. In some years many of the fall migrants were infected with pathogenic fungi that resulted in their mortality soon after they reached the roses, before many, or any, nymphs were deposited. At other times, near-epizootic conditions occurred among the potato aphids

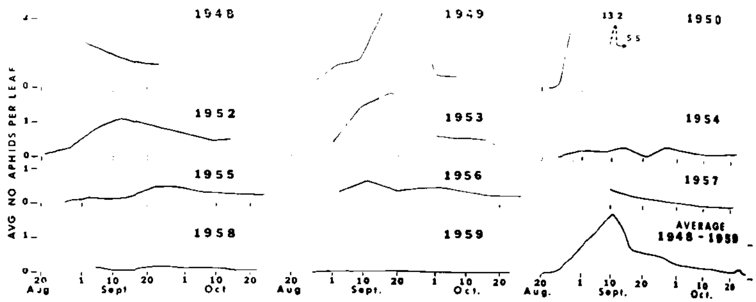

FIGURE 7. Fall population trends of the potato aphid on swamp rose at 12 stations in central and southern Aroostook County, Maine, 1948 to 1959, inclusive.

from fungi in September when moist, warm conditions prevailed. There was much variability among years in the effectiveness of fungi in reducing the potential size of the population of oviparous adults; in some years it was over 95%.

Spiders were probably the most effective predators of the potato aphid on swamp rose in fall. Coccinellids and syrphids were sometimes present in very small numbers.

Parasitized potato aphids were observed on swamp rose, usually at a low level of abundance. However, dissections of oviparous adults in late fall showed that attacks by parasites, even though not apparent to the naked eye, were probably an important factor influencing the size of overwintering egg populations of the potato aphid on swamp rose (Shands *et al.*, 1961). In 1957, immature parasites were found infesting 0 to 100% of the oviparous adults at various sampling stations in autumn. Infested oviparae were found at three of eight stations where collections were made. The dissections revealed that affected oviparae contained few if any eggs; where present, the immature eggs were usually small. Thus, parasitized oviparous adults probably deposited few if any eggs; also, the mummified oviparae are likely an important source of parasites for infesting early spring populations of the potato aphid on swamp rose.

ABUNDANCE OF APHID EGGS ON SWAMP ROSE

Sampling was done semiannually at 4 to 12 locations in central and southern Aroostook County from 1942 to 1959, inclusive, to determine abundance of overwintering aphid eggs on swamp rose (Figure 8). The sampling each fall was done about November 7 and each spring in mid April. These times were selected because they represented, respectively, the approximate end of the egg deposition and the latest autumn date that could be relied upon for sampling before the onset of winter and the possibility of deep snows, and the latest date in spring before hatching of the eggs might start.

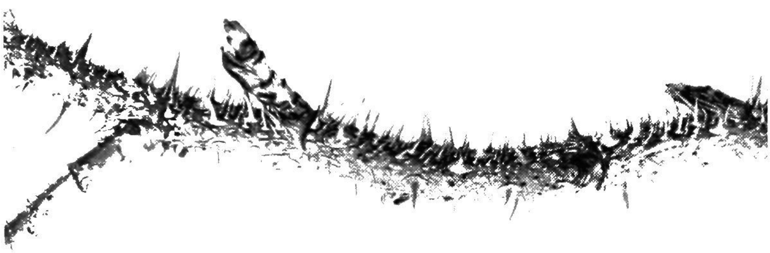

FIGURE 8. The oval black specks are aphid eggs on this section of wild rose stem.

The sampling procedures (Shands and Simpson, 1954) included three units of plant sample, viz., groups of buds, single crotches, and unit lengths of stems or trunks. At each location a sample consisted of nine buds on each of 30 branch or stem terminals, a total of 270 branch or limb crotches and, only during the period 1954 to 1959, inclusive, a total of 45 6-inch lengths of trunk distributed from ground level to a height of 18 inches. The records after 1945 showed the numbers of fully distended or shriveled (not perfectly distended) eggs by bud position on each branch or stem terminal, in each crotch, or on each basal section of trunk; from 1942 to 1944, only the numbers of fully distended eggs were recorded. Shriveled eggs are not known to hatch. All plant-sample units were randomly located vertically on the plants so as to include the area covered by swamp rose at each station. A reading glass was used in examining, *in situ,* the plant buds, crotches or trunk for aphid eggs. Each egg was examined with a 14-x hand lens to determine whether it was fully distended or shriveled.

RESULTS AND DISCUSSION

The average abundance of aphid eggs per unit of sample varied greatly both in fall and in spring (Table 5). The average total number of eggs per 100 buds in November ranged from 3.0 in 1950 to 25.3 in 1948. The corresponding range per 100 branch or limb crotches was 1.4 in 1951 to 19.7 in 1948. For the 6-year period 1954 through 1959, the comparable range was 3.0 to 23.1 on 6 inches of trunk or stem. The fall averages for all years were 8.1 eggs per 100 buds, 9.5 per 100 crotches, and 11.4 per 100 inches of trunk.

The average total number of eggs in mid April ranged from 0.3 per 100 buds in 1951 to 18.0 in 1949; from 0.6 per 100 crotches in 1951 to 19.0 in 1949; and from 2.4 per 100 inches of trunk in 1955 to 10.3 in 1956. For all years, the spring egg averages were 5.3, 7.2, and 6.1 for these numbers of buds, crotches, or lengths of trunk, respectively.

There was much variability in the percentage of shriveled eggs among years and kinds or positions of sample units on the plants (Table 5). In November, the range among years in percentage of shriveled eggs was 0 to 65.5 for eggs by buds, 2.9 to 63.6 for those in crotches, and 0.3 to 5.2 for those on trunks. The November average percentages for all years were 15.1, 11.4, and 1.8 for eggs by buds, in crotches, or on trunks, respectively. The comparable ranges by years for percentage of shriveled eggs in mid April were 0 to 59.8 for eggs by buds, 3.5 to 78.1 for those in crotches, and 3.3 to 38.3 for those on the trunks. The average percentage shriveled for all years was 32.7 for eggs by buds, 28.6 for those in crotches and 20.2 for those on the trunks. The lesser amount of shriveling of eggs on trunks may have resulted in part because of the higher relative humidity in the undergrowing stands of grasses and weeds frequently present around the base of the roses.

Greatest average winter loss of eggs occurred among those by buds (58.6%), followed by those in crotches (50.4%), and on the trunk (45.4%). These differences likely were due principally to the relative degrees of protection afforded the eggs in the three kinds of locations from the predatory action of birds, from washing rains after the counts were made in November, and after the winter's snow had melted in early spring. In most winters the snow was at least 18 inches deep and at some stations the snow drifts almost completely covered the swamp rose in some patches for more than half of the winter. Thus, aphid eggs on the three units of sample received some protection from birds during much of the winter; those on the lower halves of the plants were best protected from this kind of loss.

Our studies show varying relationships between the abundance of aphid eggs on swamp rose and abundance of the potato aphid developing

Table 5
Abundance of aphid eggs in late fall and early spring of following year by buds, in limb crotches and on the stems of swamp rose

		Fall Counts					
	No. sampling	Per 100 buds		Per 100 crotches		Per 100 in. trunk[1]	
'ear	Stations	Total no.	% shriveled	Total no.	% shriveled	Total no.	% shriveled
942	4	—	—	5.3[2]	—	—	—
943	8	10.0[2]	—	5.1[2]	—	—	—
944	8	1.0[2]	—	0.2[2]	—	—	—
945	8	14.3[2]	—	11.6[2]	—	—	—
946	9	5.2	65.5	2.1	63.6	—	—
947	9	7.1	14.6	4.3	7.8	—	—
948	9	25.3	3.1	19.7	2.5	—	—
949	11	16.0	20.9	14.3	15.3	—	—
950	11	9.1	7.4	9.7	12.5	—	—
951	10	3.0	8.7	1.4	4.9	—	—
952	11	7.1	16.1	5.5	8.0	—	—
953	11	9.8	18.2	15.1	12.9	—	—
954	11	3.1	6.4	3.5	11.4	23.1	0.3
955	12	8.1	16.4	15.6	6.4	9.8	1.2
956	12	5.6	10.1	12.7	5.6	9.4	5.2
957	12	7.8	18.6	18.9	10.8	16.4	3.6
958	12	3.3	0.	7.2	2.9	6.7	.6
959	12	3.2	4.8	3.1	6.1	3.0	0.
\verages 1942 - 1959)		8.1	15.1	9.5	11.4	11.4	1.8

	Spring Counts								
	Per 100 buds		Per 100 crotches		Per 100 in. trunk		% winter loss of fully distended eggs		
'ear	Total no.	% shriveled	Total no.	% shriveled	Total no.	% shriveled	By buds	In crotches	On stems
942	0.[2]	—	0.2[2]	—	—	—	—	70.3	—
943	0.6[2]	—	1.9[2]	—	—	—	93.9	63.7	—
944	0.1[2]	—	0.[2]	—	—	—	90.8	100.	—
945	7.2	36.8	11.1	31.1	—	—	68.3	34.2	—
946	3.4	59.8	2.4	78.1	—	—	24.4	32.1	—
947	6.5	25.7	4.0	20.4	—	—	19.4	18.3	—
948	18.0	16.1	19.0	3.5	—	—	38.4	4.6	—
949	9.1	27.7	12.9	26.8	—	—	48.3	22.3	—
950	3.6	46.4	6.7	39.6	—	—	77.1	51.8	—
951	0.3	0.	0.6	37.5	—	—	90.1	70.8	—
952	4.0	33.4	3.2	31.3	—	—	54.9	56.0	—
953	3.6	48.2	7.9	31.4	—	—	76.4	58.5	—
954	2.1	22.9	3.2	16.9	2.4	28.5	46.1	14.2	92.7
955	5.6	33.3	9.3	12.6	10.3	3.3	45.5	44.8	–2.9
956	4.3	42.1	6.2	19.7	7.6	16.3	52.4	58.4	28.8
957	4.5	41.1	9.5	25.9	4.1	38.3	58.1	58.0	84.0
958	2.0	24.6	4.8	25.2	5.9	14.7	54.2	48.9	24.2
959	—	—	—	—					
.verages (1942-1959)	5.3	32.7	7.2	28.6	6.1	20.2	58.6	50.4	45.4

6-in. lengths of stem randomly located between the soil surface and 18 in. above.
Fully distended eggs only; shriveled eggs not included in the counts until spring, 1946.

on the plant after the eggs hatch. Weather and biotic factors were among the important variables that influenced this relationship. They influenced survival of the developing stem mother nymphs, the rate of aphid development and degree of suitability of the environment for aphid breeding, as well as the length of time the host plant remained in satisfactory condition for spring breeding of the aphid. However, the variable, possibly of greatest importance, was the proportion of total egg population on the plant that was deposited by the potato aphid.

Our studies indicate that swamp rose in northeastern Maine is a primary host for several species of aphids in addition to the potato aphid. These include *C. potentillae, C. tetrarhodus, Myzaphis buctonii* Jacobs and *Macrosiphum rosae* L. Ordinarily, the most abundant of these are *Capitophorus* spp., especially *C. potentillae*. None of them is particularly abundant on swamp rose until toward the end of the spring breeding season of the potato aphid. However, *Capitophorus* spp. and *M. buctonii* apparently utilize swamp rose as a host throughout the year and, frequently, may be relatively abundant on the plants in autumn before the oviparae of the potato aphid mature and oviposit.

PROBABLE USEFULNESS OF SEASONAL SURVEYS OF ABUNDANCE OF APHIDS AND APHID EGGS ON SWAMP ROSE

Comparisons were made of relevant data from our biology studies to assess reliability for predicting potato aphid abundance on the primary host or on field-growing potatoes. Regression analyses were made using data for potato aphid abundance on swamp rose in fall and in spring of the year following, aphid egg abundance on this plant in early November and in April of the year following, and potato aphid abundance at two times on potatoes not treated with insecticides, viz., about July 10 to 20 and, again in the same places, August 10 to 20. These two times corresponded, respectively, to the end of the aphid's spring migration, to a point in time before supplemental infestation of the potato plants occurred from flights of summer dispersal forms, and to the seasonal peak of abundance of the aphid on potatoes.

In the regression study, the data used for potato aphid abundance on swamp rose in fall or in spring were those in Figures 5, 6, and 7. The statistics used for aphid egg abundance were weighted averages made by applying the weights 19 and 1, respectively, to the average numbers of eggs per 100 buds, and per 100 limb crotches in years when the counts were limited to eggs observed on these parts of the plants, and by using the weights 19, 1, and 1 when the counts included also eggs per 100 inches of trunk or stem of the plants (Table 5). The data for abundance of the potato aphid on untreated potatoes, at each time of comparison, were the average number of apterae on three leaves per plant (top, middle, bottom) (Shands and Simpson, 1953; Shands *et al.*, 1954). These averages were computed by giving equal weight to the average number on three leaves per plant found at each field or sampling location.

The population counts of the potato aphid on untreated potatoes, on each occasion, were made in an average of 16 fields well distributed over central and southern Aroostook County during the period 1943 to 1945, inclusive. In 1946 and 1947, the counts were made in an average of 10 fields located on or in the vicinity of Aroostook Farm, near Presque Isle. Beginning in 1948, the counts were made in an average of seven to eight locations on Aroostook Farm. On Aroostook Farm, in most instances, the average number of aphids on three leaves per plant at a location was based on examination of these leaves on 150 plants or a total of 450 potato leaves. Usually, the averages for fields not on Aroostook Farm were derived from similar counts on 100 plants or 300 potato leaves at each location. The data for aphid abundance on potatoes used in the regression analyses are not included in this bulletin but are available from the Maine Life Sciences and Agriculture Experiment Station.

RELATION BETWEEN ABUNDANCE IN FALL AND SPRING OF APHIDS OR OF APHID EGGS

Results and Discussion

For three out of five consecutive years at 12 locations there was a highly significant ($P=0.01$) direct relationship between the numbers of apterous forms of the potato aphid or of all aphid species on the foliage of swamp rose at the fall peak of aphid abundance and the abundance of aphid eggs in early November (Table 6). There was no correlation ($P=0.05$) during the other two years. Lack of correlation during these two years is not understood since during the preceding two years, 1953 and 1954, it was highly significant ($P=0.01$).

Abundance of aphid eggs on swamp rose in mid April was directly related ($P=0.05$ or 0.01) to the abundance of all aphid eggs or only the fully distended ones on the plants in November of the preceding year (Table 6).

Although not shown in Table 6, only in 1958 was the abundance of eggs on swamp rose in spring found to be dependent (at the 5% or

Table 6

Year-to-year relationships between average abundance in fall and in spring of apterous aphids or of aphid eggs on swamp rose at 12 sampling stations[1] in central and southern Aroostook County.

Variables compared		Correlation coefficient (r-value)				
Independent (X)	Dependent (Y)	1955[1]	1956	1957	1958	1959
No. aphids/leaf at fall peak	No. aphids eggs/100 buds in November					
All species	Total numbers	0.002	0.334	0.801**	0.803**	0.743**
Potato aphid	Total numbers	–.098	.402	.779**	.745**	.771**
No. aphids eggs/100 buds in November	No. aphid eggs/100 buds in April[2]					
Total numbers	Total numbers	.764**	.629*	.708**	.982**	.778**
Fully distended	Total numbers	.793**	.617*	.629*	.979**	.777**
No. aphid eggs/100 buds in April[2]	No. aphids/unit at spring peak[2]					
Total numbers	All species	–.313	–.338	.090	–.063	.105
	Potato aphid	–.310	–.318	–.406	–.353	–.093
Fully distended	All species	–.312	–.357	.027	.159	.103
	Potato aphid	–.309	–.321	–.407	–.427	–.007

[1] 11 stations in 1955.
[2] Year following.

1% levels) upon the numbers of apterous aphids of all species or of only the potato aphid at the peak of aphid abundance in the preceding fall.

The spring peak abundance of the apterae of all species of aphids, or of only the potato aphid, on swamp rose, was not correlated with abundance of aphid eggs on plants prior to the time of hatching (Table 6). This was not surprising since many factors influenced the size and trend of spring potato aphid populations. Among the more important of these factors were arthropod parasites and predators, entomogenous fungi and weather, including the harmful effect of low temperature upon survival of the stem mother nymphs in early spring (Shands *et al.*, 1958).

The use of data for total aphid egg population in correlation or regression analyses may be preferable to that of data for only the fully distended eggs. Because of greater abundance and more uniform distribution of the total egg population, including shriveled eggs, the standard error of estimate was less for abundance of all eggs than for only the fully distended ones. This was especially evident when considering the smaller egg populations in spring which resulted from substantial winter loss (Table 5). Likewise, the error of estimates of abundance for total aphid population on the roses generally was less than that for only the potato aphid. However, the statistical significance and general level of the correlations were not materially affected whether total populations of aphids or of aphid eggs were used as opposed to those of only the potato aphid or of only fully distended eggs. Correlation between abundance of the potato aphid on swamp rose in spring and that of aphid eggs on the plant in that spring or in the fall of the preceding year was improved when the number of potato aphid eggs was estimated on the basis of the proportion of the peak fall aphid population that was comprised by the potato aphid only.

RELATIONSHIPS BETWEEN ABUNDANCE OF APHIDS AND OF APHID EGGS ON SWAMP ROSE IN FALL AND SPRING AND OF POTATO APHIDS ON POTATOES

Results and Discussions

The peak summer abundance of the potato aphid on untreated potatoes was correlated in a positive manner ($P = 0.05$) with its peak abundance on swamp rose during the preceding fall (Table 7). The lack of a similar relationship between abundance of the potato aphid on potatoes at the end of the aphid's spring migration and on swamp rose at the peak in the preceding fall may have been due largely to insufficient numbers of samples for accurate measurements of aphid abundance at the low density levels of the aphid at these times, especially on potatoes

Table 7

Correlations (*r* values) of average abundance on swamp rose of the potato aphid or aphid eggs in fall and in spring or in summer of the following year on potatoes

	Factor[a]						
Factor[a]	X_2	X_3	X_4	X_5	X_6	X_7	X
X_1	0.122(11)[b]	0.134(11)	–0.006(10)	–0.111(10)	0.336(11)	–0.372(10)	0.713
X_2			* 0.618(16)	** 0.927(13)	–0.269(12)	0.328(16)	0.312
X_3			0.382(11)	** 0.937(13)	0.514(12)	0.361(11)	0.37
X_4					–0.200(12)	0.255(16)	0.334
X_5					–0.152(12)	–0.117(13)	–0.303
X_6						–0.024(12)	–0.16

[a] Description of factors correlated, below.
[b] In parenthesis, number of years of paired comparisons used in computing the correlation coeffi

Factors	Description
X_1	No. apterous potato aphids at fall peak per 100 leaves of swamp rose.
X_2	Total no. aphid eggs per 100 sample units of swamp rose in early November.
X_3	No. fully distended aphid eggs per 100 sample units of swamp rose in early November.
X_4	Total no. aphid eggs per 100 sample units of swamp rose in April of year following.
X_5	No. fully distended eggs per 100 sample units of swamp rose in April of year followin
X_6	No. apterous potato aphids at spring peak of following year per 100 units of swamp rose
X_7	No. apterous potato aphids on 3 leaves per plant of potatoes at the end of the aphid's s migration.
X_8	No. apterous potato aphids on 3 leaves per plant of potatoes near the summer peak of aphid.

but also on swamp rose in some years. Neither was abundance of aphid eggs on swamp rose in spring or in fall correlated with maximum pre-ovipositional aphid abundance on the plant. Some possible reasons for this were discussed in the immediately preceding section of this bulletin.

Abundance of fully distended eggs on swamp rose before the time of hatching in mid April was significantly correlated (P=0.01) with abundance of the fully distended eggs at the onset of the preceding winter (Table 7). The size of the total egg population in spring, also, was significantly dependent upon its size at the beginning of winter but significance was at a lower level (P=0.05). However, the total population of aphid eggs in spring was not correlated at the 5% level with that of only the fully distended eggs at the start of winter. Possibly this was because winter loss of shriveled eggs was proportionately more than winter loss of fully distended eggs.

Abundance of the potato aphid at the spring peak on swamp rose tended to be directly proportional to abundance of fully distended eggs on this plant at the onset of the preceding winter but the level of significance was low more than $P = 0.05$, but less than $P = 0.10$) (Table 7).

Abundance of the potato aphid on potatoes, either at the end of the aphid's spring migration or near the summer peak, was not proportional to abundance of the aphid on swamp rose at the spring peak or to abundance of aphid eggs on the plant in spring before hatching began (Table 7). This was not unexpected since the estimate of potato aphid abundance on potatoes in most years was based on counts in fields located on or near Aroostook Farm, near Presque Isle, while the sampling stations for swamp rose were widely distributed over central and southern Aroostook County.

We believe it inadvisable to attribute much dependability to the significant positive correlation between potato aphid abundance on potatoes in mid August and abundance of the aphid at its peak on swamp rose in the preceding fall. Even if dependable, to make a reliable estimate would require much time and effort of workers in making the required number of aphid counts on swamp rose at a large enough number of widely distributed sampling stations during much of the fall each year.

Abundance of the potato aphid on potatoes would probably have shown a greater degree of dependency upon or association with that of the aphid or of aphid eggs on swamp rose had the number and distribution of the sample-potato fields been the same as that of sampling stations of swamp rose, and if the aphid counts on potatoes could have been made just prior to the start of activity of the entomogenous fungi. The time and size of the potato aphid population at the peak on potatoes may be influenced greatly by the time of appearance, and the rate and amount of increase in activity of entomogenous fungi (Shands *et al.*, 1963).

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