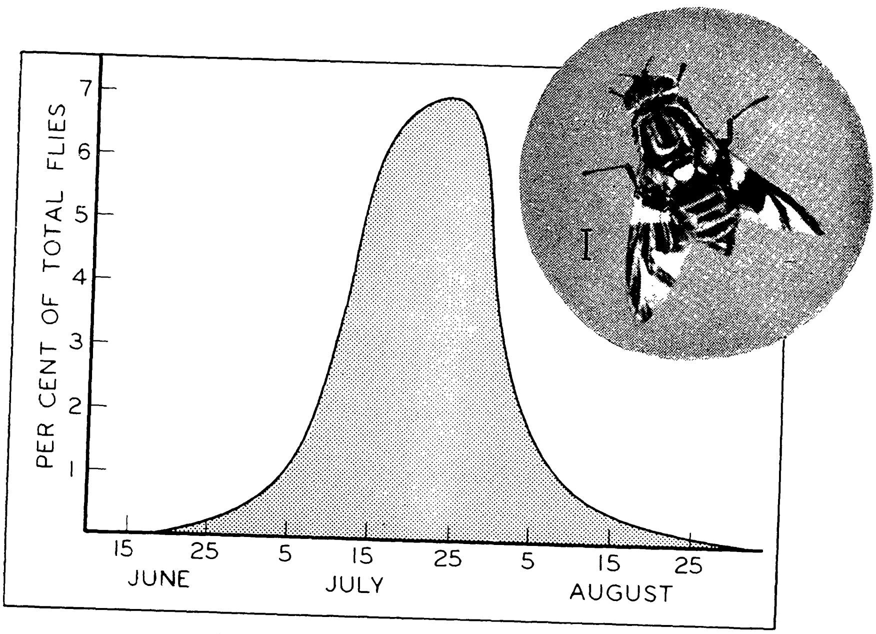
Apple Maggot Fly Emergence in Western New York

By E. H. Glass



NORMAL FLY EMERGENCE

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E. H. Glass

Abstract

Detailed records of apple maggot fly emergence for the years 1951 through 1956 are presented. A review of the weather record for western New York shows that these years are representative both in terms of averages and extremes. The dates first flies were found in cages varied from June 18 to 29, peak emergence from July 17 to 28, while the last flies were recorded during early September. Heaviest fly emergence occurred during the last three weeks of July and the first week of August.

The reason for the observed differences between the time of emergence from the several seedings for any one year is traced to the source and variety of the fruit used. A fairly good correlation was found between the time apple varieties mature and when flies emerged from infested fruits of this variety the following year. Thus, eariest emergence came from maggots produced in early maturing varieties. Seasonal variations in temperatures appear to have caused peak emergence to vary over a 10-day range.

Fly emergence in western New York was on the average about one week later than comparable emergence at Poughkeepsie. The range of differences was: for first emergence, 4 to 15 days later; for peak emergence, 2 to 13 days later. Late emergence was similar in both places.

A discussion of the practical use of the emergence data is presented. Also, suggested procedures are given for anyone who may wish to obtain fly emergence records.

Introduction

The apple maggot, *Rhagoletis pomonella* (Walsh), has been one of the major pests of apples in the northeastern apple-growing regions of the United States and southern Canada. The recorded literature tells of very serious losses by this pest as early as 1866 when more than 25 per cent of some apple crops were rendered useless. In the northeast noncommercial plantings, particularly in backyard trees, the apple maggot continues to destroy more fruit than does almost any other insect. The species is usually well controlled in commercial plantings. It occasionally causes appreciable losses in such orchards in outbreak years if the spray treatments applied are faulty in any respect.

While the range of the apple maggot covers the northeastern states as far south as the northern tip of Georgia (in the mountains), as far west as the Dakotas, and into southeastern Canada, it is by far most destructive and difficult to control in New England and eastern New York, including the Lake Champlain fruit district. In western New York the apple maggot can be destructive if not controlled and it normally is present in fruits on unsprayed apple trees.

During the period from the late 1920's to 1945 lead arsenate was extensively used for codling moth control in western New York. As used, it also provided excellent control of the apple maggot. Growers and others here began to think that the apple maggot was no longer a problem in the area. When DDT was substituted for lead arsenate, however, it gave such good control of the first brood codling moth that spraying for the second brood seemed unnecessary. This meant the cessation of spraying by mid-July. A consequence of these practices was a general increase in apple maggot. It became particularly serious in 1950 and 1951 in all parts of the State.

Apple growers in western New York were confronted with a new problem, i.e., they had to apply certain sprays to control apple maggot primarily, whereas, formerly their attention was focused on the codling moth. Furthermore, they were using DDT which has a shorter residual activity against maggot flies than does lead arsenate, thus making timing more critical. In this situation it was evident that growers needed precise information on the emergence of flies in western New York. The emergence data reported in this bulletin were obtained primarily to satisfy this need.

In addition to the emergence data for western New York, certain other information is presented on the apple maggot and its control for the purpose of assisting the reader in the proper interpretation and use of these records. Much of this additional discussion is based on the work of Dean (2, 3, 4, 5) [1] and Chapman and Hammer (1) whose studies were made in the Hudson Valley and Lake Champlain apple-growing areas.

Life Cycle and Habits

The apple maggot passes the winter in the top 2 or 3 inches of soil in the pupal stage. In the summer these pupae give rise to flies which

[1] See Literature cited, page 29.

emerge from the soil during the period from late June through early September.

The flies do not begin to lay eggs until 8 to 10 days after emergence. During this period—called the preoviposition period—both the males and females rest and feed in and around the general area from which they emerged. They move readily from tree to tree but normally only for short distances, usually not exceeding 200 or 300 yards. The flies are not particularly attracted to apple fruits during this period and may be found in unfruited trees and shrubs in and around the orchard.

At the end of the preoviposition period and after mating, the female flies seek out the fruits. The eggs are placed just under the skin through a puncture made by the sharp needlelike ovipositor. Females may lay eggs over an extended period of time. Eggs usually hatch in less than a week. Maggots hatching from these eggs tunnel through the apple causing a breakdown and discoloration of the pulp. Maggots leave a characteristic brown trail through the flesh of the apple which can readily be seen when the fruit is cut open. When there are several maggots in a fruit the interior tissues may break down and show depressions and discoloration from the outside. Injured apples usually drop prematurely. The mature maggots leave the fruit and enter the soil where they transform to the pupal stage.

Most pupae remain in the soil until the following summer, but a very few emerge in the early fall (6). These latter appear too late to cause any damage. There are also a few individuals that do not emerge until the second season; i.e., they remain in the pupal stage during the first winter, all the next season, and the following winter. They emerge at the normal time during the second summer. These are not of much significance to growers who maintain good control every year, but they might be of importance in an orchard where the pest was allowed to become very numerous. Thus, even after a vigorous and successful control program had been carried out for one year, there would still be some carryover for the second season.

Basis for Control

Up to the present time, the only practical control of the apple maggot is based on killing the flies before the eggs are deposited. Measures directed against any of the other stages have not proved successful. Eggs are deposited through minute punctures under the skin and cannot be killed by known ovicides. Furthermore, the skin punctures are undesirable blemishes on the fruit and should be prevented. The maggots are also protected within the fruits. From the fruit the maggots go directly to the soil where they, and the pupae into which they transform, cannot be reached readily with insecticides. Up to the present time no practical method of treating soil to destroy these stages has been devised.

Successful apple maggot control by killing the flies before egg deposition is possible and practical because of the 8 to 10 day preoviposition period. This usually allows sufficient time to kill the flies before they can infest the fruit. From a theoretical point of view a toxic spray need not be applied until 8 days after the first emergence and not again until 8 days after the residual action of the spray is gone. In practice, however, Dean (4) has found that a material with 10 days residual activity like DDT must be applied at 10 day spray intervals to insure good control. Practically, then, it has been found necessary to maintain a toxic residue in the orchard during most of the period of fly emergence.

It should be noted, as mentioned previously, that flies move about freely in vegetation around the apple trees, particularly during the preoviposition period. It is desirable, therefore, to spray interplanted and adjacent trees and shrubs. This free movement makes maggot control in backyard plantings very difficult.

Host Plants

The apple maggot is a native pest. In fact it is not known to exist outside of the United States and Canada. It has been found in several species of Crataegus, or hawthorn, which were probably the original host of the apple maggot. Cultivated host plants include apple, crab apple, plums, and pears.

A smaller form of the apple maggot, or possibly a separate species, infests the fruits of huckleberry and blueberry and is an important pest of these fruits.

Fly Emergence Studies

Apple maggot fly emergence in western New York was studied from 1951 through 1956. The data obtained are reported herewith. Comparable records are also included from the Hudson Valley to make the account more statewide in coverage.

Methods

During late July and August a search was made each year for heavily infested apple fruit. For the most part this was found in isolated trees in backyards, along the edge of woodlands, and in recently abandoned orchards that were still bearing some fruits. No sprayed plantings were found with adequate infestations. Because of the known influence of variety on the time of emergence, several apple varieties were collected. The best source of infested fruits were Yellow Transparent, Wealthy, and McIntosh. All collections were made in Ontario and Wayne counties.

Infested fruits were brought to Geneva and placed on the ground under mature Rhode Island Greening trees maintained in sod culture. Due to shading, the grass under the tree where the seedlings were made was very thin. The soil is a heavy clay loam. There was considerable debris and humus on the ground so that the soil did not dry out and bake hard even during drought periods. Conditions in this orchard can be considered reasonably normal for most orchards in the area under consideration.

Apples from each source were kept in separate seedings so the influence of variety, time of collection, and other details could be observed. A seeding consisted of an area 3 feet wide by about 6 feet long. Up to 3 or 4 bushels of fruit were spread out over the ground, but never in piles more than 3 apples deep. These were left in place until late fall or spring when the remains of the apples were raked off the plot. The exact area was then marked off by four stakes. Four to nine seedings were made each season.

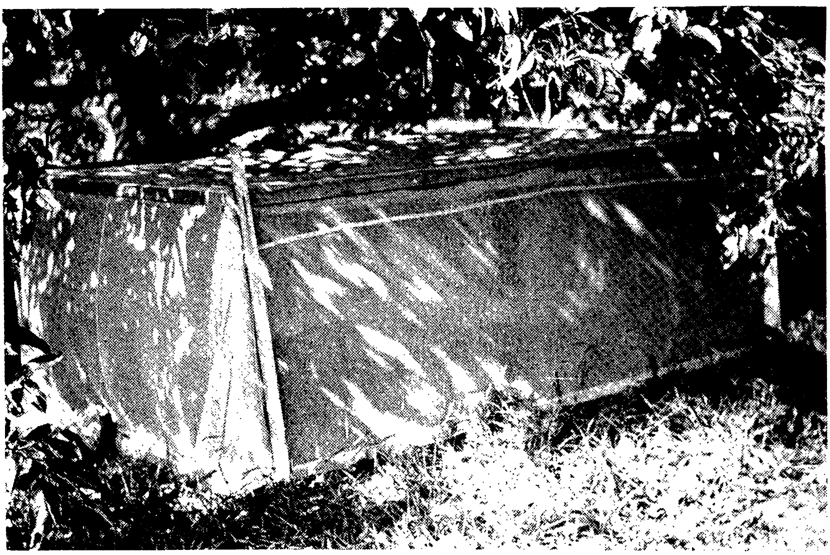

Fig. 1. Cage set up over seeding to determine apple maggot fly emergence.

The following June wooden frames were set up over each seeding. These were 4 by 8 by 3 feet high, large enough to cover the entire area and to allow a person to crawl inside. The frames were tightly covered with cheesecloth so that no emerging flies could escape (Fig. 1). Soil was banked around the bottom of the cages to prevent fly escape at this point. On one end the cloth was held in place by a board that could easily be lifted to permit a person to crawl into the cage. Cages were put in place before fly emergence was expected. Flies were collected daily during the periods of heavy emergence and every two or three days during the early and late parts of the season. These were killed and then examined to determine the number of each sex present.

When there were only a few flies in a cage they were collected with a simple aspirator (Fig. 2) motivated by the collector. When flies were

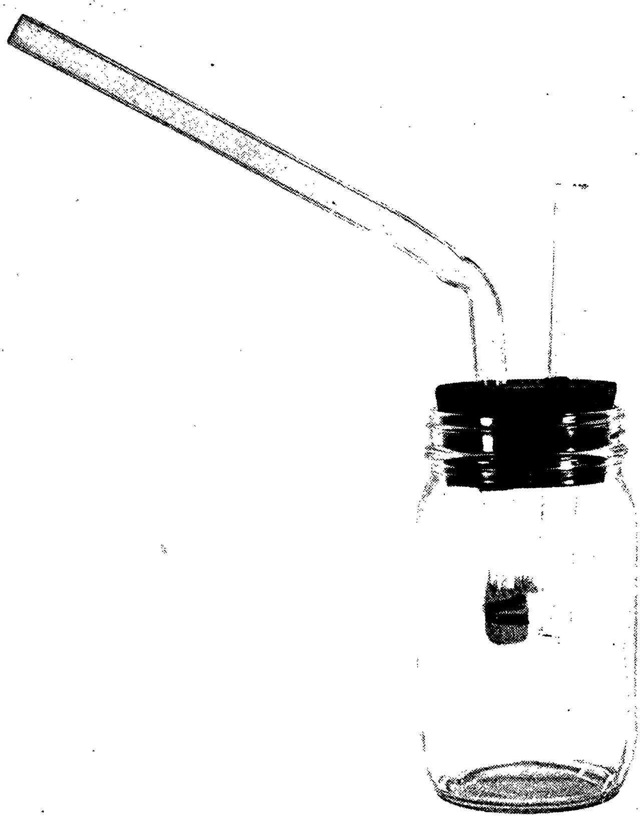

Fig. 2. Aspirator used to collect flies from inside cages.

TABLE 1.—SUMMARY OF APPLE MAGGOT FLY EMERGENCE IN CAGES AT GENEVA, N. Y., FROM 1951 THROUGH 1956.

YEAR	NO. OF SEEDINGS	TOTAL FLIES	FEMALE, PER CENT	FLY EMERGENCE				MEAN TEMPERATURE, OF MAY–JULY
				First	Peak	50 per cent	Last	
1951	4	5,256	55	June 27	July 25	July 21	Sept. 4	64.5 (—1.9)
1952	5	8,695	56	June 19	July 24	July 21	Sept. 9	65.2 (—1.2)
1953	9	9,155	56	June 19	July 20	July 18	Sept. 4	65.5 (— .9)
1954	9	9,666	54	June 22	July 23	July 22	Sept. 7	64.5 (—1.9)
1955	9	9,242	56	June 18	July 17	July 17	—	67.9 (+1.5)
1956	9	9,895	54	June 29	July 25	July 28	Sept. 7	62.2 (—4.2)
Average			55.2	June 22	July 22	July 21	Sept. 6	66.4 *

* Mean temperature for period weather records kept at Geneva.

numerous the aspirator was connected by a suitable long rubber tube to the windshield wiper opening on the intake manifold of any available truck or car. The vehicle was as close to the cage as feasible and the motor allowed to run at just above normal idling speed. The suction was adequate to permit easy capture of the flies.

Results

The data in Table 1 show that relatively large numbers of flies were present in the seedings in each of the six seasons. No particular significance is attached to the fact that about the same number of flies were recovered each year. There were large variations in emergence among the cages in any one year. The data show that the sex ratio was uniform each year, varying only from 54 to 56 per cent females with an average of 55.2 per cent for all years. This is slightly less than the 58.3 per cent reported by Porter (8) and by Dean (unpublished data). The earliest emergence was June 18 in 1955 and the latest was September 9 in 1952. The peak emergence varied from July 17 to July 25, with the average date of July 22.

The daily fly emergence and percentage of females are shown for the six years in Figs. 3 to 8. These indicate very similar emergence patterns for the years 1951 through 1955. The emergence started slowly in late June, increased somewhat in early July, leveled off for a few days, and then rose sharply to a high peak in the latter half of July. It then dropped off sharply in late July and early August. The graph for 1956 (Fig. 8), shows an appreciably different pattern. Here, emergence followed the same pattern until the peak in late July, but then, instead of falling off sharply, increased again in early August. There were relatively large numbers of flies emerging until mid-August with a sub-peak on August 8. The reasons for this variation are discussed later.

Several workers have reported that there are more female flies than male flies early in the season with a reverse trend late in the season. Dean (unpublished data) has shown that the peak of the fly emergence closely coincides with the time when the sex ratio is 50–50. For the first five years of this study the sex ratio has followed this pattern very closely, as shown in Figs. 3 to 7. During the early emergence there was considerable variation due to the very small numbers involved. In early July about 70 to 75 per cent of the flies were females. This percentage fell off to about 50 to 55 per cent when the first plateau was reached or just after the early sub-peak. The percentage then climbed back to 65 to 70 per cent and then dropped steadily downward, reaching the 50 per cent level within a day or two of the peak emergence. The percentage continued to drop for the next few days to a low of about 30 per cent and then became very erratic due to small numbers, but generally reapproached the 50 per cent level.

The sex ratio for 1956, like the fly emergence, varied from that for the other five years. Figure 8 shows that the sex ratio dropped following

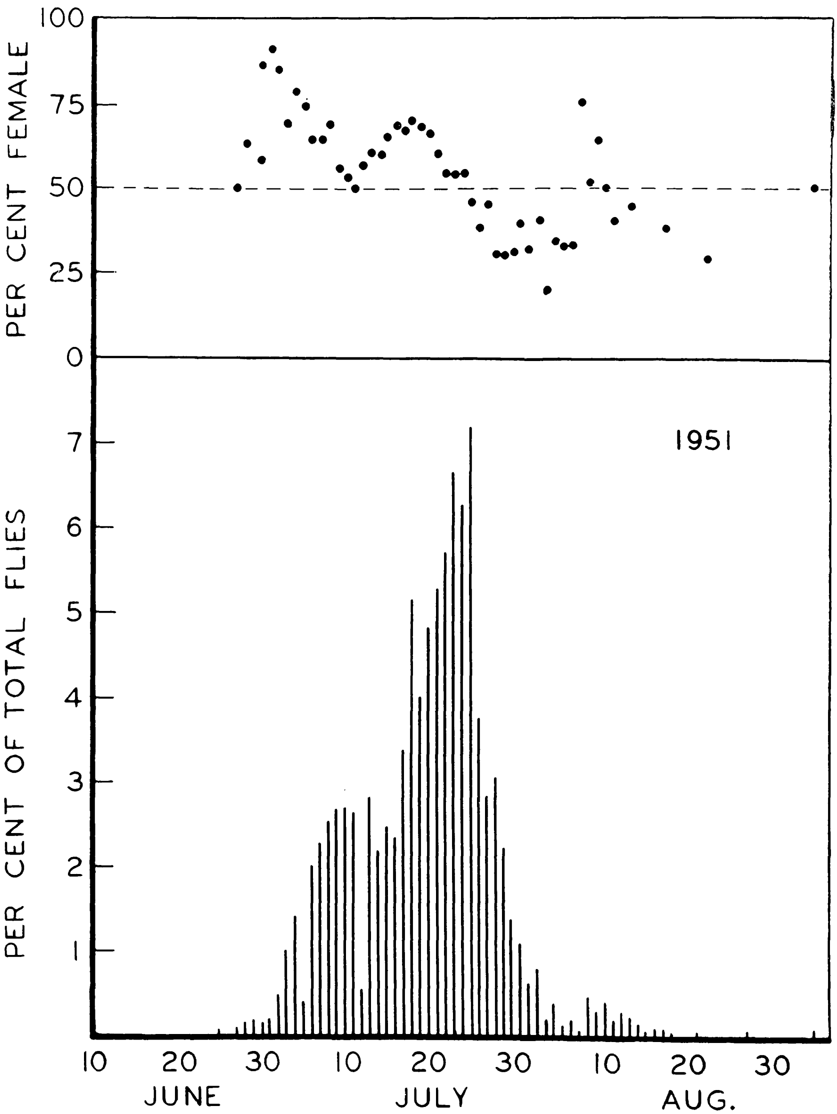

Fig. 3. Apple maggot fly emergence and sex ratios, 1951.

the early sub-peak of July 11 to about 55 per cent females. It then returned to 65 to 70 per cent and then fell to 50 per cent just after the main peak of July 25–29. At this time, however, it went back up to 55 per cent for three days before it again fell below the 50 per cent

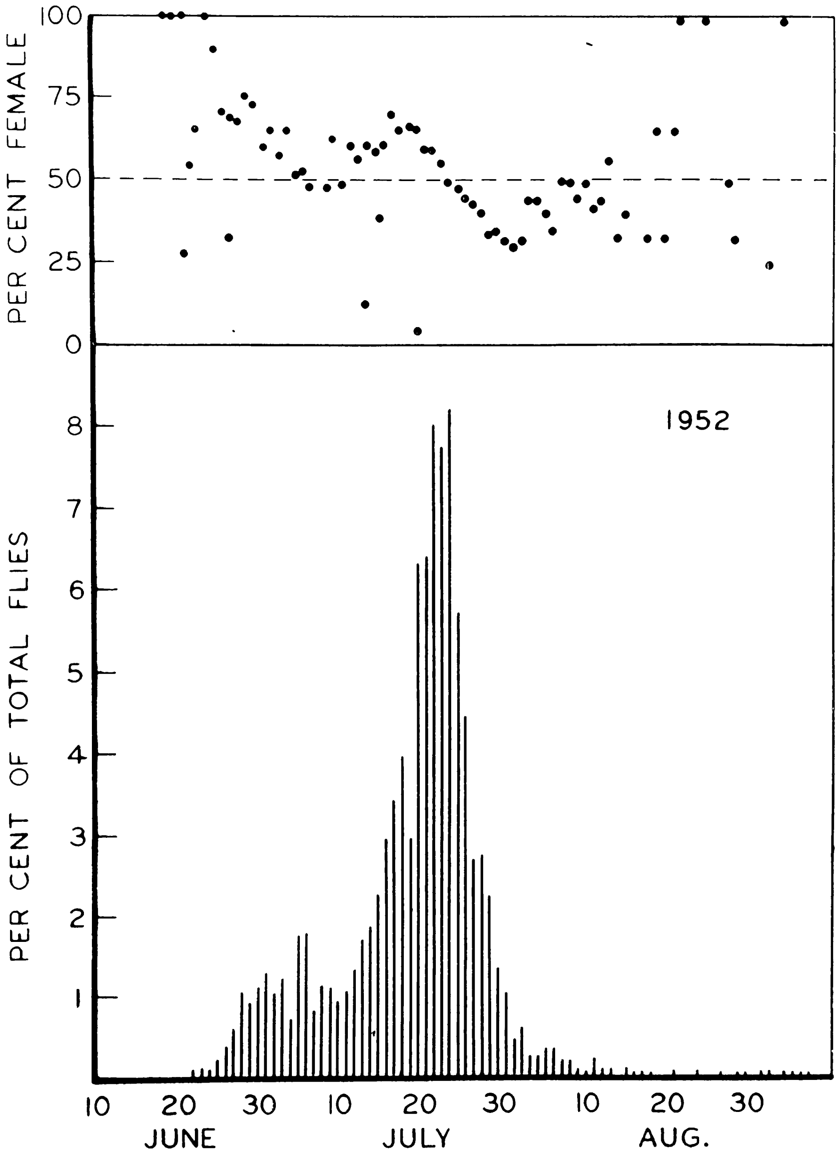

Fig. 4. Apple maggot fly emergence and sex ratios, 1952.

level. Thus, there was not a good correlation between the peak emergence and the 50 per cent sex ratio in 1956.

A detailed study of the fly emergence has shown very large differ-

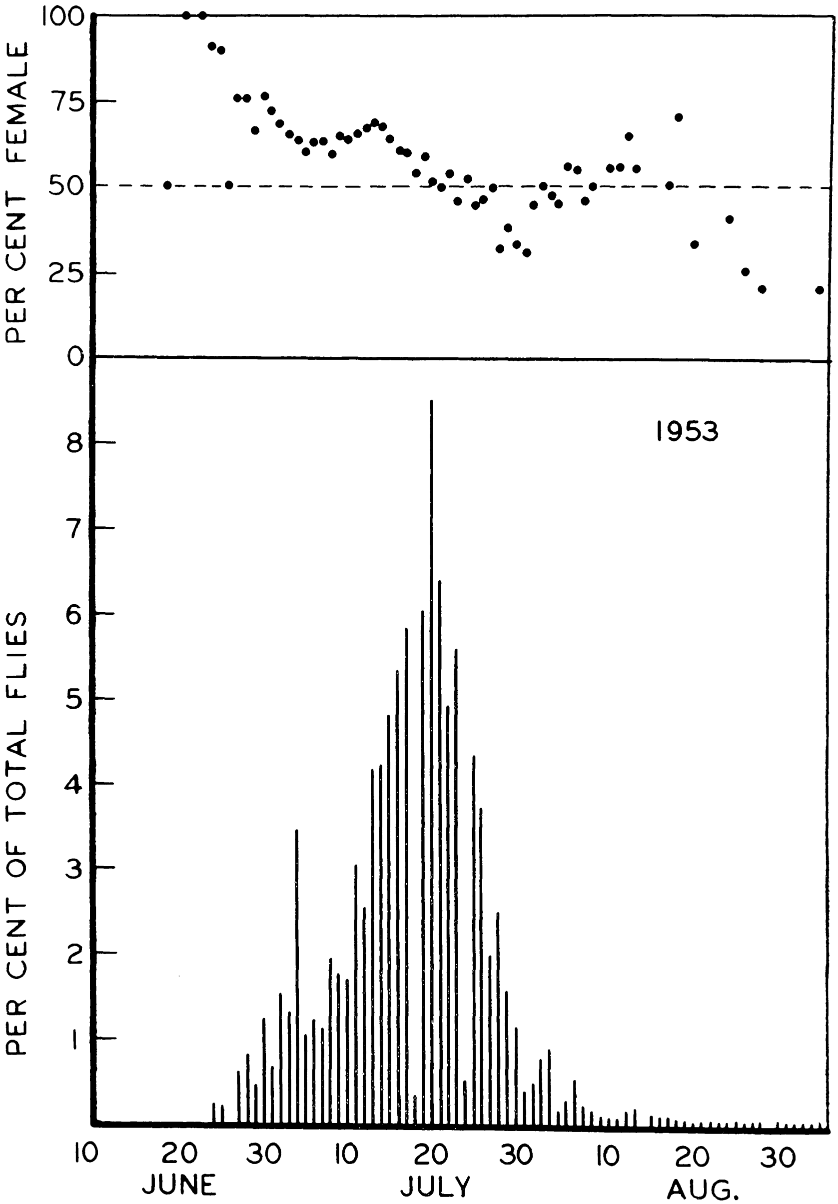

Fig. 5. Apple maggot fly emergence and sex ratios, 1953.

ences in time of emergence from the various seedings for any one year. In Fig. 9 the emergence curves for 1952 for cages 1 and 2 are plotted separately along with the percentage of females for all cages. (Flies from individual cages were not sexed separately.) The curves show that fly emergence in cage 2 was nearly 3 weeks later than in cage 1. Of the other three seedings for the same year, the emergence from one was similar to cage 1, while the other two were later and like that from cage 2. Further study of Fig. 9 shows that the sex ratio dropped to just less than 50 per cent females directly following the peak of cage 1. It then climbed back to 70 per cent as emergence got under way in cage 2 (and the other two late cages). It began falling and crossed the

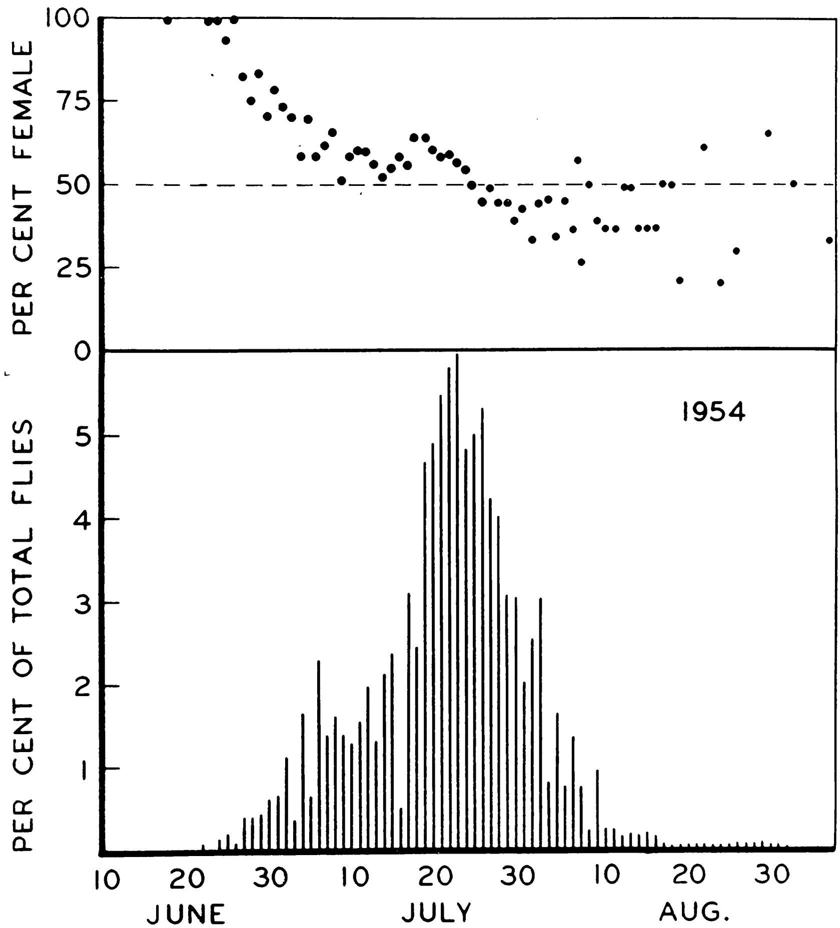

Fig. 6. Apple maggot fly emergence and sex ratios, 1954.

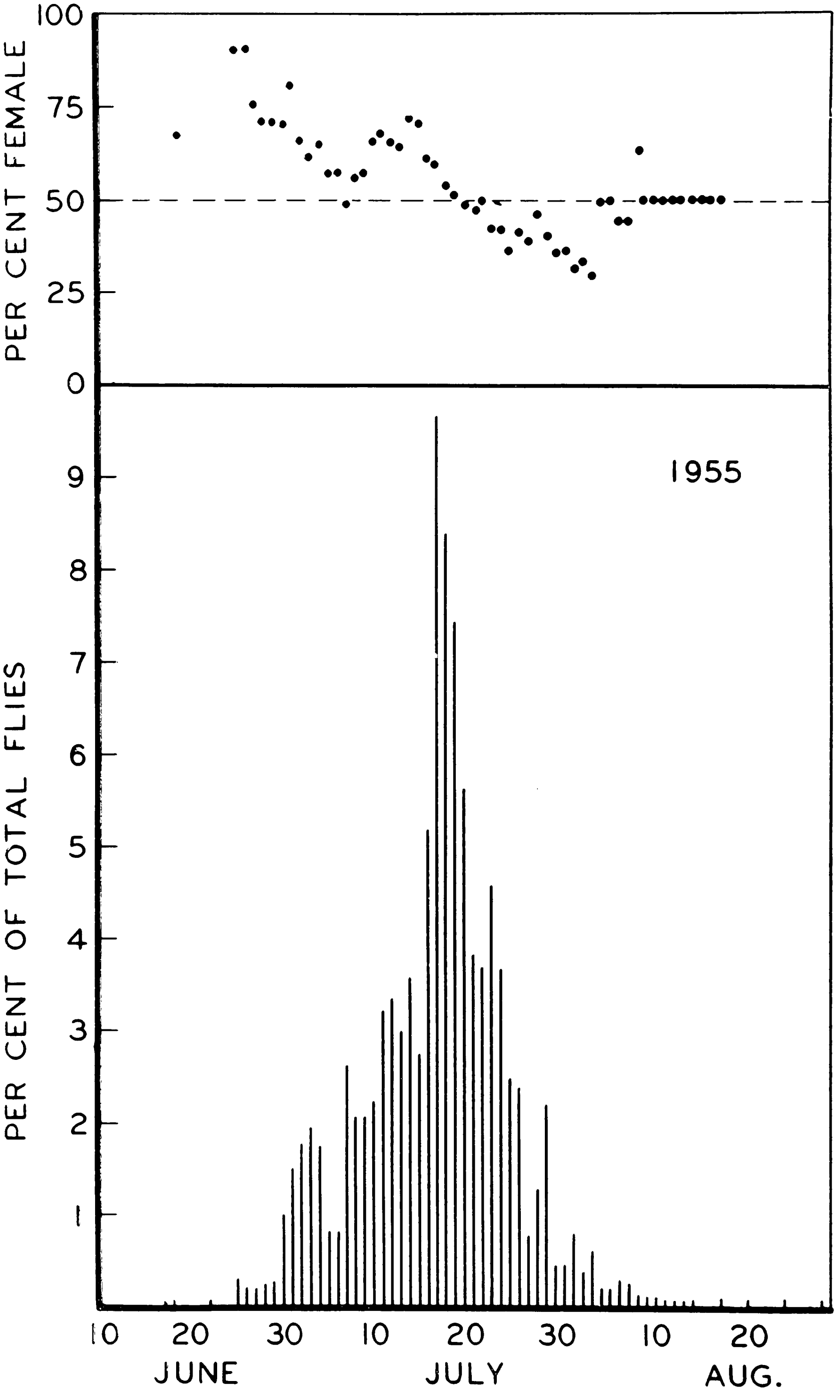

Fig. 7. Apple maggot fly emergence and sex ratios, 1955.

50 per cent point on the day that peak emergence occurred. This indicates that each seeding follows its own distinct emergence and sex ratio pattern.

When the emergence records are combined and plotted, as in Figs. 3 to 8, the differences in early, medium, or late cages may not be evident because the numbers of flies are not always alike. In the seedings made at Geneva, heaviest emergence for most years has come from those cages reaching a peak in the July 20–25 period. In 1956, however,

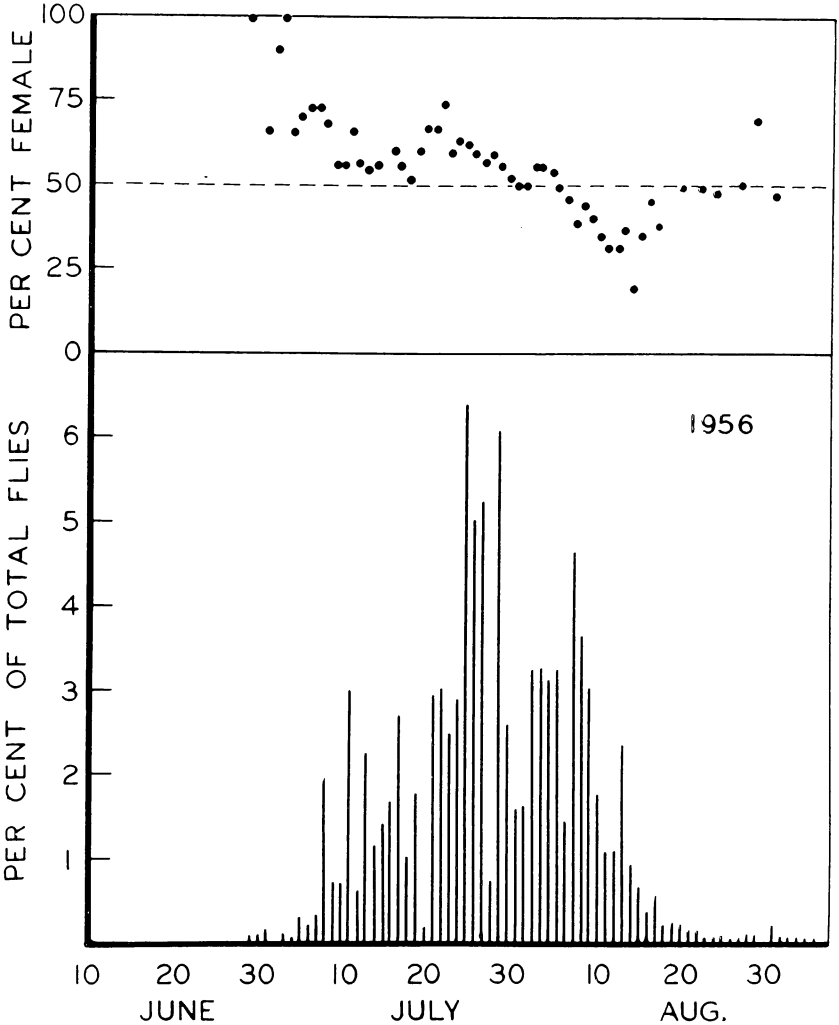

Fig. 8. Apple maggot fly emergence and sex ratios, 1956.

the number of flies in all cages but one was appreciable, ranging from 672 to 1,890 flies per cage. One of the early cages produced 1,447 flies and one of the late ones 1,647 flies. When the combined fly emergence is plotted for 1956 (Fig. 8), there are three apparent peaks, July 11, July 26, and August 7. The fly emergence in cages 4, 6, and 9 is plotted separately in Fig. 10. It is evident that cages 4 and 6 represent early and medium emergence similar to cages 1 and 2 in 1952. Cage 9 shows a considerably later emergence. Of the other six cages, one was similar

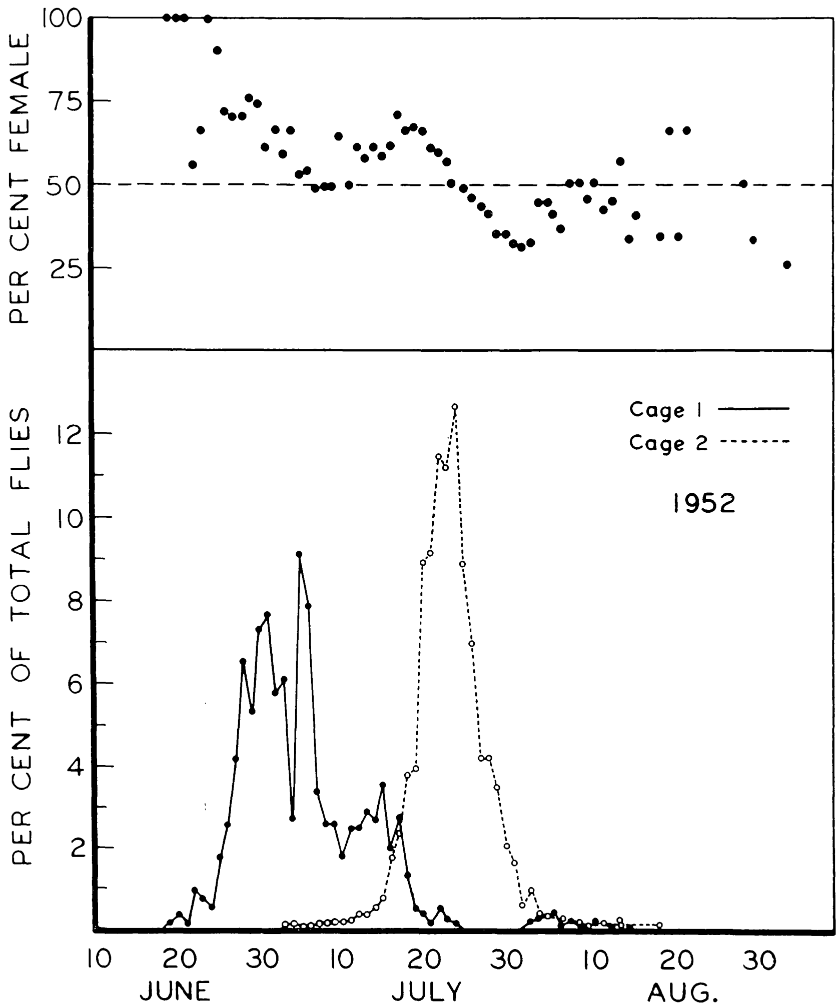

Fig. 9. Apple maggot fly emergence in cages 1 and 2 for 1952.

to cage 9, two were like cage 6, and two like cage 4. The remaining cage had only 74 flies for the season. The three peaks for 1956 are due apparently to peak emergence from the early, middle, and late emerging cages rather than some other factor such as weather. The sex ratio for

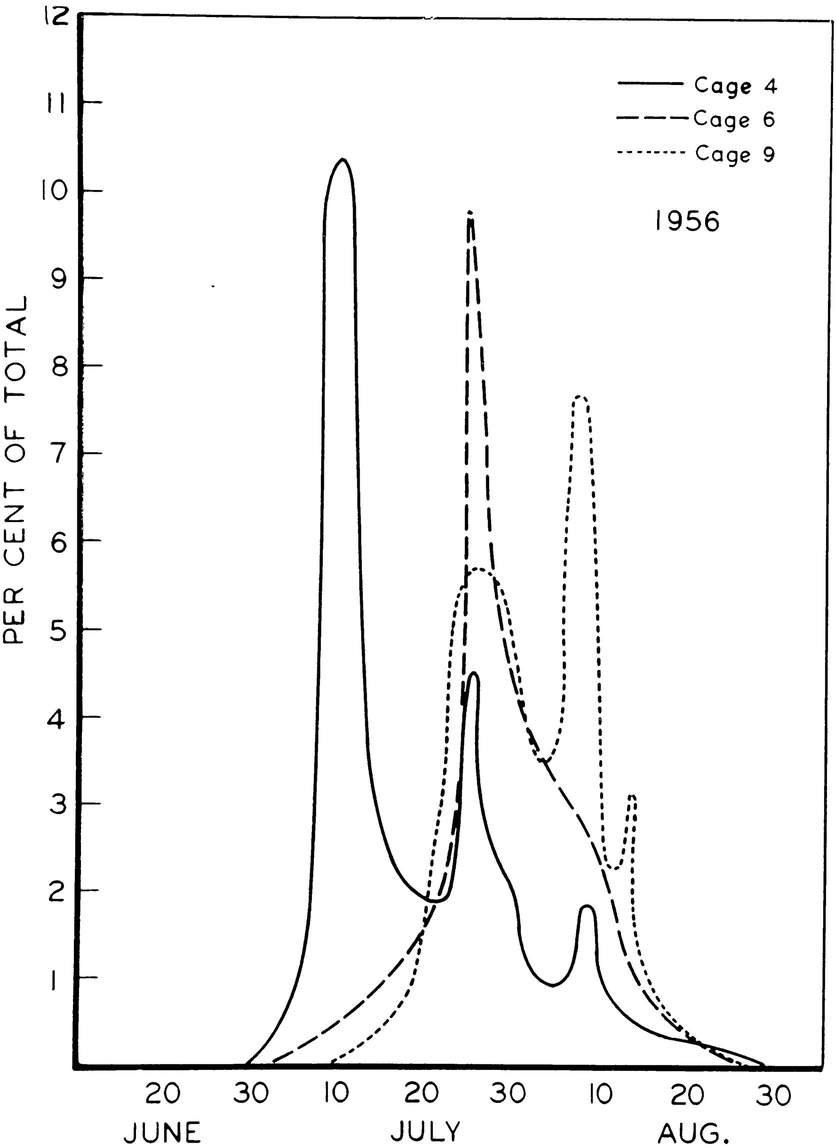

Fig. 10. Apple maggot fly emergence in cages 4, 6, and 9 for 1956.

emergence for all cages seems to reflect the peaks of early, middle, and late emergence just as in 1952.

Although the heavy emergence of flies in the first half of August in 1956 appears to be due at least in part to emergence from two late seedings, a study of Fig. 10 shows that fly emergence in early and medium late seedings continued in appreciable numbers into early August. This was appreciably later than the normal for the other years included in this study.

Some Factors Influencing Time of Emergence

The data presented so far show that emergence varied as much as four weeks measured at the peak from one cage to another. This is in spite of the fact that all seedings were made under rather uniform conditions under a few trees in the same orchard. Variations from seeding to seeding due to such factors as shade density of the tree appear to have had very little influence on the time of maggot emergence. For example, several pairs of seedings were made by dividing several bushels of fruits collected from the same trees. These pairs are: 1952, cages 1 and 5; 1953, cages 1 and 2 and cages 3 and 8; and 1954, cages 8 and 9. Only the last pair of cages were under the same tree. The emergence data in Tables 3, 4, and 5 show that the pattern for paired cages was nearly identical under variable shading conditions. The results indicate that the location of the seeding within the test orchard was not a significant factor in time of emergence.

After the first year an attempt was made to collect apples from several sources, including early, medium, and late maturing varieties. In one instance collections were made from the same trees on three separate dates. The data for individual seedings for all the years are given in Tables 2 to 7.

Variety of apple

Several workers have reported that flies originating from early-maturing apple varieties emerge earlier than do those from late-maturing varieties. This fact was confirmed in these studies. Emergence from seedings made with Yellow Transparent apples started and reached the peak and 50 per cent points 10 to 16 days ahead of those from other varieties such as Wealthy and McIntosh. Flies from Williams apples also emerged somewhat earlier than the other varieties in most instances. On the other hand, flies from Baldwin apples were somewhat later than from Weathy apples.

TABLE 2.—APPLE MAGGOT FLY EMERGENCE IN CAGES AT GENEVA, N. Y., 1951.

CAGE NO.	SOURCE OF MAGGOTS		DATE FRUIT COLLECTED	TOTAL FLIES	DATE OF		
	Location	Variety			First	Peak	50 per cent
1	Geneva	Yellow Transparent	Aug. 1950	—*	—*	July 10	—*
4	Geneva	Williams Early Red	Aug. 1950	—	—	July 9	—
2	Lyons	Wealthy	Aug. 1950	—	—	July 25	—
3	Lyons	Wealthy	Aug. 1950	—	—	July 18	—
All cages				5,256	June 27	July 25	July 21

* Separate records for each cage were not taken in 1951.

TABLE 3.—APPLE MAGGOT FLY EMERGENCE IN CAGES AT GENEVA, N. Y., 1952.

CAGE NO.	SOURCE OF MAGGOTS		DATE FRUIT COLLECTED	TOTAL FLIES	DATE OF		
	Location	Variety			First	Peak	50 per cent
5	Geneva	Williams Early Red	Aug. 13, 1951	684	June 19	July 6	July 6
1	Geneva	Williams Early Red	Aug. 13, 1951	1,019	June 19	July 5	July 4
2	Lyons	Wealthy	Aug. 13, 1951	4,514	July 2	July 24	July 23
3	Geneva	Wealthy	Aug. 27, 1951	1,344	June 27	July 24	July 21
4	Williamson	Wealthy	Aug. 27, 1951	1,134	July 2	July 20	July 20
All cages				8,695	June 19	July 24	July 21

TABLE 4.—APPLE MAGGOT FLY EMERGENCE IN CAGES AT GENEVA, N. Y., 1953.

Cage No.	Source of Maggots: Location	Source of Maggots: Variety	Date fruit collected	Total flies	Date of: First	Date of: Peak	Date of: 50 per cent
1	Geneva	Yellow Transparent	Aug. 1, 1952	1,016	June 23	July 4	July 8
2	Geneva	Yellow Transparent	Aug. 1, 1952	449	June 19	July 4	July 4
9	Lyons	Wealthy	Aug. 21, 1952	493	June 27	July 15	July 17
8	Williamson *	Wealthy	Aug. 18, 1952	1,013	June 24	July 17	July 19
3	Williamson *	Wealthy	Aug. 18, 1952	789	June 25	July 20	July 20
6	Williamson *	Wealthy	Aug. 25, 1952	2,184	June 28	July 20	July 21
5	Williamson *	Wealthy	Sept. 9, 1952	1,208	June 26	July 20	July 20
4	Geneva	Wealthy	Aug. 29, 1952	1,001	June 27	July 20	July 17
7	Geneva	McIntosh	Aug. 21, 1952	1,002	June 23	July 20	July 14
All cages				9,155	June 19	July 20	July 18

* Collections from same orchard.

TABLE 5.—APPLE MAGGOT FLY EMERGENCE IN CAGES AT GENEVA, N. Y., 1954.

Cage No.	Source of Maggots: Location	Source of Maggots: Variety	Date fruit collected	Total flies	Date of: First	Date of: Peak	Date of: 50 per cent
4	Williamson	Wealthy	Aug. 17, 1953	697	June 29	July 26	July 26
5	Sodus	Wealthy	Aug. 17, 1953	1,193	June 27	July 20	July 20
6	Lyons	Wealthy	Aug. 17, 1953	1,653	June 29	July 26	July 25
2	Sodus	Wealthy	Aug. 31, 1953	768	June 28	July 25	July 25
1	Lyons	Wealthy	Aug. 31, 1953	2,095	June 18	July 23	July 23
7	Geneva	Williams Early Red	Aug. 19, 1953	970	June 23	July 26	July 21
8	Geneva	Mixed Var.	Aug. 18, 1953	940	June 24	July 6	July 14
9	Geneva	Mixed Var.	Aug. 18, 1953	965	June 24	July 6	July 14
3	Fairville	Seedling	Aug. 31, 1953	385	July 1	July 26	July 24
All cages				9,666	June 18	July 23	July 22

TABLE 6.—APPLE MAGGOT FLY EMERGENCE AT GENEVA, N. Y., 1955.

Cage No.	Source of Maggots: Location	Source of Maggots: Variety	Date fruit collected	Total flies	Date of: First	Date of: Peak	Date of: 50 per cent
4	Geneva	Yellow Transparent	Aug. 12, 1954	784	June 18	July 3	July 4
3	Lyons	Wealthy	Aug. 12, 1954	310	June 27	July 18	July 18
8	Williamson	Wealthy	Aug. 20, 1954	2,317	June 26	July 19	July 19
9	Sodus	Wealthy	Aug. 20, 1954	919	June 19	July 17	July 18
6	Hopewell	Seedling	Aug. 20, 1954	1,439	June 25	July 17	July 18
2	Geneva	Wealthy	Aug. 26, 1954	759	June 23	July 11	July 9
1	Williamson	Baldwin	Aug. 26, 1954	1,062	July 7	July 19	July 21
5	Lyons	Wealthy, King	Aug. 31, 1954	657	June 25	July 17	July 17
7	Lyons	Pound Sweet	Aug. 31, 1954	995	June 22	July 17	July 16
All cages				9,242	June 18	July 17	July 17

TABLE 7.—APPLE MAGGOT FLY EMERGENCE FROM NINE SEEDINGS AT GENEVA, N. Y., 1956.

Cage No.	Source of Maggots: Location	Source of Maggots: Variety	Date fruit collected	Total flies	Date of: First	Date of: Peak	Date of: 50 per cent
1	Geneva	Yellow Transparent	Aug. 4, 1955	74	July 6	July 11	July 21
2	Geneva	Mixed	Aug. 4, 1955	873	July 8	July 17	July 27
3	Geneva	Mixed	Aug. 4, 1955	672	July 1	July 17	July 21
4	Geneva	Wealthy	Aug. 5, 1955	1,447	June 29	July 11	July 15
5	Lyons	Wealthy	Aug. 4, 1955	654	July 6	July 17	July 22
6	Williamson	Wealthy	Aug. 5, 1955	1,890	July 6	July 25	July 29
7	Williamson	Wealthy	Aug. 5, 1955	1,087	July 2	July 25	July 27
8	Williamson	Baldwin	Aug. 22, 1955	1,647	July 10	July 29	Aug. 2
9	Williamson	Baldwin	Aug. 22, 1955	1,551	July 3	Aug. 7	Aug. 3
All cages				9,895	June 29	July 25	July 28

Time of collecting fruit

In 1953 collections from the same group of Wealthy trees were made at Williamson on August 18, August 25, and September 9. For the most part, only infested drop fruits were taken. Emergence data in Table 4 show that there were no appreciable differences in emergence between cages. This probably means that larval emergence from the fruit was essentially the same regardless of when the fruit was collected.

In 1954, Wealthy apples were collected from the same orchard near Sodus on August 17 (cage 5) and on August 31 (cage 2). Although peak and 50 per cent emergence occurred 5 days earlier in cage 5 than in cage 2, this difference is small in relation to differences noted in other cages. It seems likely that the time of collecting infested fruit from any one locality and variety does not influence appreciably the time flies will emerge the following season.

Seasonal temperature variations

For this study no single source of infested apples was available for all six years due to the biennial bearing nature of the varieties used. Therefore a very critical study of the possible effects of variations in the weather from year to year on time of emergence may not be justified. However, a large enough series of seedings was made each year from both early and mid-season apples so that the average emergence of all cages as affected by source should be reasonably comparable. The exception to this was in 1955 when one Baldwin seeding was made and in 1956 when two Baldwin seedings were made.

For the purpose of this study the average mean temperatures at Geneva for the months of May, June, and July are given in Table 1 along with the average fly emergence. These three months are probably the most critical in affecting the time of fly emergence. Such a supposition is based on the assumption that pupae entering the ground in late summer and fall are in the arrested state of diapause and development would not be influenced appreciably by temperature abnormalities during this period. Following the winter and early spring it can be assumed that diapause is broken and that temperature fluctuation could influence the rate of development and the time required to reach the adult stage. The fact that flies from individual pupae carrying over to the second summer emerge at a normal time supports this theory.

Examination of the data in Table 1 shows that there is a rough correlation between the mean temperature for the three-month period and the date of peak emergence and 50 per cent emergence. The dates for first and last flies depend on so few individuals that they are not considered in this comparison. The warmest year, 1955, had peak and 50 per cent emergence 9 and 11 days, respectively, earlier than in 1956 which was the coolest. The other years with intermediate temperatures had intermediate emergences. In Fig. 11 the 1956 emergence for cages 1 through 7 has been plotted to eliminate the influence of the Baldwin seedings. It is apparent that there still was appreciable emergence later than during the other years included in this study.

Practical use of this correlation could be made only within broad limits. Thus, if the months of May, June, and early July were 4° or 5° below normal, one could predict safely that there would be relatively heavy fly emergence in late July and early August; whereas if the mean temperatures were above normal, heaviest emergence would be expected during the middle and latter part of July with light emergence in August. Both of the foregoing generalizations are based on the assump-

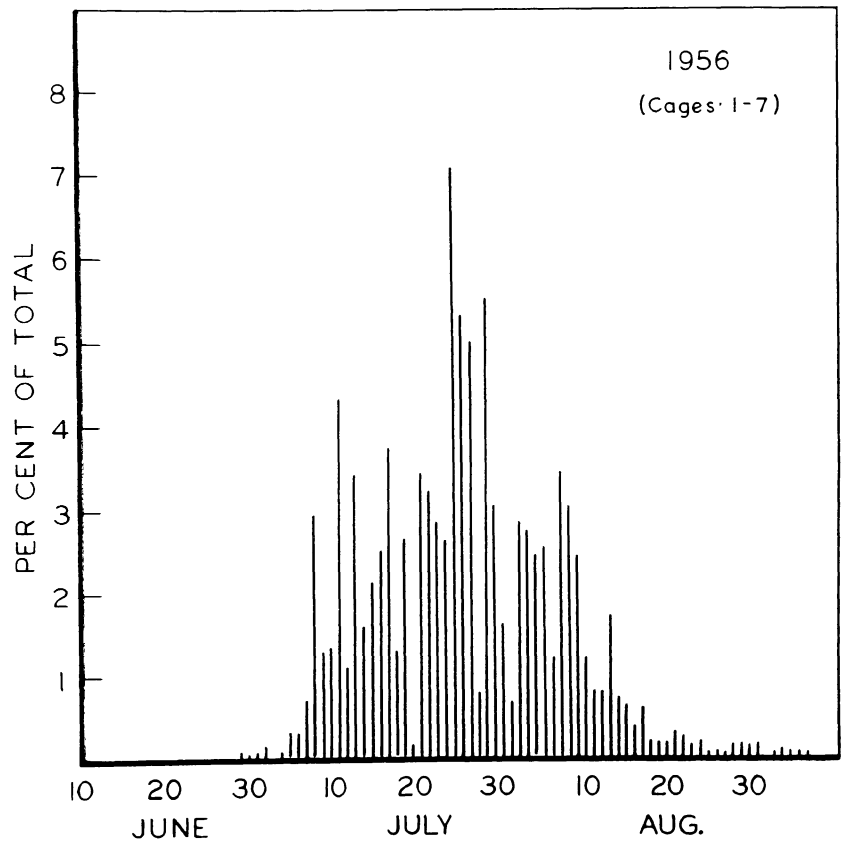

Fig. 11. Apple maggot fly emergence in cages 1-7 for 1956.

tion that rainfall was more or less normal for the period, especially from June 15 to August 1.

Comparison of Western New York and Hudson Valley Emergence

Apple maggot fly emergence studies have been conducted at Poughkeepsie, N. Y., for many years by Doctor R. W. Dean, including the period of 1951–56. The methods of seeding used in this study were essentially the same as those used by him so that a comparison of emergence in the cages at Geneva and Poughkeepsie can be made. The Poughkeepsie emergence data for the years 1951 through 1954 are taken from Dean (5). That for 1955 and 1956 are unpublished data from the same source. A comparison is given in Fig. 12.

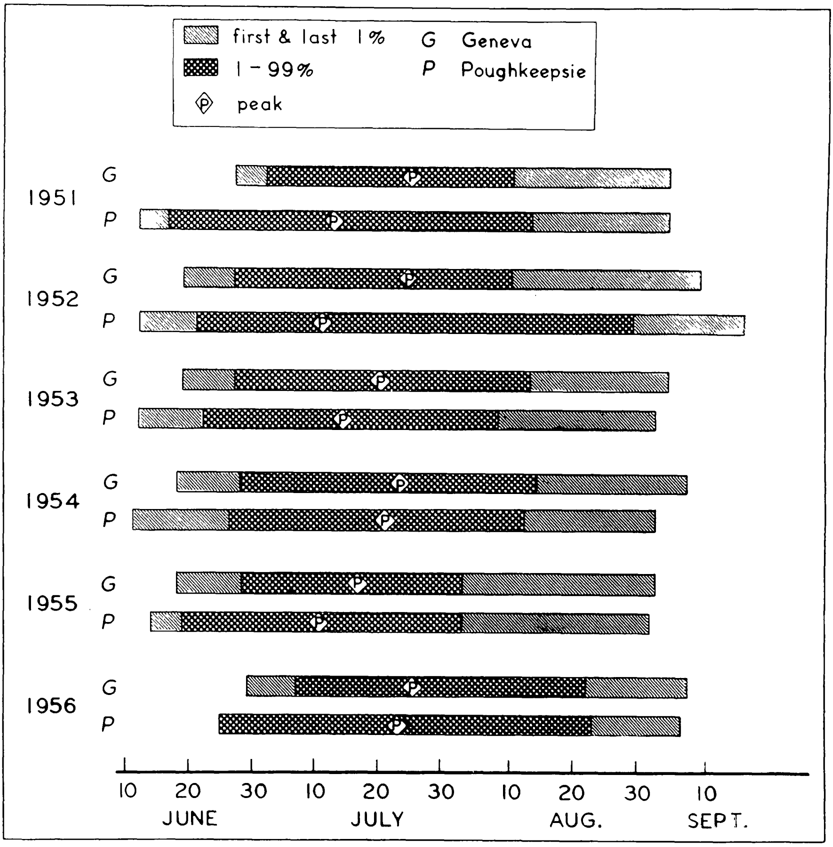

Fig. 12. Apple maggot fly emergence for Geneva and Poughkeepsie, 1951–1956.

A study of the graph shows that fly emergence in Geneva started and reached a peak later than at Poughkeepsie. The range for first fly was 4 to 15 days later, with an average of 7.3 days. The 1 per cent of total flies at Geneva was reached from 2 to 15 days and on the average 8.1 days later than at Poughkeepsie. The peak occurred 2 to 13 days later with an average of 6.8 days. The emergence records in August were somewhat erratic, but there appeared to be less difference between emergence in the two localities at this time than during the earlier part of the season. There was a tendency for fly emergence to continue longer at Poughkeepsie than at Geneva as indicated by the fact that 99 per cent of total flies was reached 2.7 days later at Poughkeepsie than at Geneva. There was little difference regarding the dates of last fly emergence.

Practical Use of Fly Emergence Data in Western New York

As stated previously, practical control of the apple maggot depends upon killing the flies before eggs are laid. This is accomplished by maintaining a film of toxic insecticide on the trees during the period when flies are present. Experience has shown that it is not necessary to provide protection against the very earliest and very lastest flies because they are so very few in number. Therefore, the period when protection is needed spans 6 to 8 weeks, instead of the approximately 10 weeks of the entire emergence period.

In some of the earlier discussions it has been brought out that a number of variables may influence the time of fly emergence. These include source of maggots, seasonal temperatures, rainfall, exposure of site to sunlight, and probably others. These factors can vary appreciably from orchard to orchard. The emergence data for 1951 through 1956 in western New York appear to cover most of the variables, except soil type, exposure to sunlight, and sub-climatic zones. It is judged, however, that the site used to obtain the data is about average for the western New York apple-growing areas. An exception might be a narrow strip along Lake Ontario which normally is several days later than the rest of the district.

Another assumption is made that the period of study includes seasonal temperature extremes as great as might occur except in the most unusual years. Thus 1955 was unusually warm and 1956 unusually cool. Support for this assumption is found in the records of Dean (4, 5) and his unpublished records for 1955 and 1956. These show almost as extreme emergence variations for 1951 to 1956 as for the entire 1935 to 1956 period.

Generally, apple maggot fly emergence can be considered to start during the last two weeks in June in western New York and continue to the first week in September. For most seasons, however, the major emergence occurs during the month of July and the first week of August. Only in 1956, an exceptionally cool season, was there significant emergence after August 10. Heaviest emergence has consistently occurred during the last two weeks in July.

In commercial plantings where regular spray schedules are followed, apple maggot presents no special problem in western New York. For the most part insecticides applied for either codling moth or red-banded leaf roller provide protection against the apple maggot during the emergence period. It is necessary, however, that such summer sprays be applied frequently enough to maintain a toxic film on foliage and fruits at all times, especially during the latter half of July. The necessary frequency of application depends upon the insecticide used. Information on this point can be obtained elsewhere.

If the months of May, June, and July have been unusually cold, protection should be maintained until August 20. This more or less general situation may be adjusted locally to compensate for such factors as the varieties of applies grown, presence of unsprayed apple trees nearby, type of exposure, etc. If there are no early varieties such as Yellow Transparent, Williams, and Wealthy present in the orchard or in adjoining unsprayed trees, no serious fly emergence is likely before July 4. On the other hand, the presence of these varieties means that significant numbers of flies may be present during the last week of June. Unsprayed fruit trees in the immediate area create a source of infestation over a longer than normal period of time. Flies emerging from such sources may spend some time in the unsprayed areas and then migrate into the sprayed orchard after spray protection is weak or gone. Growers within a mile of Lake Ontario may expect fly emergence to be several days to a week later than the records show for Geneva.

Apple maggot control in home orchards may be very difficult. The length of the fly emergence period means the use of from four to six sprays. Even then control may be unsatisfactory because of the influx of flies from nearby unsprayed apple trees and the presence of untreated shade trees and shrubs in the yard. Continued efforts over a period of several years should result in reasonable control.

Suggestions for Obtaining Apple Maggot Fly Emergence Records

County agents, commercial pesticide representatives, and growers may wish to determine fly emergence in a certain area or season. A study of the data presented in this bulletin indicates some of the difficulties and pitfalls that may be involved in such efforts and what conditions must be met to obtain satisfactory information. Some of these are pointed out here.

1. *Selection of site for making seedings.* Obviously the site should be typical for the area to be studied. Preferably the seedings should be under apple trees that are not to be sprayed during the season when flies are to emerge. The site should be close by because it will have to be visited daily or every other day for a period of about three months.

2. *Source of fruit.* Early, mid-, and late-season apples should be collected and placed under trees on the seeding site. Early season fruit should be collected in late July or early August. The others can be collected in mid and late August. Recently abandoned orchards and roadside trees are good sources of infested apples.

3. *Seeding.* From 1 to 3 bushels should be spread over an area of ground that can be covered by the cages to be used. In this study the cages covered 4 by 8 feet of ground, while the fruit covered area of about 3 by 7 feet. The pile of fruit should not be more than two or three apples deep. In late fall or early spring the old apples should be raked off the area. To insure satisfactory records, at least six and preferably more seedings should be made.

4. *Cages.* A wooden frame 4 x 8 x 3 feet high should be placed over the seeding about June 15. This is then covered with cheesecloth. The cloth used is the type employed to produce shade-grown tobacco. It can be purchased in strips wide enough to cover the entire cage. One

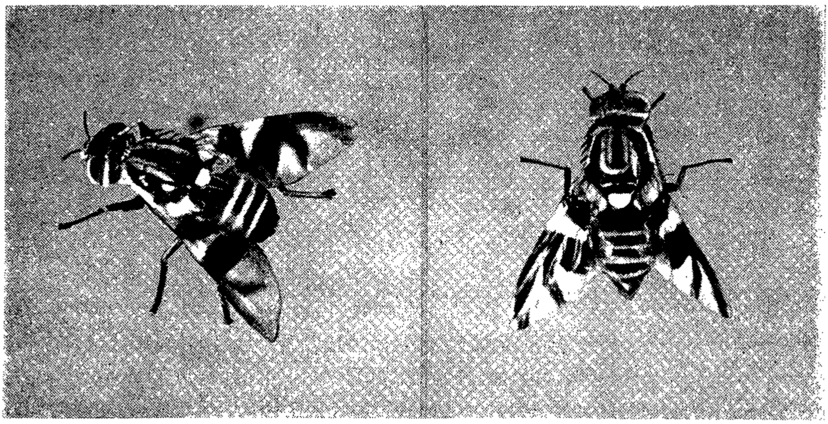

Fig. 13. Male apple maggot fly with three white abdominal bands (left) and female fly with four white bands (right).

end should be adapted to permit a person to crawl into the cage to collect the flies.

5. *Collecting.* A suitable technique is explained earlier under "Methods". When several hundred flies are emerging daily, two or three hours may be required to collect the flies.

6. *Sexing.* The sex ratio is a valuable indicator of the stage of emergence. This is best done after the flies have been collected and killed with a fumigant such as ethylene dichloride. The females have four white bands across the dorsal surface of the abdomen whereas the males have only three (Fig. 13).

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