STUDIES IN TRYPETIDAE

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WITH SPECIAL REFERENCE TO

THE GENUS *RHAGOLETIS* LOEW

By

A. D. Pickett

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INTRODUCTION

The stimulus for initiating the studies reported herein was the very pronounced economic interest created when steps were taken by the United Kingdom in 1929 to prevent the introduction into that country of the apple maggot Rhagoletis pomonella (Walsh). Since the great markets of the British Isles are of such importance to the apple industry of all apple growing areas in the United States and Canada, it is only natural that everything possible should be done to prevent the total loss of this market. Although Canadian exports of apples were not affected by restrictions, there was, nevertheless, general concern in all apple growing sections in Canada as to whether or not these restrictions were concerned with the import of Canadian fruit, since a closing of this market would mean an over supply of apples on all Canadian markets and a subsequent demoralization of the industry.

Nowhere was this general concern more manifest than in the Province of Nova Scotia, since anywhere from 75 to 90% of the total apple crop produced is exported, and the great bulk

of these go to the United Kingdom. The immediate result of this condition was a stimulation in the interest taken by fruit growers regarding the control of this pest; and machinery was put in motion to effect a general cleanup of infested properties. The technical men were called on to outline a control policy which would eventually lead to the practical extermination of this insect from the main apple producing sections. In order that this might be done, many things had to be considered. At that time no one had made any serious attempt to study the relationship between the different forms of this fly which had been reported as develoeping on various fruits. This relationship was, and is, of very great importance economically, since many apple orchards are surrounded by, or are adjacent to, areas on which are growing hawthorns or blueberries, or both. In fact, both these plents are found in abundance practically throughout the main apple growing sections; and all three species may be found in close proximity. Whether or not the flies developed in the fruit of one host would oviposit in one of the other fruits was not definitely known; and, therefore, it was necessary to ascertain, if possible, whether or not it was practicable to completely control this insect in an apple orchard when infested hawthorns or blueberries were in the near vicinity. A solution of this problem is of the greatest importance economi-

cally since, as above stated, many orchards are practically surrounded by either one or both of these host plants of Rhagoletis pomonella.

In 1930 an intensive survey of all orchards in the Annapolis and adjacent Valleys was undertaken to determine how widespread the infestation was. The inspection work was carried on under the general supervision of the writer; and he was responsible for checking the identification of all the insects in regard to which there was any doubt. In order to carry this out successfully a careful study of the different larvae found in apples, and also the adults of the same, was made. The present paper is a report on these studies, the scope of which has been somewhat broadened from the original problem outlined above.

GENERAL CONSIDERATIONS

In order to determine the relationship of the above mentioned group an investigational program was outlined. This was divided into two main sections: 1st, the morphology of the forms in question, and also of other related Trypetids which were available; and 2nd, a biological study of the forms developing in the apple, the hawthorn and the blueberry. The results of these investigations are given below.

MORPHOLOGICAL STUDIES

Rhagoletis pomonella (Walsh)

The pomonella group is a somewhat different problem; and after a careful study of a long series of specimens, along with a painstaking survey of the literature, there is still a considerable amount of doubt as to the status of various forms.

According to Illingworth (20), Porter (29), and Benjamin (4) the species Rhagoletis pomonella was described by Walsh (34) in 1867 under the genus Trypeta; the writer has not examined the original manuscript. This description refers to the flies developed on the apple and on the hawthorn; and there is no question as to its status. However, when Snow (31) described zephyria in 1894, the status of the group became somewhat complicated since the differences between the two forms were comparatively slight. Doane (12) and Aldrich (1) questioned the validity of the latter. Curran (9 & 10), however, after an examination of one female specimen accepted zephyria as a definite species on the basis of color variations between it and pomonella (Walsh). A related form, found in the snowberry Symphoricarpus racemosus Michs., was described by Curran (ibid) under the name of symphoricarpi on the basis of the characters of the male genitalia. Cresson (8) regards the latter as a synonym of pomonella on

the basis of his examination. Benjamin (4) has examined one of the cotypes of zephyria Snow and cannot distinguish between it and those reared from the snowberry; consequently he has designated symphoricarpi Curran as a synonym of zephyria Snow.

In 1932 Curran (11) examined specimens collected from blueberry, which were submitted to him by the writer for identification, and he described it as a new species R. mendax on the basis of the characteristics of the male genitalia. Woods (35) studied the blueberry maggot in Maine; and, after comparing all stages with Illingworth's (20) figures of pomonella, could observe no difference except in size and habits. A series of specimens collected from apple, hawthorn, and blueberry were submitted to Dr. Aldrich of the United States National Museum in 1933; and he was of the opinion that there was not enough difference between the blueberry form and the others to give the former specific rank; although he said he had been unable to decide definitely (3).

During the last four years the writer has spent a considerable amount of time studying the male genitalia of a number of species of Rhagoletis. A long series of the forms collected or reared from apple, hawthorn, blueberry and snowberry have been carefully examined and a number of figures have been prepared.

In regard to the forms which occur on apple, hawthorn and blueberry there does not appear to be any constant difference

in the male genitalia, as a reference to figures 1, 2 and 3 will show. Curran's figures (11) are only partially complete; and the specimens were evidently not examined in the same plane. Further, his statement that the so-called sustentacular apodeme (ejaculatory apodeme) furnishes a "ready means of determining the species" and that "this organ exhibits striking differences in shape in the various forms studied" cannot be substantiated by the writer after an examination of a series in each group. In the specimens examined there is a great variation in the form of the ejaculatory apodeme in each group; and this character cannot be used for the purpose of identification. The writer is of the opinion, although this point was not definitely proven, that this organ develops and becomes larger in accordance with the period of time elapsing after the fly leaves the puparium. However, specimens of apple and blueberry flies which had just emerged showed a weak development of this organ. A careful examination of the ejaculatory apodemes of each form shows that neither the crescentic rings, the width and shape of the apical portion of this organ,nor any other feature can be used to differentiate between these forms. A brief reference to figures 1, 2 and 3 will show some differences in the ejaculatory apodemes. These are drawings of certain specimens that were chosen at random for this purpose and none of the slight variations are constant. It will

be noted that these figures show a greater difference in the size of this organ between the flies from hawthorn and those from apple than between the apple and the blueberry forms; but this difference is not constant. The observations of the writer indicate that the tip of the penis is the most constant feature found in the male genitalia of all the species of the genus studied. As Curran (11) has pointed out, the proper orientation of these structures is of the greatest importance, otherwise wrong conclusions may be drawn. If mounted in liquid glycerine these organs can be readily handled. A reference to the figures will show the type of apical termination and, so far as can be ascertained from a study of a series of each form, the character is constant.

On a basis of the morphology of the genitalia of these three forms there is, in the opinion of the writer, no grounds for considering that more than one species is involved.

The figures shown by Benjamin (4) are different from those of Curran (10) in regard to the tip of the male clasper. The writer examined Snow's (31) figure of the wing of zephyria and came to the conclusion that the characters of the wing banding, on which he distinguished the form from pomonella, are not to be relied on. On the basis of an examination of ten specimens reared from each of the following fruits, hawthorn, apple and blueberry, the hyaline indentation between crossbands two and

three reach the fourth vein in some of each of these forms. In those bred on hawthorn one specimen out of ten exhibited this condition; in the apple flies four specimens out of ten; and with the blueberry flies seven specimens out of ten showed this character.

The situation regarding the form from the snowberry is slightly different. The writer has not had an opportunity to examine the form reared from the sparkleberry Batodendron arboreum Marsh (Nutt) which Benjamin (4) considers to be conspecific with the snowberry form and also with Snow's zephyria.

Curran (11) in reaffirming his identification of symphoricarpi as a species states that in his examination of the male genitalia he probably overlooked the most striking differences. Benjamin (5) maintains that the differences in the male genitalia as referred to by Curran (10) are sufficiently constant to separate this form from pomonella (Walsh).

The writer has examined the genitalia of a long series of each form and although certain of the characters mentioned by Curran (ibid) are fairly constant, even though somewhat variable, he cannot agree that the differences mentioned in Curran's (11) key are constant. Curran's (10) figures, however, are essentially correct in so far as they show the general shape of the claspers; but the statements regarding the lobe of the clasper and the length and shape of the hooks

are not borne out by the present studies, as a reference to figures 16 - 25 will show. In most specimens, however, with careful orientation it is possible to see the more curved condition of the clasper in the apple form; the more ventral position of the apical tip or point of the clasper as compared with the form on the snowberry; and the wider and more compressed condition of the clasper beyond the spurs as seen in the latter. In this connection it should be pointed out that it is necessary to study these forms very carefully to note these apparent differences. A slight variation in the position during the examination changes the appearance of these parts entirely.

If one studied only the forms found on apple and on snowberry it would be fairly easy to come to the conclusion that these differences were of sufficient significance and consistency to separate the forms as different species; but when the forms reared on hawthorn and on the blueberry are considered in connection with these, a considerable amount of doubt develops. A proportion of the male hawthorn flies show an even greater divergence from those of the snowberry than do the apple flies. That is, the differences referred to above appear to be somewhat more intense, as shown by figures 14 - 16. This does not hold true for all individuals. When forms from the blueberry are studied, certain individuals, probably

the minority, show these characters as being nearly midway between the apple and snowberry forms. These characters may be noted by comparing figures 14 - 25. With this additional information, the writer is inclined to believe that the snowberry form should not be regarded as a separate species.

One other feature which exhibits the very close relationship between all these forms is the nature of the tip of the penis. There is absolutely no variation in these so far as can be found when complete specimens were obtained. Between all of the well defined species studied by the writer in this genus, with one possible exception which will be referred to later, there were distinct differences in this part of this organ.

A study of the larval characters which are mentioned by Greene (17) in his study of Trypetid larvae was completed. This failed to indicate any significant differences between maggots taken from hawthorn, apple, blueberry and snowberry.

The specimens from snowberry were supplied by Mr. W. Downes, Victoria, B. C.

Rhagoletis cingulata (Loew)

In the past this has been considered a very stable species with clearly defined characters to distinguish it, but in 1932 Curran (11) named two new species from closely related forms. The writer obtained specimens of both of these and dissected

and studied the male genitalia in comparison with the form reared from cultivated cherries. In comparing a series of the form which Curran (ibid) has designated as *indifferens* with a series of *cingulata* there is no doubt in the mind of the writer the two are identical in so far as the male genitalia are concerned; and that *indifferens* should be considered as a synonym of *cingulata*. The differences mentioned by Curran (ibid) do not hold; and here again it may be pointed out that the size and shape of the ejaculatory apodeme is so variable in all these forms that it cannot be used as a taxonomic character. A brief reference to figures 7 and 8 will show that in the two forms figured, the form designated as *indifferens* by Curran has a somewhat wider ejaculatory apodeme than has the form from the cultivated cherry. This feature is not constant, however, and varies greatly in the specimens studied. The other differences mentioned, but not specified by Curran (ibid), were not observed by the writer. It will also be noted by the figures that the tip of the penis, which appears to be a fairly good taxonomic character, is similar in both forms. The findings as cited above agree with the observations of Benjamin (4) on forms reared in Florida.

The specimens of *cingulata* studied were supplied by Prof. L. Caesar, Guelph, Ontario, and Dr. F. L. Gambrell, Geneva, N. Y. The western form from wild cherry was supplied by Mr. S. C. Jones, Corvallis, Oregon.

Rhagoletis berberis Curran

This is a new species established by Curran (11) on the basis of the nature of the wing banding. The wing pattern figured by Curran (ibid) appears constant in the specimens examined by the writer which were from the type locality. Further, an examination of the male genitalia indicates that the species is distinct from cingulata. A reference to figures 7 - 9 will show a number of differences, but the writer considers the nature of the tip of the penis to be of particular significance.

Referring to the resemblances of this species to R. completa Cresson, as mentioned by Curran (ibid), there does appear to be a fairly close relationship in regard to both the wing banding and the male genitalia. The writer, however, is of the opinion that, as the differences found in the latter, as shown in the figures, are fairly constant and as the general body color is much darker in berberis, they should be regarded as distinct species.

Curran's types were reared from the fruits of Berberis nervosa at Hood River, Oregon, by S. C. Jones. The writer's specimens were supplied by Mr. Jones, but are labelled as being from grape.

Rhagoletis fausta (Osten-Sacken)

There appears to have been very little confusion about the status of this species since Aldrich (2) established the synonomy of R. intrudens Aldrich. A good description of the species is given by Cresson (8) but the male genitalia have not been figured previously so far as can be ascertained. Figure 10 shows that in this regard, this species is quite different from the other species studied and thus indicates the value of these characters in a taxonomic study of the genus.

I have examined specimens obtained from Dr. F.L. Gambrell, Geneva, New York.

Rhagoletis sauvis (Loew) and R. completa Cresson.

Rhagoletis sauvis was described by Loew (2) in 1862; and in 1929 Cresson (8) established completa as a subspecies. Boyce (5) considers the differences great enough to establish the latter as a distinct species. He figures two characters found in the male genitalia, the validity of which the writer must question. It is true that there are slight differences in the claspers, but these are not so pronounced as shown by Boyce (ibid) and it would appear that a different perspective was used in each case. Boyce's figure of completa compares favourably with figure 12, but to get the claspers of sauvis to appear like Boyce's figure, it is necessary to orientate

the part so that a posterio-lateral view is obtained. Figure 11 shows the condition observed by the writer. Further, these studies showed no constant difference in the size or shape of the ejaculatory apodeme and as pointed out previously in connection with other species, this character cannot be relied on in taxonomic determinations. A comparison of figures 11 and 12 show these organs as they are found in the two specimens chosen at random for drawing. The distinguishing characters, as illustrated by Boyce (ibid), may occur in some specimens in either form, but cannot be considered as constant. A reference to the figures will show the very close relationship of the two forms. The differences between these are certainly not marked the character of the wing pattern being probably the most pronounced. It was not possible to make out any distinct differences in the tip of the penis. There may be sufficient justification for establishing completa as a subspecies, but in the opinion of the writer there is not sufficient evidence of differences to consider that two distinct species are involved. However, in order to definitely establish the status of these forms, genetical and cross-breeding investigations should be undertaken.

The specimens of sauvis were obtained from Dr. F. L. Gambrell, Geneva, N. Y.; and those of completa from Dr. A. M. Boyce, Riverside, California.

Rhagoletis tabellaria (Fitch) and R. ribicola Doane

Rhagoletis tabellaria was described by Fitch (13) in 1856 under the genus Tephritis. In 1898 Doane (12) described a closely related form found on currant and gooseberry in Washington as R. ribicola. Aldrich (1) recognized this as a valid species and figured the wing. In 1915 Marcovitch (23) described a new species which he called juniperinus from flies reared on Juniperus virginiana in New York State. This was accepted by Phillips (27) as a valid species. The writer has not had an opportunity of studying the latter form, but the wing pattern as figured by Marcovitch (23) and Phillips (27) appears to resemble the form ribicola rather than tabellaria. Cresson (8) regards ribicola and juniperinus as synonyms of tabellaria. The writer has dissected and studied the male genitalia of one specimen of ribicola from Washington and considers it to be quite distinct from the specimen of tabellaria studied. A reference to figures 5 and 6 will indicate very distinct differences between these species in regard to the shape and length of the claspers and also the nature of the tip of the penis. It will be noted that there are marked differences in the size and shape of the ejaculatory apodemes in the two figures, but it would require a study of a long series of specimens to determine the value of this character and these are not available. However, there are such wide variations in these organs in all species where a

series was available for study that this character should be disregarded, at least until proven to be of value. On the basis of this examination the writer considers that tabellaria (Fitch) and ribicola Doane should both be regarded as distinct species.

Specimens examined were as follows: one specimen of tabellaria and one of ribicola from W. J. Brown, Entomological Branch, Ottawa; one specimen of ribicola from Mr. J. F. Gates Clarke, Pullman, Washington; one specimen of tabellaria from Dr. E. A. Chapin, U. S. Nat. Museum, Washington, D. C.

BIOLOGICAL STUDIES

Historical

Walsh (34) described Rhagoletis pomonella from specimens reared from apple and hawthorn and therefore, inferentially, he regarded them as being identical. Other authors, so far as can be determined by the literature, have not considered there were differences between the flies which pass their larval stages in the apple and those found in haws.

In addition to the apple and hawthorn, the following fruits have been reported as hosts: crab-apple, pears and plums; and Lathrop and Nickels (21) reared this species from the following plants found on blueberry barrens:

"Blueberries:
Vaccinium angustifolium Kalm (m.a.)
V. canadense Ait. (m.a.)
V. corymbosum L. (m.a.)

Bunchberry:
Cornus canadensis L. (m.a.)

Chokeberry:
Aronia melanocarpa (Michx.)
Britton (m)

Huckleberry:
Gaylussacia baccata (Want) C. Kock (m.a.)

Mountain Cranberry:
Vaccinium vitisidaea minus Lodd (m)

Dwarf Serviceberry:
Amelanchier bartramiana Roem. (m)

Wintergreen:
Gaultheria procumbens L. (m)

(m) indicates fruits in which maggots were found presumably R. pomonella. (a) indicates species from which adults were reared."

Whether or not these flies would change from one host to another has not been studied until recently, although several authors record observations on this point.

Illingworth (20) published a detailed account of investigational work on this species carried on at Cornell University in 1911 and 1912. He also gives a technical description of all stages of the insect and records data on distribution and host plants. O'Kane (25) gave comprehensive historical and distributional reports, as well as information on the known hosts.

Woods (35) succeeded in successfully transferring very small larvae from huckleberries and blueberries to the fruit of the chokeberry Pyrus melanocarpa, with the result that these individuals completed their development and pupated. He further observed that only in certain localized areas were blueberries infested with this insect; and that in many cases blueberries growing in the near vicinity of severely infested apple orchards showed no trace of the insect.

The same writer (ibid) failed to induce apple flies to oviposit in blueberries by confining them in cages on blueberries both in the field and laboratory. Attempts were made to transfer half-grown blueberry maggots to apples by inserting them beneath the skin; but these failed to develop. An attempt to induce flies taken on the blueberry

to oviposit in apples also proved abortive. He does not state whether or not he got flies reared on any fruit to oviposit in captivity on that fruit. Wood's (ibid) conclusion is quoted as follows:

"At any rate the writer is inclined very strongly to believe that biologically at least there are two distinct strains or races of Rhagoletis pomonella Walsh, the one breeding in the apple and related fruits and the other in small fruits such as the blueberry and huckleberry. There does not seem to the writer to be any other conclusion which will explain the data given above. Certainly in so far as Rhagoletis occurs in Maine, the form on apple and the form on the blueberry are entirely independent."

Similar observations and conclusions are recorded by Patch and Woods (26).

Porter (29) says "Whether the flies which infest the different fruits are all of the same species is open to serious question. The occurrence of the species in fruit of hawthorn in localities in which the apple is free or virtually free from attack, the reverse condition in other localities, the presence of maggots in blueberries in certain restricted areas and in huckleberries in others, and the distinctly different habits of the blueberry flies from the flies in the apple orchard, all point to the possibility that there may be several distinct

species, biological races, or incipient species, which at present cannot be distinguished from one another."

According to Porter (ibid) the earlier investigators found difficulty in inducing flies to oviposit in cages.

Lathrop and Nickels (21) encountered difficulty in rearing specimens in confinement and therefore they were unable to carry on cross breeding and other experiments in order to procure biological data on the relationship of the flies reared on different hosts. They were able to transfer first instar blueberry maggots to the apple and have them develop. From two hundred second instar blueberry maggots treated as above, about twenty developed to the pupal stage and one adult was obtained. These were normal in size for the blueberry form. Second instar apple maggots were transferred to blueberries and some of these formed puparia but no adults emerged. The puparia were normal in size for the apple form. They also state that each maggot consumed two or more blueberries during its development. Their concluding paragraph is quoted as follows: "It seems probable that the blueberry maggot and the apple maggot exhibit an example of incipient species formation, and from an ecological viewpoint the two forms seem distinct and independent."

In 1931 Fluke and Allen (14) reported on an investigation carried on in Wisconsin in which they secured ready mating and oviposition in cages by feeding a mixture of one to three per cent yeast in five per cent honey water. This greatly facilitated the ease with which investigations on these insects could be carried out.

McAlister and Anderson (24) working on the blueberry maggot in Maine used a modification of Fluke and Allen's method. They carried on interbreeding experiments and found mating occurring when virgin females reared on apple were caged with males reared on the blueberry. However, copulation was less frequent when reciprocal crosses were made. No maggots developed from the latter cross, but of the ten apple females used in crosses with blueberry males, seven deposited eggs in blueberries from which seventeen maggots hatched, fifteen of which matured and pupated.

Methods Used in Breeding Work

During the first two years a fairly satisfactory technique for handling the flies was worked out. This is described as follows:

In the summer heavily infested fields of blueberries were located and about the time the maggots began to emerge in numbers large quantities of these berries were picked for the purpose of obtaining flies for the following season's investi-

gations. The berries, in some cases, were spread out over the ground to a depth of one to two inches in a sheltered location and the maggots emerged from these and entered the soil to pupate. In other cases the berries were placed on soil in flats made with wire screen bottoms. These were set in the ground so that conditions would be as nearly normal as possible. Where virgin flies were needed for crossing experiments, the flats were removed to the insectary the next June; but where they were used in studying host relationships, wire cages constructed in a four-sided dome shape and covered with black cloth were placed over the soil or flats in which the puparia were located. On the top of the cage was placed a small removable wire screen cage. The flies were allowed to enter this as they emerged from the soil and a shutter made of a thin piece of board or a shingle was so arranged that the passageway between the large and small cages could be closed. This allowed for a removal of the small wire cage so that the flies could be removed from it; or it could be replaced by another without the loss of flies.

In the rearing of apple and hawthorn flies, heavily infested fruit was located in the autumn; and when the majority of the maggots were nearing maturity the fruit was gathered and taken to the insectary. Here they were placed in boxes having coarse wire bottoms which would keep the fruit in, but

would allow the maggots to pass through freely. Underneath these boxes flats, filled with ordinary fine garden soil, were placed. As soon as all the maggots had emerged from the fruit and entered the soil, the flats were set in the earth in a sheltered place, out of doors, and left there until the following June.

Just before it was time for the flies to begin to emerge, the pupae were washed out of the soil by floating them in water. They were then put in sand in wire cages made about six inches in diameter and eight inches high with wooden ends. These cages were covered with dark paper, and a three-quarter inch hole was made in the centre of the top end of each cage. A paper cone leading up to this, inside the cage, directed the flies toward the opening. A glass tube connected this cage with a small wire cage about 3" x 3" and constructed exactly as the larger ones, except that the wire screening was not covered. When the flies emerged they were attracted to the light and, consequently, crawled up into the smaller cage. These small cages were made with a three-eights inch glass tube in the upper end through which the flies might be fed. The flies were kept in the small cage until there were enough to take to the field; then the cage was removed and replaced by another.

Before any flies had emerged, clusters of fruits located in suitable situations and of susceptible varieties were selected and breeding cages placed over these. The breeding

cages were made of twenty meshes to the inch jappaned wire screening. A circular wood end made of pine about three-quarters of an inch thick formed one end. In this was bored two holes, one three-quarters of an inch in diameter for putting the flies into the cage, and the other three-eights of an inch with a glass tube just long enough to reach to the inside of the end and to project about one inch on the outer end; and through this the flies were fed. To the other end was attached a cotton sleeve. In the case of apples and hawthorns, the end of the limb on which the fruit to be covered was located was cut off just beyond the fruit, or in the case of small limbs, they were doubled back and the cages pulled up over the fruit and the cotton sleeve attached tightly to the limb above it. Usually another limb was tied to the first to prevent swaying and subsequent damage to the cage. The cages were placed so that they were fairly well protected and not exposed to too much direct sunlight. With the cages on blueberries great care had to be exercised in regard to the latter point. The cages were so close to the ground and the air moved through them so slowly, due to the protection afforded by the dense, low-growing vegetation, that a heavy mortality occurred during bright warm days unless a very appreciable amount of shade was provided.

When enough flies were procured from the emergence cages,

or from field collections, they were taken to the field cages in vials or in the small cages described above. In any case the flies were put into the cage through the large hole in the end. For transferring the flies to these from the small cages a piece of glass tubing about one and one-half inches long and of the proper diameter to fit into the hole in the end of each cage, was used to connect the two. The small cage was then covered with a piece of black paper or cloth and the flies would move toward the light and enter the larger cage. When they were all in, the small cage was removed and the opening in the breeding cage stoppered. This could be easily removed to permit more flies to be put in. Although this method of transferring flies to the field cages was fairly satisfactory, it proved very slow at times and in many cases the cotton sleeve was loosened and the small cage placed inside and allowed to remain there until feeding time the following day, when it would be removed.

During the first two years of the investigations the flies were fed according to Fluke and Allen's (14) formula. In 1933, however, the writer was informed by Mr. James Marshall, Assistant Entomologist, State College of Agriculture, Washington, that Dr. L. B. Ripley (30) working on the Natal fruit fly in South Africa had used cow's milk along with the Fluke and Allen mixture and had obtained excellent results.

Dr. Ripley's letter to Mr. Marshall is quoted in part as follows: "The Fluke-Allen food does not develop eggs in our females and mating very rarely occurs on this diet, but when it is made with 50% milk, egg production is much increased and mating fairly frequent in large cages."

As this information was originally given to the writer verbally, he was under the impression that the percentage of milk was five per cent instead of the fifty per cent as quoted above. Consequently the five per cent mixture was used with fairly satisfactory results, although the stronger mixture might have been better. The mixture used was five per cent honey, five per cent milk and two to three per cent yeast in distilled water. The feeding mixture was made up fresh before each feeding and the feeding was mostly done quite early in the day, usually between eight and ten o'clock, as it was observed that the flies appeared to feed more at that time. Small pieces of absorbent cotton were soaked in the feeding mixture and these were inserted into the glass tubes in the ends of the cages. New cotton was used at each feeding, the one used the previous day being removed and discarded.

In securing virgin flies for cross-mating experiments, the methods described above were followed until the time the pupae were washed from the soil. In order to isolate each

individual, five-eights inch holes were bored in two-inch planed hardwood planks. The holes were placed about half an inch apart each way so that several hundred were put in each plank. The planks were cut into pieces about four feet in length so they could be easily handled. Two or three thicknesses of blotting paper of the proper size to fit the holes were placed in the bottom of each. The pupae were placed one to each cell and a piece of fine wire screening put over the top of each and held in place by two tacks. The planks were covered with damp newspapers to hold the moisture and then stacked up in the insectary. Each morning all flies which had emerged during the previous twenty-four hours were removed and the cells containing pupae were moistened by a few drops of distilled water inserted into each cell with a medicine dropper. As the flies were removed they were examined and sorted according to sex and host plant and then placed in small wire cages like those described above, and fed. They were kept in the insectary until enough of each group had been accumulated to start a cage, when they were transferred to the field cages.

In the cross-breeding experiments the method followed was to put the females in cages on the host on which they developed as larvae. It was thought that if mating did occur the females would be more likely to oviposit in these than in

a fruit of some other species. Where males for the crosses were not available from reared material, they were collected from their host plants.

Observations were made each day on the flies in the cages and records kept of any data of interest such as the behaviour, copulation, egg-laying, and so forth.

When the flies were all dead, or when there was evidence that the fruit was likely to deteriorate rapidly, the cages were removed and the fruit either deposited over earth in wire cages, or placed in glass vials covered with cheesecloth. When the maggots had all left the fruit, the earth was sifted and the pupae counted. Later they were placed in earth and put in a protected place out-of-doors for further observation the following year.

The variety of apple used in the 1934 and 1935 investigations was the Bough Sweet. This is a soft, early, sweet variety, which is very susceptible to apple maggot attacks. Gravenstein was also used in the earlier investigations, but this variety is not so susceptible as Bough Sweet.

Breeding Investigations (1931-32-33)

At the time these investigations were initiated there was no definite information regarding the biological relationship of the flies developing on the apple, hawthorn and blueberry. In 1931 experiments were undertaken to find out if

the flies which had developed during their larval period in the fruits of one host could be induced to oviposit in another host and, if oviposition did take place, would larvae develop in the new hosts.

Since it was generally considered that the apple and hawthorn flies would cross from one host to the other fairly freely, the first experiments were to find out if the blueberry fly would oviposit and develop in apple; this being the more important economic problem in Nova Scotia.

The breeding work undertaken may be divided into two divisions: First, to find out if flies reared on one host would oviposit on any other host; and second, to determine if flies raised on different hosts would interbreed.

Transferring from One Host to Another

In 1931 a small Cox Orange apple tree, a variety susceptible to apple maggot attacks, at Morristown was entirely covered with a cheesecloth cage and made as tight as was possible. It was felt that if a large cage were used the flies would be more contented and would be more likely to oviposit. A large number of flies, approximately one hundred, consisting of both sexes, were gathered from blueberry bushes in an adjacent pasture and liberated in the cage. No attempt was made to feed these flies, as it was thought they would be

able to find sufficient food in such a large cage (approximately 12' x 12' x 10'). Although frequent examinations of the tree were made, none of the flies were ever observed and it was assumed that they either escaped or died. On trees nearby, blueberry flies were confined in cages similar to those described by Fluke and Allen (14) and they were fed on the yeast-honey-water mixture suggested by the last mentioned workers. The flies were fed daily and lived on the average from ten days to two weeks. None were ever observed to make any attempt to oviposit and the flies seemed restless in the cages. When the cages were removed no stings were visible on the apples and no maggots were found in the fruits.

In 1932 more extensive trials were carried out. Before any flies emerged, cheesecloth bags were placed over fruits of hawthorns, blueberries and susceptible varieties of apples. When flies began to appear on these different fruits in locations where they were plentiful, they were captured in fairly large numbers and placed in cages on the various hosts mentioned; that is, flies collected from each host plant were confined in cages on apple, hawthorn and blueberry. During this year a considerable amount of difficulty was encountered in getting the flies to live for any period of time. Some difficulty was experienced at first in getting wire fine enough to hold the smaller flies collected from the blueberry.

the wire at first used being ordinary jappaned wire screening, fourteen meshes to the inch. A twenty mesh per inch copper wire was procured, but the flies did not appear to live a normal period in these and it was thought that the copper must be toxic to them. Finally when a suitable type of wire was procured it was too late in the season to be of value that year. Difficulty was also experienced, especially in the cages on blueberry, in getting the proper amount of shade. If the cages were left too much exposed to the sun, a very warm day with bright sunshine would produce a high mortality. Similar observations have been reported by McAlister and Anderson (24). However, in spite of the difficulties encountered, the flies in cages on the host in which they developed as larvae appeared quite contented. Oviposition occurred, maggots developed,and puparia were formed. In only one did any crossing occur and that was in the case of the apple fly on the hawthorn; in one of these cages one maggot developed and formed a puparium.

The work carried on in 1933 proved to be, largely, a repetition of the 1932 results. The flies behaved normally in cages on the host plants in which they developed as larvae but no crossing occurred, and it appeared that if crossing did occur, it was so rare that it might be regarded as accidental. However, the economic importance of the problem was

so great that it was decided to carry on the work another year.

Results of Breeding Work (1934-35)

Table I shows the results obtained in the 1934 investigations. It is to be regretted that the data recorded was lacking in some respects, but it might be said also, that where there was any question as to the validity of data, it has been deleted.

It will be noted that eight out of the twelve cages gave negative results. Cage No. 1 contained flies which were collected in the adult stage from the leaves of the apple. These flies seemed to behave normally and the apples were heavily marked by egg-laying punctures. It will be noted that seventy-seven pupae were obtained.

Cage No. 2 contained flies which had developed as larvae in apples and had emerged from puparia in the insectary and were then transferred to the orchard. Why there was no oviposition here cannot be explained. It might be contended that the flies which emerged in the insectary were not as virile as those collected from the trees, but other data do not substantiate this, as the female apple flies used in Cage No. 3, emerged in the insectary. This latter cage included apple females and blueberry males and twenty-seven

TABLE I

Cage No.	Host	Host in Which Females Reared	Host in Which Males Reared	Where Emerged	No. Flies	Noted Mating	Noted Stings	Date Started	No. Pupae
1	Apple	Apple	Apple	Apple trees	--	--	Yes	Aug. 9	77
2	"	"	"	Insectary	--	--	No	--	0
3	"	"	Blueberry	Insectary (females)	--	Yes	Yes	--	27
4	"	"	Hawthorn	Insectary (females)	Small	--	No	--	0
5	"	Blueberry	Blueberry	Collecting cages	--	--	--	--	0
6	"	"	"	Bushes	--	--	No	--	0
7	"	Hawthorn	Hawthorn	"	--	--	No	--	0
8	Blueberry	Blueberry	Blueberry	"	24	--	--	--	21
9	"	"	"	Insectary	Small	--	No	--	0
10	"	"	Apple	"	5	--	No	--	0
11	"	Hawthorn	Hawthorn	Bushes	--	Yes	No	--	0
12	"	Apple	Apple	Apple trees	--	--	--	Aug. 9	6

pupae were obtained. This confirms the results of the work conducted in Maine by McAlister and Anderson (24). These flies appeared to behave in a normal way and lived a fairly long time, and mating was noted on several occasions. No results were obtained in cages where blueberry or hawthorn flies were placed on the apple.

Blueberry flies collected from the bushes oviposited in Cage No. 8 and twenty-one pupae were obtained. Blueberry flies which emerged in the insectary showed negative results in Cage No. 9, but the number of flies involved here was small. In Cage No. 12, apple flies collected from the trees oviposited in blueberries and six pupae were obtained. The flies in this cage appeared quite contented after being caged for a few days and they were frequently noted feeding on the surface of the berries. The number of pupae collected appeared small compared to the number of berries apparently infested; and it is felt that a number of larvae escaped before pupation, as three were found outside the cage. The report of McAlister and Anderson (24) is hereby confirmed, since it was the female apple flies which they got to oviposit in blueberries.

The results of the work on hawthorn are somewhat in doubt, since the fruits were not covered early enough to preclude all possibilities of them being infested, so that they may therefore be disregarded.

No adults emerged from the cross-bred puparia which were kept over the winter, but this is not regarded as significant, since those reared on their own hosts also failed to emerge. It is thought that environmental conditions during the winter may not have been normal.

Table 2 shows the results obtained in 1935. As more complete data were kept and since some of the observations made indicate some rather interesting points, the records on the individual cages are included in detail in the supplement attached hereto.

It will be noted that information on Cages Nos. 28 and 29 is missing; this is due to the unreliability of the data. Some of the points of interest to note are as follows: In Cage No. 10 on blueberry, apple flies collected from the trees gave one pupa. Cage No. 11 with similar flies on blueberry produced two pupae. All the crosses on these gave negative results, as did also flies reared on the hawthorn.

In Cage No. 5 it will be noted that in the cross between apple females and blueberry males, positive results were obtained and twenty-six pupae were collected, which further confirms the work of the previous year.

Cage No. 12 is probably the most interesting of all. Here it will be noted that blueberry males and females collected from the blueberry bushes produced fourteen pupae in

TABLE II

Cage No.	Host	Host in Which Females Reared	Host in Which Males Reared	Total No. Flies	Noted Mating	Noted Stings	Date Started	Date Removed	No. Pupae
1	Blueberry	Blueberry	Blueberry	92	Yes	No	July 15	Aug. 16	0
4&4a	"	Apple	Apple	200	No	Yes	" 20	" 20	0
7	"	Blueberry	"	62	Yes	No	" 20	" 19	0
8	"	"	Blueberry	49	--	--	" 22	" 19	11
10	"	Apple	Apple	35	--	Yes	" 24	" 19	1
11	"	"	"	44	--	Yes	" 24	" 19	2
13	"	Hawthorn	Hawthorn	114	--	Yes	" 26	" --	0
16	"	Blueberry	"	5	--	--	Aug. 1	" 19	0
17	"	Hawthorn	"	16	--	--	" 1	" 19	0
31	"	"	"	80	--	--	" 2	" 24	0
35	"	Blueberry	Blueberry	34	--	--	" 13	" 20	0
2	Apple	Blueberry	Blueberry	199	Yes	Yes	July 18	Aug. 20	0
3	"	"	"	181	Yes	Yes	" 20	Sept. 4	0
5	"	Apple	"	122	Yes	Yes	" 20	Aug. 28	26
6	"	"	Apple	170	Yes	Yes	" 20	" 20	42
9	"	"	"	20	Yes	Yes	" 24	" 20	16
12	"	Blueberry	Blueberry	52	--	Yes	" 25	" 28	14

TABLE II (continued)

Cage No.	Host	Host in Which Females Reared	Host in Which Males Reared	Total No. Flies	Noted Mating	Noted Stings	Date Started	Date Removed	No. Pupae
15	Apple	Apple	Hawthorn	30	Yes	Yes	Aug. 1	Sept.13	0 (1 dead larva)
33	"	Hawthorn	"	170	--	Yes	" 5	" 2	17
20	Hawthorn	Apple	Apple	275	Yes	Yes	July 24	" 13	17
21	"	"	"	77	Yes	Yes	" 24	" 13	9
22	"	Blueberry	Blueberry	114	Yes	Yes	" 25	" 13	0
23	"	Hawthorn	"	70	Yes	Yes	" 26	" 13	0
24	"	Apple	Apple	160	Yes	Yes	" 29	" 13	59
25	"	Hawthorn	"	63	Yes	Yes	Aug. 1	" 13	36
26	"	Apple	"	275	Yes	Yes	" 2	" 13	35
27	"	Hawthorn	Hawthorn	180	Yes	Yes	" 7	" 13	73
14	Pear	Apple	Apple	55	--	Yes	Aug. 1	Sept.13	3
18	"	"	"	166	--	Yes	" 1	" 13	0
32	"	"	"	140	Yes	Yes	" 5	" 13	0
19	Plum	Apple	Apple	235	--	(?)	Aug. 1	Sept.13	0
30	"	"	"	32	--	No	" 1	" 13	0
34	Chokecherry	"	"	140	--	--	" 7	Aug. 30	0

apples. This is the first time crossing in this direction has been recorded so far as the writer can determine.

In Cage No. 15 a cross between apple females and hawthorn males on apple gave only one larva, which was found dead in an apple.

In Cage No. 33 it will be noted that hawthorn flies which emerged in the insectary deposited eggs in apples and seventeen larvae developed and pupated.

Apple males and females on the hawthorn appeared to behave in a normal way and pupae were procured from cages which contained flies that emerged in the insectary, as well as those collected from apple leaves (Cages Nos. 20, 21, 24 and 26). Also it will be noted that in Cage No. 25, hawthorn females mated with apple males produced offspring; and thirty-six pupae were procured.

The blueberry males and females on hawthorn in Cage No. 22 failed to produce pupae, although evidence of stinging was quite distinguishable and the flies appeared to be quite contented and lived a goodly length of time. An interesting observation made in connection with these flies was that they appeared to have difficulty in penetrating the haws to deposit eggs; and it may be for this reason that no maggots or pupae were found. A similar observation was made in connection with the blueberry flies on apple, although in one cage they did manage to deposit eggs. In the cage containing

hawthorn females and blueberry males (No. 23) negative results were obtained.

Apple males and females were placed in cages on pear, plum and choke-cherry, Prunus virginiana L. In the latter two, negative results were obtained, although the plum is recorded as a host by a number of authors, and the writer has taken larvae from an unknown variety of very early soft plums in Nova Scotia. In one of the cages on pear (No. 14) where flies collected from apple leaves were used, three pupae were obtained. This confirms the observations of Porter (29) and others that larvae of this species are occasionally found in pears.

One interesting observation made in these studies was in connection with the relative activity of the flies on the various hosts. Woods (35), Patch and Woods (26) and Caesar and Ross (6) point out that apple flies are much more sluggish than those found on the blueberry. This is true to a certain extent, but then again the hawthorn flies are more active than are apple flies, and the writer found them more difficult to collect than blueberry flies. It was noted that apple and hawthorn flies could be observed and captured much more easily on a bright, calm day, but on such a day it was difficult to observe blueberry flies, and it is thought that the direct rays of the sun, especially in the middle of

the day, is too hot for them and they keep in the shade. They may be observed and captured more easily between eight and ten o'clock in the morning and from four to six o'clock in the afternoon. The ideal kind of a day to make observations on these flies, or to collect them, is a calm, dull, sultry day; and it was observed on more than one occasion that they could be taken with more ease than usual if an electrical storm was approaching.

It was found to be no more difficult to study the blueberry flies in the field, when one had learned their habits, than in the case of apple flies. When one is looking down into a mass of vegetation it is more difficult to make observations than when examining leaves which are somewhat removed from other vegetation, as with the apple, and the contrasts are much less sharp.

DISCUSSION OF RESULTS AND CONCLUSIONS

It is somewhat difficult to draw definite conclusions from the data obtained, since some of it is somewhat conflicting and not entirely clear-cut. However, as pointed out by Porter (29), negative results in breeding work are of no significance, since none of these flies were reared successfully in captivity until Fluke and Allen (14) worked out a satisfactory feeding mixture. Even with this information the writer did not get positive results in crossing from one host to another until milk was added to the diet, and one cannot predict what may happen with further work on diet and improved methods of handling and breeding.

The writer has made many field observations regarding the habits of these flies, which are not enumerated above, but which have been reported on by other authors. When one observes hawthorns absolutely free from maggots year after year growing within a few feet of apples or blueberries, which are very heavily infested, and vice versa, it is easy to see how the conclusion may be reached that there is some fundamental difference between these flies. However, since it has been possible in some cases, by using improved methods of feeding, to induce them to adopt hosts other than those on which they were reared, may it not be possible to obtain even more striking results if the proper environmental and dietary conditions

are found?

Rhagoletis pomonella (Walsh) has generally been considered as an insect with food habits approaching the monophagous condition; and various authors have referred to it as having "strains" or "forms" feeding on and developing in certain specific fruits.

Some writers, particularly Curran (9, 10, 11) regard the forms feeding in the blueberry and the snowberry as distinct species. After spending considerable time studying flies and larvae from the different fruits, the writer is of the opinion that only one distinct species is involved and that there is not sufficient evidence on the basis of biological or morphological interpretations, or both, to insure the presence of more than a single species. It would appear that a reasonable interpretation would be to regard Rhagoletis pomonella (Walsh) as an oligophagous insect, in which the "host selection principle" as enunciated by Hopkins (19), has become highly developed. This theory is quoted from Hopkins (ibid) as follows: "That an insect species which breeds in two or more hosts will prefer to continue to breed in the host to which it has become adapted." One of the first entomologists to record observations in this connection was Walsh (33), the describer of the species now under consideration. However, numerous experiments which indicate that this phenomenon is not of rare occurrence in insects have

been reported. Craighead (7) carried on investigations for six years with certain cerambycid beetles in the United States. Two of his conclusions are quoted here, since they appear to have a bearing on the point under discussion: (1) "In general, the fewer the hosts in nature, the more marked the predilection for a particular host, and vice versa"; (2) "Continued breeding in a given host intensified the preference for that host".

The work of Glendenning (16) in British Columbia on the satin moth, observations by Fryer (15) in connection with apple capsids, the work of Thorpe (32) on Hyponomeuta padella L. in England, and of Pictet (28) in France, as well as others of lesser importance, lend weight to this theory. Until such time as further investigations have disproved this hypothesis, it would appear to the writer a reasonable one to accept.

SUMMARY

1. The studies reported on in this paper are confined almost entirely to the genus Rhagoletis Loew and are composed of two sections; one dealing with the morphological relationships of a number of species and forms; and the other with the biological relationship of forms occurring in the species Rhagoletis pomonella (Walsh).

2. The morphological studies are confined largely to the male genitalia and it would appear that some of the interpretations made by a number of authors concerning the nature of these parts are faulty.

3. Rhagoletis mendax Curran and R. symphoricarpi Curran are regarded as synonyms of R. pomonella (Walsh).

4. Rhagoletis indifferens Curran is considered to be a synonym of R. cingulata (Loew).

5. The establishment of Rhagoletis completa Cresson as a distinct species is questioned.

6. It is suggested that Rhagoletis ribicola Doane should be established as a distinct species, but sufficient specimens were not available to study a series in this species, nor in the closely related R. tabellaria (Fitch).

7. The biological studies of Rhagoletis pomonella (Walsh) indicate that there are no definite biological differences in the forms developing as larvae in the apple, the hawthorn and the blueberry.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the assistance and advice received from Drs. W. H. Brittain and M. E. DuPorte of Macdonald College, McGill University, under whose direction this thesis has been prepared. Especial mention should be made of the painstaking assistance received from Messrs. S. V. Nichols and M. E. Neary in carrying out the breeding investigations. The Nova Scotia Department of Agriculture has cooperated in making it possible for the writer to spend a considerable amount of time on this project. The assistance of those mentioned, as having donated or loaned specimens, is also greatly appreciated.

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EXPLANATION OF PLATE I

All figures of male genitalia drawn to the same scale.

Fig. 1. Rhagoletis pomonella (Walsh) (apple form).

Fig. 2. Rhagoletis pomonella (Walsh) (hawthorn form).

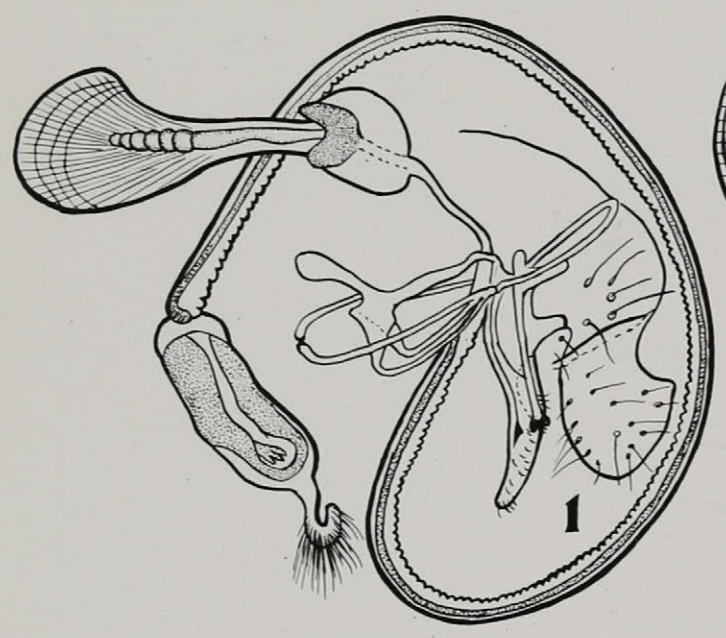
Fig. 3. Rhagoletis pomonella (Walsh) (blueberry form).

Fig. 4. Rhagoletis pomonella (Walsh) (snowberry form).

Fig. 5. Rhagoletis tabellaria (Fitch).

Fig. 6. Rhagoletis ribicola Doane.

PLATE 1.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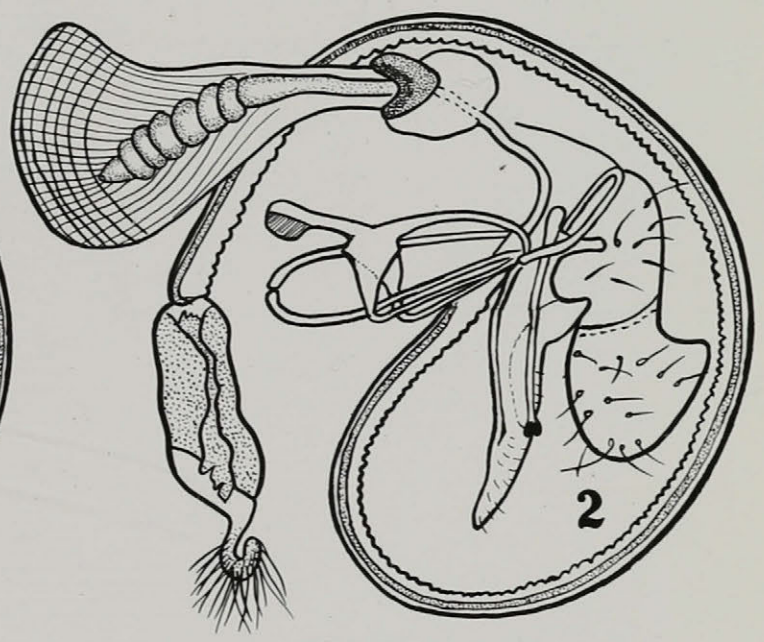
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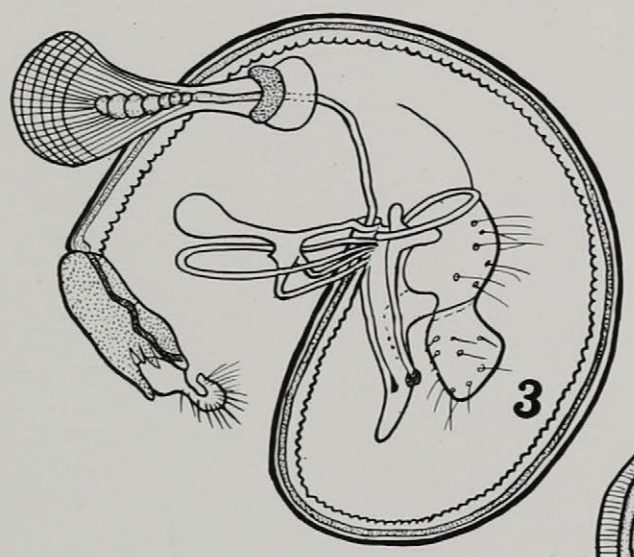
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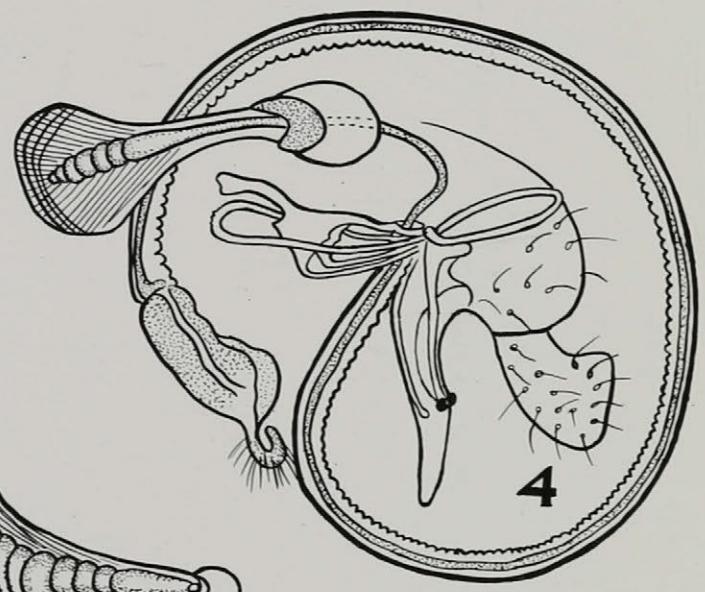
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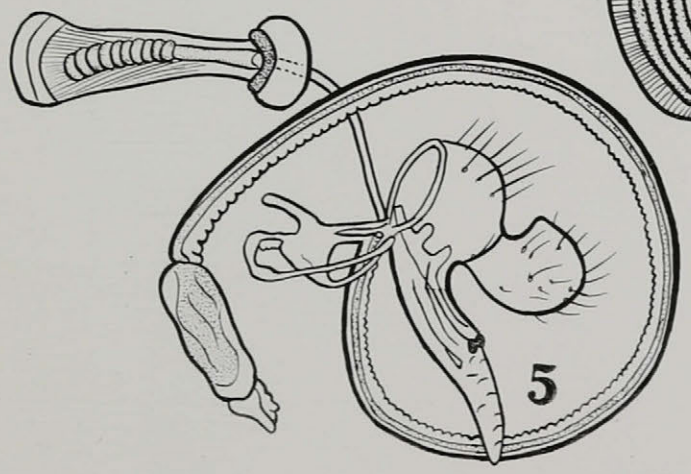
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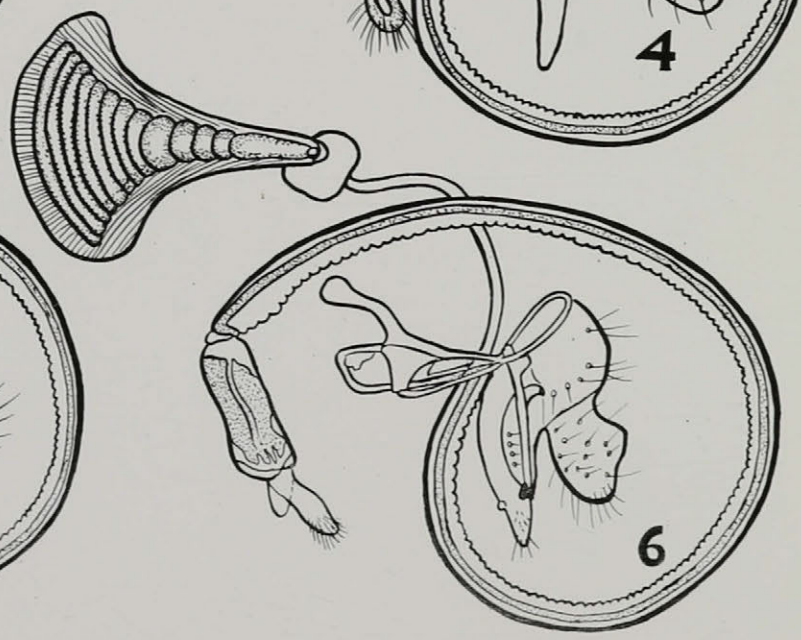
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EXPLANATION OF PLATE 2.

All figures of male genitalia drawn to same scale.

Fig. 7. Rhagoletis cingulata (Loew) (cultivated cherry).

Fig. 8. Rhagoletis cingulata (Loew) (wild cherry).

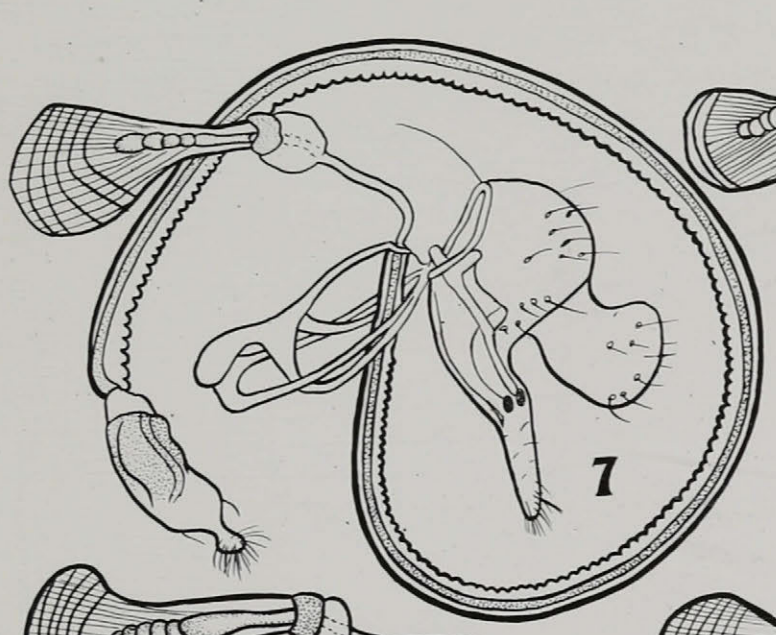
Fig. 9. Rhagoletis berberis Curran.

Fig.10. Rhagoletis fausta (Osten-Sacken).

Fig.11. Rhagoletis suavis (Loew).

Fig.12. Rhagoletis completa Cresson.

PLATE 2.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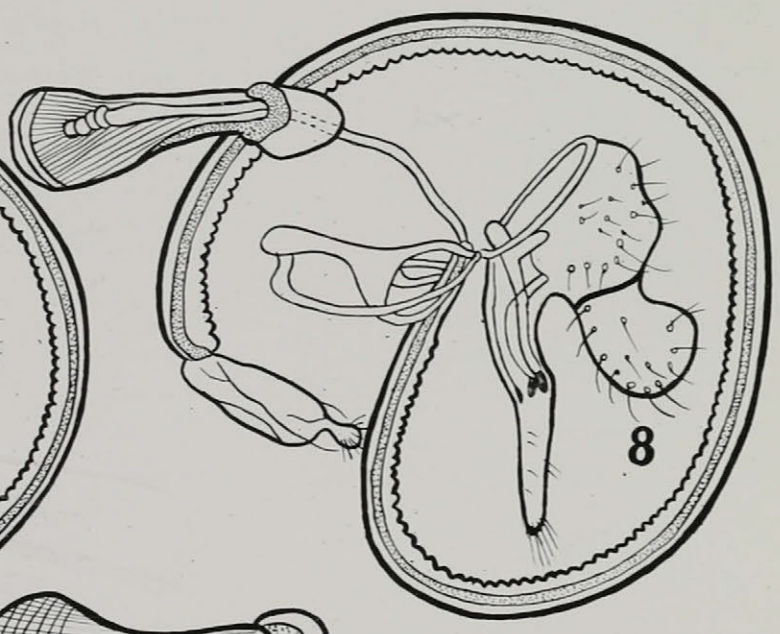
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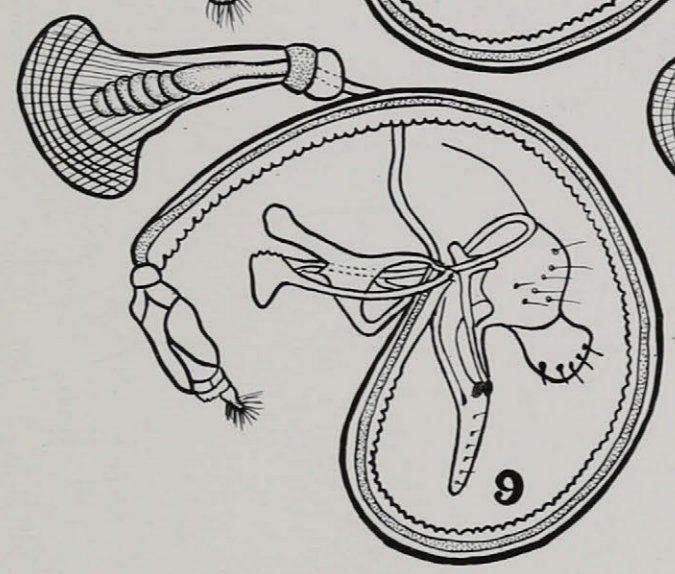
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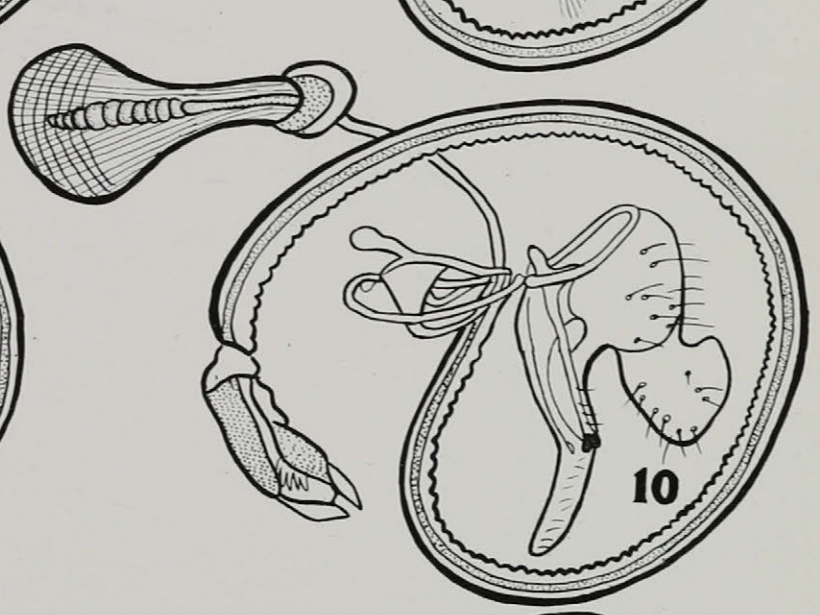
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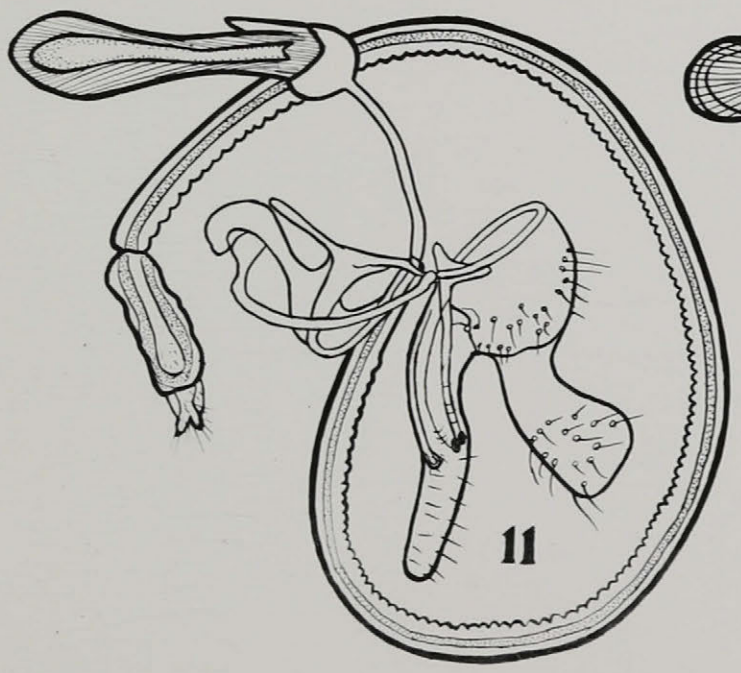
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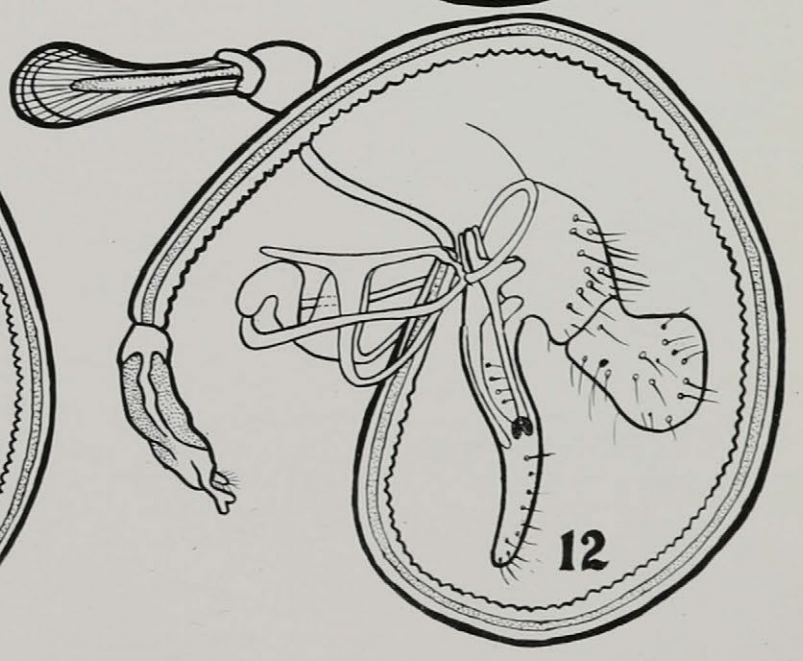
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EXPLANATION OF PLATE 3.

Fig. 13. Male genitalia of Epochra canadensis Loew.

a. Ejaculatory apodeme
b. penis
c. penis tube
d. claspers.

Figs. 14-25. Claspers of Rhagoletis pomonella (Walsh).

Fig. 14. Right clasper of hawthorn form (latero-medial aspect)

Fig. 15. " " " apple " (" " ")

Fig. 16. " " " snowberry " (" " ")

Fig. 17. Posterio-lateral aspect of clasper shown in Fig. 16.

Figs. 18-20. Right claspers of blueberry form showing variations in apex.

Fig. 21. Clasper of apple form showing three hooks.

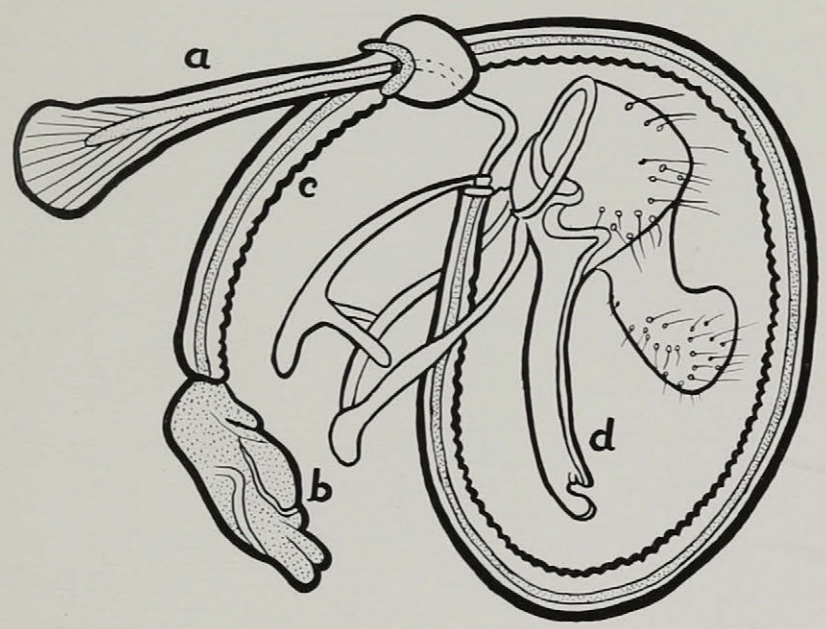
Fig. 22. Clasper of apple form showing shape of lobe opposite hooks.

Fig. 23. Clasper of snowberry form showing shape of lobe opposite hooks.

Fig. 24. Posterior aspect of clasper of apple form showing hooks and lobe.

Fig. 25. Posterior aspect of clasper of snowberry form showing hooks and clasper.

PLATE 3.



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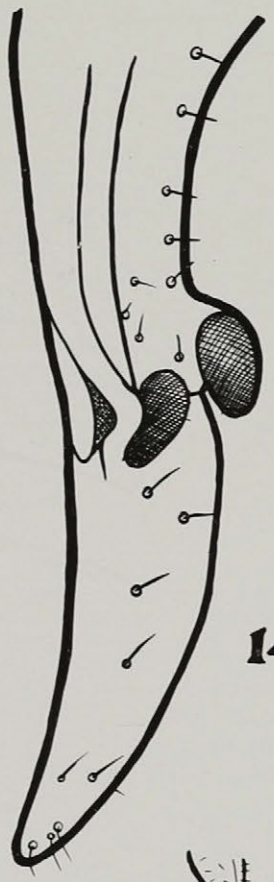

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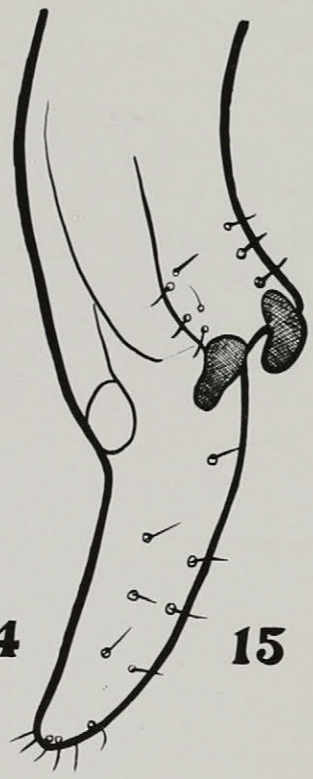

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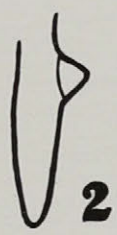

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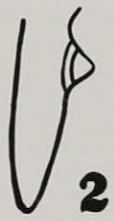

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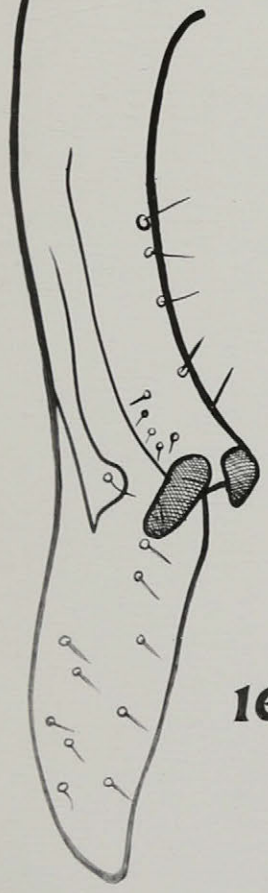

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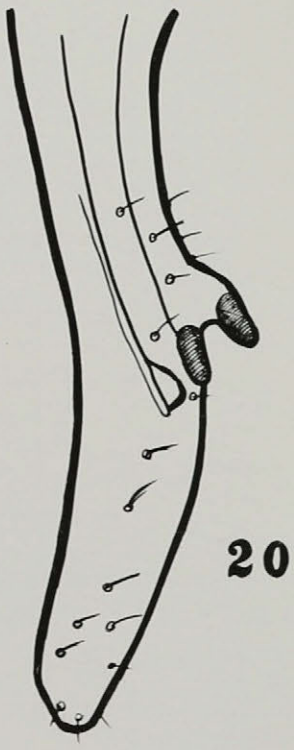

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S U P P L E M E N T

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 1 Host - BLUEBERRY Place - MORRISTOWN

Females reared on BLUEBERRY. Males reared on BLUEBERRY.

Place collected CAGE. Date of placing flies in cage JULY 15/35.

No. of flies put in cages and dates:

July	15	7 flies
"	16	17 "
"	17	68 "

Stings first appeared -

No. of pupae collected - 0. Date of removal - AUG. 16/35.

Observations and notes:

July 22 - first dead noted; first mating noted.

August 1st - noted only a few flies in cage, lately.

August 12th - collected most of the mature berries from this cage. Some berries had the soft texture of containing maggots.

August 15th - One live male fly noted in cage.

August 16th - No live flies could be located so the cage was removed and the berries collected to be deposited for pupae.

It will be noted that the flies in the above cage disappeared rather quickly. The wooden end of the cage shrunk on being exposed and made a space between the screening and the wood which may account for some of the flies disappearing.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 2. Host - APPLE Place - MORRISTOWN

Females reared on BLUEBERRY. Males reared on BLUEBERRY.

Place collected CAGE. Date of placing flies in cage JULY 18/35.

No. of flies put in cages and dates.

July	18	80 flies
"	19	59 "
"	20	60 "

Stings first appeared - JULY 25th.

No. of pupae collected - 0. Date of removal AUGUST 20/35.

Observations and notes:

First dead noted July 23; first mating noted July 23.

July 25 - Observed marks resembling stings.

July 29 - Took branch out of cage and examined marks under hand lens. The marks appeared to be definite stings, located about mid-way down the side of a lower apple.

August 16 - Two flies still alive in cage. Heavy mortality of flies during the last week.

August 19 - No live flies could be seen.

August 20 - Removed cage and deposited apples over earth for pupae collection.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 3 Host - APPLE Place - MORRISTOWN

Females reared on BLUEBERRY. Males reared on BLUEBERRY. Place collected INSECTARY. Date of placing flies in cage JULY 20/35. No. of flies put in cages and dates:

July	20	90 flies
"	24	45 "
"	26	31 "
"	29	15 "

Stings first appeared - JULY 26th.

No. of pupae collected - 0. Date of removal - SEPTEMBER 4th.

Observations and notes:

July 23 - first mating noted.

July 26 - Marks on fruit noted which resembled stings, located on the under half of the apple.

August 10 - Heavy mortality of flies noted of late.

August 19 - No live flies could be noted.

September 4 - Removed apples which were still very firm. Quite a number of marks appeared on the skin which resembled stings very closely, but the fruit was rather too firm to contain maggots.

October 29 - Apples were still whole and solid in flesh. No traces of maggot work could be found on breaking the fruit open.

FRUIT FLY EXPERIMENTS - 1935

CAGE No. 4 & 4A Host - BLUEBERRY Place MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - JULY 20/35. No. of flies put in cage and date:

July 20th 200 flies

Stings first appeared - JULY 25th

No. of pupae collected - 0. Date of removal - AUGUST 20th.

Observations and notes:

July 26 - Noted females ovipositing in berries.

July 29 - Moved flies with cage to another covered bush to make Cage 4A as the berries in cage 4 appeared to be severely stung. Covered cage 4 bush with another cage. Eight flies remained in cage 4 bush. Flies lived approximately a week without being fed. However, there would be quite a collection of dried food on the bush from the drippings from the tube previously.

July 10 - Removed cage and bush of cage 4. Collected most of the mature berries from cage 4A; quite a large number of active flies still in cage 4A.

July 20 - Found flies all dead and removed cage. The extreme temperature of from 90° to 100° in the shade apparently has caused a very heavy mortality in all cages on the blueberry.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 5 Host - APPLE Place - MORRISTOWN

Females reared on APPLE. Males reared on BLUEBERRY. Place collected INSECTARY. Date of placing flies in cage JULY 20/35. No. of flies put in cages and dates:

July 20	8 males
" 20	20 females
" 23	35 females
" 23	11 males
" 26	11 females
" 29	25 males (bushes)
" 30	12 males "

Stings first appeared JULY 26th.

No. of pupae collected - 26. Date of removal AUGUST 28th.

Observations and notes:

July 26 - Noted marks resembling stings.

July 27 - Additional marks like stings.

July 29 - Several additional marks which are quite definite stings.

August 1 - Observed female stinging fruit.

August 2 - Additional stings, showing as time goes on.

August 6 - Very common to note pairs mating, especially since males were added from the bushes. New stings continue to show.

August 10 - Fruit well stippled with stings.

August 12 - Quite a few dead flies in bottom of cage, particularly males; quite common to note mating.

CAGE NO. 5 (continued)

August 28 - Removed the apples as they were completely honey-combed by maggot work; as a few flies remained alive a fresh apple was added.

August 31 - Noted some well defined stings on the apple added from outside.

September 4 - More stings have appeared until the surface is being quite well perforated.

September 13 - Removed cage to deposit the added apple over earth. Several areas were breaking down on the surface as if covering maggot work.

October 29 - Two pupae were collected from the apple added from outside.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 6 Host - APPLE Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage JULY 20/35. No. of flies put in cages and dates:

July 20 170

Stings first appeared - JULY 23rd.

No. of pupae collected - 42. Date of removal - AUGUST 20th.

Observations and notes:

July 23- First mating noted.

" 25 - First female noted in act of ovipositing.

August 10 - Fruit completely perforated with stings. Still common to note mating.

August 16 - Quite a heavy mortality of flies taking place the past few days which has been extremely hot and dry.

August 20 - Flies all dead and removed cage. First pupae were noted.

The extreme heat of the past week apparently has made a quick finish to flies nearing the age limit.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 7. Host - BLUEBERRY Place - MORRISTOWN

Females reared on BLUEBERRY. Males reared on APPLE. Place collected INSECTARY. Date of placing flies in cage - JULY 20/35. No. of flies put in cages and dates:

July	20	15 females
"	20	9 males
"	24	15 males
"	24	3 females
"	26	2 females
"	26	18 males

Stings first appeared -

No. of pupae collected - 0. Date of removal - AUGUST 19th.

Observations and notes:

August 2nd - Noted a pair copulating.

" 12 - Collected most of the mature berries from the cage.

August 12 - Noted 15 males alive and active but no females were to be seen.

August 19 - No live flies. Removed cage and branch to deposit the fruit for pupae.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 8 Host - BLUEBERRY Place - MORRISTOWN

Females reared on BLUEBERRY. Males reared on BLUEBERRY.

Place collected CAGES. Date of placing flies in cage JULY 22/3

No. of flies put in cages and dates:

July	22 & 23	36 flies
August	14	3 flies
"	15	2 "
"	16	2 "
"	19	2 "
"	20	4 "

Stings first appeared -

No. of pupae collected - 11. Date of removal - AUGUST 19/35.

Observations and notes:

August 2 - Only a few flies noted in cage.

August 12 - One male and one female noted in cage. About ten days ago the wooden end of the cage was discovered to have shrunken away from the wire sufficiently to make an easy exit for the flies; as the population appeared to diminish rather too quickly it is felt that many escaped. Probably some will be added if available from the cages.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 9. Host - APPLE Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected ANNAPOLIS. Date of placing flies in cage JULY 24/35. No. of flies put in cages and dates:

July 24th 9 females

" 24th 11 males

Stings first appeared - JULY 25th

No. of pupae collected - 16. Date of removal - AUGUST 20/35.

Observations and notes:

July 25th - First female noted in act of ovipositing.

August 1st - Many stings on fruit.

August 5th - Apples well perforated with stings.

August 12th - Only a few flies still alive in cage, but copulation continues at this late date.

August 17th - No live flies.

August 20th - Maggot was noted working out of an apple. Fruit is well perforated with stings.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 10. Host - BLUEBERRY Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected ANNAPOLIS. Date of placing flies in cage JULY 24th. No. of flies put in cages and dates:

July 24 16 females

" 24 19 males.

Stings first appeared - JULY 25th.

No. of pupae collected - 1. Date of removal AUGUST 19/35.

Observations and notes:

July 25 - Noted females ovipositing in berries.

August 12 - Collected most of the berries from this cage. Only a few flies alive.

August 17 - No live flies noticeable.

August 19 - Removed cage to deposit berries.

August 21 - Opened a blueberry which contained a maggot.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 11. Host - BLUEBERRY Place - MORRISTOWN

Adult females reared on APPLE. Males reared on APPLE. Place collected ANNAPOLIS. Date of placing flies in cage - JULY 24. No. of flies put in cages and dates.

July 24 21 females

" 24 23 males

Stings first appeared -

No. of pupae collected - 2. Date of removal AUGUST 19th.

Observations and notes:

July 26 - Noted two females in act of stinging fruit.

August 12 - Removed most of the berries from this cage; very few flies alive on this date.

August 19 - No live flies evident and removed cage to deposit berries.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 12 Host - APPLE Place - MORRISTOWN

Females reared on BLUEBERRY. Males reared on BLUEBERRY. Place collected BLUEBERRY BUSHES. Date of placing flies in cage JULY 25th. No. of flies put in cages and dates:

July	25	8 females
"	25	13 males.
"	29	7 females
"	30	5 females
Aug.	3	3 females
"	3	2 males
"	12	6 females
"	12	8 males

Stings first appeared - JULY 29 (sting like marks).

No. of pupae collected - 14. Date of removal - AUGUST 28th.

Observations and notes:

August 5th - Noted female in act of stinging an apple. The location was on the underside of the apple and near the apex. The process of boring was underway when noted and continued under observation for approximately five minutes in a very vigorous fashion. The abdomen appeared to raise and lower the full length of the ovipositor about two-thirds of the time. It appeared to make considerable more effort than the apple maggot fly when ovipositing.

August 28th - Apples were very ripe so were removed. Quite a number of definite stings showed on the skin. A section was broken out and a practically fully grown maggot was discovered in a well excavated chamber.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 13 Host - BLUEBERRY Place - MORRISTOWN

Adult female reared on HAWTHORN. Males reared on HAW-THORN. Place collected INSECTARY. Date of placing flies in cage JULY 26/35. No. of flies put in cage and dates:

July	26	6 females
"	26	8 males
"	29	13 females
"	29	17 males
Aug.	1	14 females
"	1	16 males
"	20	40 males & females

Stings first appeared - JULY 29th (green berries)

No. of pupae collected - 0. Date of removal -

Observations and notes:

July 29th - Observed several green berries bearing marks that resembled stings very closely. Due to the thin skin and color of the ripe blueberry the stings of the fruit fly are very difficult to determine even when observing the surface after seeing a female in the act of ovipositing.

August 17th - Heavy mortality in the population the past few days.

August 19th - Only a few flies remain alive. Practically all ripe berries were removed.

August 20th - Flies were added to this cage as it enclosed a late variety which still has a few green berries.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 14 Host - PEAR (Clapps Favorite) Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected ANNAPOLIS. Date of placing flies in cage - AUGUST 1st. No. of flies put in cages and dates:

August 1st - 30 females

" 1st - 25 males

Stings first appeared - AUGUST 11th.

No. of pupae collected - 3. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 11th - Definite stings noted about two-thirds distance down the side of a pear.

August 17th - More marks have shown up of late which resemble stings. Quite a heavy mortality during the prevailing high temperatures.

September 4th - Two flies remain alive.

September 13th - Two flies found alive. A maggot was observed on breaking a pear open after removing cage at this date.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 15 Host - APPLE Place - MORRISTOWN

Female reared on APPLE. Males reared on HAWTHORN. Place collected INSECTARY. Date of placing flies in cage AUGUST 1st. No. of flies put in cages and dates:

August 1st 9 females
" 7th 5 "
" 7th 16 males

Stings first appeared - AUGUST 16th.

No. of pupae collected - 1 MAGGOT (dead). Date of removal - SEPT. 13th.

Observations and notes:

August 12 - Noted pair of flies copulating.

August 16 - Two marks resembling stings noted.

September 4 - A few flies are still alive.

September 13 - Removed cage to deposit apples over earth.

September 8 - Three flies were noted alive.

FRUIT FLY EXPERIMENTS - 1935

CAGE No. 16 Host - BLUEBERRY Place - MORRISTOWN

Female reared on BLUEBERRY. Males reared on HAWTHORN. Place collected INSECTARY. Date of placing flies in cage AUGUST 1/35. No. of flies put in cage and dates:

August 1st 2 females

" 1st 3 males

Stings first appeared -

No. of pupae collected - 0. Date of removal AUGUST 19th.

Observations and notes

August 12th - Two flies still alive in cage.

August 19th - No live flies present. Cage was removed to deposit berries for pupae.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 17 Host - BLUEBERRY Place - MORRISTOWN

Females reared on HAWTHORN. Males reared on HAWTHORN.

Place collected FALMOUTH. Date of placing flies in cage AUG. 1/35. No. of flies put in cage and dates:

August	1st	5 females
"	1st	1 male
"	7th	5 females
"	7th	5 males
"	10th	5 females
"	10th	1 male
"	16th	4 females
"	11th	4 females

Stings first appeared -

No. of pupae collected - 0. Date of removal AUGUST 19/35.

Observations and notes:

August 17th - Very few flies noted.

August 19th - Collected the berries to deposit for pupae.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 18 Host PEAR (Clapps Favorite) Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage AUGUST 1st. No. of flies put in cages and dates:

August 1 - 136 males and females

" 20 - 30 males and females

Stings first appeared - AUGUST 8th.

No. of pupae collected - 0. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 8th - Marks resembling stings on shady side of pear.

August 20th - A few more marks resembling stings can be noted.

September 4th - Several flies remain alive.

September 8th - Three flies remain alive.

September 13th - Removed cage and noted two flies alive. Pears had many marks but no maggots. Work could be noted on breaking fruit open.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 19 Host - PLUM Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - AUGUST 1st. No. of flies put in cages and dates:

August 1st 135 males and females

16th 100 males and females

Stings first appeared -

No. of pupae collected - 0. Date of removal - SEPTEMBER 13th.

Observations and notes

August 10th - Common to note mating.

August 16th - It is very unusual to note flies resting on the plums. They appear to confine themselves to the cage and foliage.

August 30th 0 Noted two marks on the side of a plum which may be stings.

September 13th - Noted 3 flies alive and active. Removed cage to deposit plums over earth. Some marks about the size of stings developed on the skin of the plums, but none could be classed as definite stings.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 20 Host - HAWTHORN Place - FACTORYDALE

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - JULY 24th. No. of flies put in cage and dates:

July 24th 175 flies

" 26th 100 flies

Stings first appeared - AUGUST 1st (Sting like mark on fruit).

No. of pupae collected - 17. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 9th - Observed a female stinging fruit. Made several attempts at boring through the skin. Sting like marks on haws are quite plentiful.

August 15th - Common to note mating.

August 26th - Common to note mating.

September 1st - The haws of the particular variety that the hawthorn cages are set on have turned so that the fruit is completely reddish in color. Other varieties of the hawthorn nearby are still very green and much smaller in size.

September 4th - Quite a number of live flies.

September 13th - Removed cage and deposited haws over earth.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 21 Host - HAWTHORN Place - FACTORYDALE

Females reared on APPLE. Males reared on APPLE.

Place collected ANNAPOLIS. Date of placing flies in cage - JULY 24th. No. of flies put in cages and dates:

July 24th	20 females
" 24th	37 males
August 9th	10 females
" 9th	10 males

Stings first appeared - AUGUST 1st (Several sting like marks on fruit).

No. of pupae collected - 9. Date of removal - SEPTEMBER 13th.

Observations and notes;

August 9th - Observed female stinging fruit. Appeared to have difficulty in piercing outer skin as several locations and haws were tried in attempting to oviposit.

August 9th - Stings on fruit are numerous.

August 15th - Common to note mating.

August 20th - All flies in cages on the hawthorn appear to withstand the high temperatures that are prevailing remarkably well, apparently the quite dense foliage of the hawthorn gives good protection. Also the flies on the hawthorn are practically all much younger than on the apple or blueberry.

August 27th - Noted mating.

September 4th - A few flies still alive.

September 13th - Removed cage and deposited haws over earth. Haws quite severely stung but very firm. One fly was noted alive and active.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 22 Host - HAWTHORN Place - FACTORYDALE

Females reared on BLUEBERRY. Males reared on BLUEBERRY. Place collected CAGES. Date of placing flies in cage - JULY 25, 1935. No. of flies put in cage and dates:

July 25	52 males and females
" 26	25 males and females
" 27	15 males and females
" 29	10 males and females
August 5	12 males and females

Stings first appeared - AUGUST 1st

No. of pupae collected - 0. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 9th - Marks showing on haws resembling stings. Noted female stinging fruit; she appeared to have difficulty in breaking the surface as several attempts were made at various locations and on several fruits. Another female was noted to make several attempts but finally worked out of vision.

August 14th - Observed three different females stinging fruit. Two of them made several attempts in different locations and finally flew out of vision; the third female remained boring in one location as if quite successful.

August 15th - Haws are beginning to show a reddish tinge.

August 28th - Noted two pairs mating. This is still a common occurrence.

September 1st - About a dozen flies noted alive.

September 8th - Three flies noted alive and active.

CAGE NO. 22 (continued)

September 13th - No live flies noted. Removed cages and deposited haws over earth.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 23 Host - HAWTHORN Place - FACTORYDALE

Females reared on HAWTHORN. Males reared on BLUEBERRY. Place collected GIVEN BELOW. Date of placing flies in cage JULY 26/35. No. of flies put in cage and dates:

July	26th	7 females	(from Insectary)	
"	26th	15 males	(from blueberry bushes)	
"	29th	5 males	"	" "
"	31st	13 females	"	" "
August	3rd	7 males	"	" "
"	5th	11 females	"	" "
"	9th	6 females	"	" "
"	15th	6 males	"	" "

Stings first appeared - AUGUST 28th.

No. of pupae collected - 0. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 14th - Noted pairs of flies copulating.

August 28th - Noted many sting-like marks.

September 4th - Noted two male flies and at least a dozen females. Fruit quite severely stung.

September 13th - Removed cage and deposited haws over earth. Five females were found alive and active. Haws well stung and very firm.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 24 Host - HAWTHORN Place - FACTORYDALE

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - JULY 29th. No. of flies put in cage and dates:

July 29th 100 males and females

" 31st 60 males and females

Stings first appeared - AUGUST 19th.

No. of pupae collected - 59. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 19th - Still common to note copulation. Many sting-like marks on fruit.

August 27th - Copulation still occurring.

September 4th - Quite a number of flies still alive.

September 13th - Removed cage and deposited the haws over earth. Eleven flies were found to be alive and active. Fruit has been very severely stung but still is hard and firm. One haw was noted to have a hole like that which would be made by the emergence of a larva.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 25 Host - HAWTHORN Place - FACTORYDALE

Females reared on HAWTHORN. Males reared on APPLE.

Place collected GIVEN BELOW. Date of placing flies in cage - AUGUST 1st, No. of flies put in cage and dates:

August	1st	20 males (Annapolis)
"	7th	3 females (Insectary)
"	9th	20 males (Annapolis)
"	16th	10 females (Insectary)
"	20th	10 females (Insectary)

Stings first appeared - AUGUST 27th.

No. of pupae collected - 36. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 20th - Noted pair of flies copulating.

August 27th - Noted several sting like marks on fruit.

September 4th - Noted three males and at least a dozen females.

September 13th - Removed cage and deposited haws over earth. Thirteen flies were found alive and active, six of which were males. Haws were well stung but still very firm. This cage enclosed 132 haws which is about the average number in each cage.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 26 Host - HAWTHORN Place - FACTORYDALE

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - AUGUST 2nd. No. of flies put in cages and dates:

August 2nd 275 males and females

Stings first appeared - AUGUST 20th.

No. of pupae collected - 35. Date of removal SEPTEMBER 13th.

Observations and notes:

August 20th - Common to note copulation. Many marks on haws which resemble stings.

August 28th - Very common to note mating.

September 4th - Noted a pair of flies copulating. Quite a number of flies alive.

September 13th - Removed cage and deposited haws over earth. Haws severely stung and very firm. Twenty flies were found to be alive and active.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 27 Host - HAWTHORN Place - FACTORYDALE

Females reared on HAWTHORN. Males reared on HAWTHORN. Place collected INSECTARY. Date of placing flies in cage - AUGUST 7th. No. of flies put in cage and dates:

August 7th 75 males and females
" 10th 30 males and females
" 16th 75 males and females

Stings first appeared - AUGUST 19th.

No. of pupae collected - 73. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 19th - Observed female stinging fruit. The piercing operations appeared to be quite an effort and took about thirty seconds to complete.

August 28th - Still common to note mating. Fruit quite well perforated with sting marks.

September 4th - Noted pair copulating. Quite a large number of flies still alive.

September 13th - Fruit is very heavily stung but haws appear very firm; two had holes as if larvae had emerged from them. Forty flies were noted to be alive and active.

Cage nos. 28-29 not mentioned in thesis.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 30 Host - PLUM Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected ANNAPOLIS. Date of placing flies in cage - AUGUST 1st. No. of flies put in cages and dates:

August 1st 12 females

" 1st 20 males

Stings first appeared -

No. of pupae collected - 0. Date of removal - SEPTEMBER 13th.

Observations and notes

August 17th - Heavy mortality during the high temperatures prevailing of late, especially in cages where the flies are near the age limit. The cages on the plum are situated in the center of the tree and well shaded on all sides. The reduction in flies appears to approximate those on the outside with ordinary shade.

August 20th - No live flies could be noted.

September 13th - Removed cage to deposit plums over earth. No definite sting marks could be noted. The fruit was very firm.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 31 Host - BLUEBERRY Place - MORRISTOWN

Female reared on HAWTHORN. Males reared on HAWTHORN. Place collected INSECTARY. Date of placing flies in cage AUGUST 2nd. No. of flies put in cage and dates:

August 2nd - 80 males and females

Stings first appeared -

No. of pupae collected - 0. Date of removal AUGUST 24th.

Observations and notes:

August 19th - Cage was well shaded but the flies have dropped off very rapidly during the past few days. No live flies could be located today.

August 24th - Removed the cage.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 32 Host - PEAR (Bartlett) Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - AUGUST 5th. No. of flies put in cages and dates:

August 5th 140 males and females

Stings first appeared -

No. of pupae collected - 0. Date of removal - SEPTEMBER 13th.

Observations and notes:

August 12th - Marks noted which resemble stings

August 19th - Quite a heavy mortality the past few days.

August 25th - Quite a number of fine marks which may be stings.

September 4th - A few flies are still alive.

September 8th - Pair of flies were noted copulating.

September 13th - Removed cage. Seven flies were noted alive and very active; numerous sting-like marks found, particularly near the stem portion. Fruit was very hard at time of removal.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 33 Host - APPLE Place - MORRISTOWN

Female reared on HAWTHORN. Males reared on HAWTHORN. Place collected INSECTARY. Date of placing flies in cage AUGUST 5th. No. of flies put in cages and dates:

August 5th - 125 males and females

" 13th - 45 males and females

Stings first appeared - AUGUST 15th

No. of pupae collected - 17. Date of removal - SEPTEMBER 2nd.

Observations and notes:

August 15th - Noted a few marks which resemble stings very much.

August 16th - Had the good fortune to observe a female in the act of stinging an apple. The location was in deep shade on the high cheek of the fruit. About 30 seconds completed the act.

August 19th - More marks resembling stings.

August 28th - Removed one of the apples as it had split open and was decaying. Quite a number of well defined stings were noted on the skin. A corner was broken open and the brown roads of a maggot were noted.

September 2nd - Removed the remaining apple which had dropped to the bottom of the cage. As quite a number of flies remained alive another apple was added from outside. Quite a

CAGE NO. 33 (continued)

number of well defined stings perforated the skin of the apple just removed.

September 13th - Removed the cage and noted five flies alive and active.

October 29th - 17 pupae were found.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 34 Host - CHOKECHERRY Place - MORRISTOWN

Females reared on APPLE. Males reared on APPLE.

Place collected INSECTARY. Date of placing flies in cage - AUGUST 7th. No. of flies put in cage and dates:

August 7th 140 males and females

Stings first appeared -

No. of pupae collected - 0. Date of removal - AUGUST 30th.

Observations and notes

August 16th - Flies appear quite at home on the fruit and common to see them feeding on the surface.

August 30th - As the fruit was very soft and only a few flies remained alive, this cage was removed and the fruit deposited.

FRUIT FLY EXPERIMENTS - 1935

CAGE NO. 35 Host - BLUEBERRY Place - MORRISTOWN

Female reared on BLUEBERRY. Males reared on BLUEBERRY. Place collected BLUEBERRY BUSHES. Date of placing flies in cage Aug. 13th. No. of flies put in cage and dates:

August	13th	7 females
"	13th	7 males
"	15th	8 females
"	15th	12 males

Stings first appeared -

No. of pupae collected - 0. Date of removal - AUGUST 20th.

Observations and notes:

August 17th - This cage was left to the last as it enclosed rather a thin branch, but was well loaded with fruit. No flies could be found alive today in this cage. Apparently not heavy enough shade for the extremely high temperature now prevailing. As this particular combination had proven so successful in the past work all flies that were captured were diverted to fill other cages thought to be of more interest.

It is believed that this cage would have been successful in producing results if ordinary weather had followed the setting.