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Title Investigation on the Life History and Habits of the Cherry Case-bearer (Coleophora pruniella Cl.) and the Cigar Case-bearer (C. fletcherella Fern.) in the Willamette Valley.

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This thesis presents the study of the seasonal history and the feeding habits of the cherry case-bearer (C. pruniella Cl.) and the cigar case-bearer (C. fletcherella Fern.)in the Willamette Valley, and gives the description of their various stages. Their distribution, plant hosts, and natural enemies are generally discussed. The literature and the control measures are also briefly reviewed. 29 figures, bibliography.

INVESTIGATION ON THE LIFE HISTORY AND HABITS OF THE CHERRY CASE BEARER (COLEOPHORA PRUNIELLA CLEMENS)

and

THE CIGAR CASE BEARER (C. FLETCHERELLA FERNALD) IN THE WILLAMETTE VALLEY

by

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The writer wishes to take this opportunity to thank Mr. R. G. Rosenstiel, graduate student of the department, for helping in the preparation of a part of the photographs.

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INTRODUCTION

The case bearers are a very interesting group of insects belonging to the family Coleophoridae of Lepidoptera. There are about ninety species of this family found in North America and all of them belong to the Genus Coleophora. They are rather small insects and the larvae usually have the habit of mining within leaves when young and bearing a case later, hence the common name. Some of the species have been recorded to be pests of cultivated plants. The cherry case bearer (Coleophora pruniella Clemens) and the cigar case bearer (C. fletcherella Fernald) are often regarded as minor pests on account of their infestation on the wild plants and their occurrence in small number. However, when they extend their hosts to cultivated plants and become abundant they cause considerable damage to the orchards.

In some orchards in the Willamette Valley, Oregon the cherry case-bearer caused sufficient damage in the season 1937 to warrant special studies of its life history, habits and control measures though the cigar case-bearer was seldom found in sprayed orchards.

The principal purpose of this study is to investigate the seasonal history and habits of the cherry case-bearer (C. pruniella Clemens) and cigar case-bearer (C. fletcher-

ella Fernald) and to give a description of their various stages. Their plant hosts and natural enemies are generally discussed and the literature and control measures are also briefly reviewed. The period of the study began during the spring 1937 and continued through the spring 1938, covering twelve months.

It is hoped that this limited information will be helpful in future work with either the control measures of these insect pests or on other members of the family.

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PART ONE; THE CHERRY CASE-BEARER (Coleophora pruniella Clemens)*

I HISTORY and DISTRIBUTION

The cherry case-bearer (Coleophora pruniella Clem.) is an obscure native species of insect of the American continent, and has been feeding on the leaves of wild black cherry (Prunus serotina) from the ancient time. The larva and its case was first described by Brackenridge Clemens (2)** in 1861. His brief description runs as follows: "The larva mines the leaves of wild cherry early in October, when it is more than half grown. The case is flattened, having a notch on the upper edge about one-third from the mouth whence it is curved regularly to the

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* Determined by C. Heinrich.

** Arabic numerals in parentheses refer to the references in the bibliography listed at the end of the article.

hinder end and the under edge is nearly straight from the mouth to about one-third of the length from the hinder end, where it is deeply notched and curved towards the upper edge thus forming a tail-like appendage. On the upper edge from the mouth of the case to the anterior notch, the edge is regularly curved."

In 1872, Clemens (3) repeated his description in his "Tineina of North America."

In 1890, A. S. Packard (22) in the fifth Report of the United States Entomological Commission quoted what Clemens had written.

Dyar (5) cited this insect in his "List of North American Lepidoptera" in 1902 and gave Atlantic States for its habitat.

Miss Annette F. Braun (1) in her "Notes on Coleophora, with Descriptions of two New Species" described the case formation briefly and separated the adults of C. cerasivorella Packard and C. fletcherella Fernald by the differences of their antennae and of C. occidentis Zeller by the difference of their cases.

Carl Heinrich in "Forbes' Lepidoptera of New York and Neighboring States, 1923" (12) described the larval case quite fully and cited Pennsylvania and Ohio for localities and Prunus serotina as the food plant.

C. E. Petch and T. Armstrong (23) in the eighteenth

Annual Report of the Quebec Society for the Protection of Plants, 1926, first gave a description of various stages and recorded it as a rather serious pest of apple trees, occurring as well on both Prunus virginiana and serotina and on certain species of Crataegus.

Since then the cherry case-bearer caused more attention of entomologists and was regarded as a major insect pest of cultivated crops.

In 1929, George Maheux and Petch (20) again accounted it as an important insect which causes serious injury to apple foliage every year, especially in the localities surrounding Montreal. They reported it to be widely distributed.

The experiment station of Wisconsin reported it as the most destructive insect pest during the 1929 season in the cherry orchards of Door County (13). A survey by A. A. Granovsky showed that 5,000 acres out of 9,000 acres of cherries in the Peninsular district were infested. It is the first time this insect was considered as a serious pest of cultivated cherries.

In 1930 (14) he again reported its occurrence on apple and paper birch.

Michigan records on cherry case-bearer began with material received in November, 1929 from Grand Tranverse County. Thereafter to 1932, R. Hutson and R. H. Pettit

(17, 18, 19, 24, 25, 26, 27) repeatedly reported its damage and the experiments of controlling measures. It was recorded to cause a defoliation of from six to fifteen per cent in 1930 over the Old Mission Peninsula and spread over the northern cherry belt (25). In 1932, Pettit (20) also recorded that it was found on apple as well as cherry.

As this insect had not hitherto been a pest of cultivated fruit trees there was no information of its control before 1929 (19). The only thing known about its control prior to the year of 1930 was that it did not succumb readily to the ordinary means of control employed against most orchard insects and that its natural parasites show the promise of becoming the major factors in the preventing of the epidemic of the species.

Granovsky (15, 16) had recommended in 1929 the use of oil spray to check this insect on cherry but it proved unsatisfactory on apple.

Hutson of Michigan in 1931-1932 (18, 19) conducted some experiments on the measure of control and reported that this case-bearer was susceptible to control by dormant applications of rather high concentrations of oil emulsions, miscible oils and tar washes, and that nicotine and derrisol combined with lime-sulphur 1-40 can be used effectively if properly timed.

Dormant lime sulphur was tried in Wisconsin by J. H.

Lilly and C. L. Fluke (7, 9, 10) during 1933-1934, in an effort to control this insect, and was reported to give very encouraging results.

Thus this case-bearer has so far been recorded only from Wisconsin, Michigan, Pennsylvania and Ohio in the United States and Quebec and Ontario in Canada and had appeared in alarming numbers in these districts. Attention was directed to the insect at about the same time in the widely separated localities of Door County, Wisconsin and Grand Tranverse, Michigan. It was discovered earlier in the localities surrounding Montreal, Quebec.

According to the records of U. S. D. A., Bureau of Entomology this insect has not previously been known from so far west as Oregon. It was discovered in this state around the Willamette Valley this year (1937). Rather heavy damage was done in the orchards near Salem. Most of the specimens in our cages were collected on the apple and cherry trees around Corvallis and a few came from the trees around Salem, Portland, and also Monroe.

II DESCRIPTION

THE EGG

The egg (figure 1) is a very minute object, measuring about 0.2mm. in diameter thus being scarcely visible to the

naked eye. It is of a delicate light lemon-yellow color and turns to dull yellow one or two days before hatching. It is circular in outline, gradually widening from the apex to the base which is flattened and fastened firmly to the surface of the leaf. At the apex there is a small circular area from which about fourteen raised longitudinal ribs run to the base. These raised areas differ in size and shape. There are often two or three of them which do not reach the small area at the apex. Under a lens it is a beautiful object and the young larva is plainly visible at the approach of hatching.

THE LARVA AND ITS CASE

The larva, when newly hatched out from the egg, is a very tiny object of less than 1mm. in length. When fully grown (figure 2) it is about 8 to 8.5mm. in length, and is usually of reddish brown color which is observed to turn into light orange soon before it pupates. The head of the larva is black and strongly chitinized. It is elongate ovoid, longer than wide; frons extending nearly to incision of dorsal hind margin. Body setae much reduced; thoracic tubercles enlarged usually fusing on dorsum of meso- and meta-thorax to form secondary shields. The three pairs of thoracic prolegs are large, dark brown, strongly chiti-

nized and with distinct segments of coxa, femur, tibia and tarsus, on the end of the last armed with a single claw. There are ten distinct abdomenal segments and on the last one is a pair of abdomenal prolegs which are well developed with a row of uniserial and uniordinal crotchlets. On each of the third, fourth, fifth and sixth abdomenal segments is one pair of abdomenal prolegs not well developed, and with two transverse bands (biserial) of crotchlets. The spiracles are indistinct. The setae on the head, thoracic prolegs and the terminal portion of the body are clearly shown.

During almost all of its life time except the first few days after hatching it bears apparently for protection a case which it makes itself out of leaf material. The case also serves as a cocoon when it pupates. A complete case (figure 3) is composed of a small curved primary case and three additional parts. The primary case (figure 4), usually dark brown in color, about 3mm. in length, is first constructed by cutting off from the mined part of the leaf and formed into an irregular oval enclosure. It is constructed as a rule near the old egg shell which the young larva hatches from and mines immediately into that part of the leaf. The additional parts are cut from the serrate edge of the mined leaf. The first addition is

usually made about two weeks after the construction of the primary case, before the larva goes into hibernation. Two additions are made to the case the following spring. These parts of the cases on apple leaves are often with one side reddish brown and the other whitish brown, the latter resulting from the hairy surface of the leaves. All the sections are clearly defined so there are often four distinct divisions appearing on one case. Each addition is joined to its neighbor in such a manner as to form a serrated upper edge and the lines of demarkation form an angle of approximately 45 degrees with the lower edge. The whole case has an average length of from 8 to 9.5mm. with posterior end curved and flatly compressed. The mouth slightly deflects to about 45 degrees.

THE PUPA

The larva, when full-grown, fastens its case mostly to the upper side of the leaf and turns around and pupates in it. The case serves as the outer layer of the cocoon lined inside with silk. The pupa (figure 5) is cylindrical in form, a little tapering at each end. It is usually of dark brown color which varies in different stages of maturity, and the average length is about 6 to 7mm.

The head is small. The mandibles are small and fixed.

Labial palpi exposed. Antennae, glued together with the wings, are long and not in contact with each other on mid-ventral line.

The three thoracic segments (figure 6) are clearly shown. The prothorax is noticeably narrower on mid-dorsal line than at side. Fore wings extend to the ninth abdomenal segment. Hind wings are almost completely covered by the fore wings except only a small portion at the base shown.

The abdomenal segments are shown clearly. The fourth one is immovably attached to the third. The fifth and the sixth are moveable and the seventh, eighth and ninth are fused again. On the caudal end of the abdomen there are lateral projections ending in spines.

The pupa turns to be yellow while it gets mature.

THE ADULT

The moth (figure 7) is a very delicate and pretty steel gray object. The body has an average length of from 5 to 6 mm. and the expanse of wings is from 14 to 15mm. In the daytime it usually rests on the surface of a leaf with its wings folded closely over its abdomen and with its long and slender antennae projecting straight forward from its head.

The head is smooth and whitish gray. The antennae are of filiform on both sexes, and about 6mm. long, slightly thickened with scales toward basal joints, without a tuft, the first three or four joints are gray, the remainder white and all are conspicuously annulated with a dark gray and white ring. While resting, both of the antennae usually point forward. Labial palpi are of moderate size, the second joint is whitish with dark gray scales and a minute projecting tuft. The third joint is dark gray. Maxillary palpi are absent, Compound eyes are large and ocelli are absent.

The thorax is gray in color and sometimes tinged with brown. The scales are often darker at the tips. The wings are generally narrow, elongated and pointed with a uniform metallic dark gray color, rarely brownish tinged. The hind border of both wings is fringed with long cilia which are especially pronounced in the hind wings. The cilia are concolorous. The legs, especially the hind pair are slender and long. Fore and middle legs in large part fuscous, with the tips of joints white, hind legs white, tibiae clothed above with long fuscous hairs.

The abdomen is all-over gray and is bluntly terminated with yellow anal tuft in the male. The abdomen of the female is larger, especially at the approach of laying, and

terminates in a slender ovipositor, which usually protrudes from the last segment.

III SEASONAL HISTORY AND HABITS

As regards its life history (figures 8 and 9) and habits this little case-bearer is one of the most interesting insects. Daily observation in the laboratory and weekly observation in the fields from the time it awakens from hibernation till its offsprings go to their winter-quarters, revealed that it has only one generation per year and that most of its life time is spent apparently in idleness in its protective case on the twigs of the tree.

In the early spring, as soon as the buds begin to open and the green tips of the unfolding leaves protrude from the scales, the little half-grown caterpillars awake from their long winter's rest, free their little cases from the twigs where they attached formerly and move to the young foliage in search of food. In 1937 the little cases began to be loosened from the branches about April 1 near Corvallis and on April 10 most of them were carried to the expanding leaves. The march continued till the middle part of April. Its feeding habit is also interesting. It firmly glues its case at the front end to the lower surface of the leaves and bores a small round hole in the epidermis of the leaf large enough to allow it to penetrate into

the inner part of the leaf. It stretches out from its protective case and feeds on the inner part of the leaf tissue between the two epidermis layers without injuring them. It feeds in this manner until the excavation becomes too large for further feeding without letting go its case. Then it loosens its case from the leaf and protrudes its head out of it, crawling along with its thoracic legs to find an uninjured place on the foliage and sticks its case to it with the posterior end pointing upward making an angle of about 45 degrees. It bores into the leaf as before and makes another excavation.

The excavations on the foliage are quite conspicuous and easily recognized. They are skeletonized, dead and brown areas of irregular forms and various sizes, with a clean-cut small round hole through one skin near the center. One larva can make as many as five to ten such excavations before it reaches the pupal stage. Thus when the insect is very numerous, often so much of the inner tissue of the leaf is eaten out that the whole leaf turns brown and dies. The caterpillars feed mainly on leaves but often times they are also observed to attack the flowers, calyx and even the young fruit.

While the larva continues feeding and growing it adds additional parts from time to time to its case in order to make it larger and larger to fit its growing

body. The additions are made by cutting the mined part on the edge of the leaf, leaving on the leaf a triangular notch which is easily recognized by one acquainted with this insect (figure 10). It first bores a hole on the edge of the leaf and mines in through it, exhausting the inner tissue, and then cuts both skins along two lines forming a triangle with the margin of the leaf and glues them together with secretion. Figure 11 may serve to illustrate the process of the work. Usually two such additions are made to the case in the spring and one often made in the late fall before it goes to hibernation and thus in a fully constructed case one can detect four clear sections.

The larvae, during their feeding period, were often observed to come down from the leaves and stick to the twigs motionlessly for a time and then go back to the leaves to feed again. Right after each addition is made or after each resting the larvae feed more vigorously.

When the larva is disturbed it ceases eating or moving and retreats immediately into its protective case and cannot be induced to come forth again. If the case is suddenly torn off when it stretches out for feeding it will remain in the excavation and cut off another irregular shaped case from a part of the excavation.

Toward the first part of June the majority of the

larvae reach maturity and fasten their cases on the upper surface of the leaves (rarely to a small branch) and begin to pupate. After fastening its case and before transforming into a pupa, the caterpillar turns around in its case so that the head end of the pupa is toward the posterior and upper end of the case. The opening at this end is closed by two compressed lobes which are readily pushed apart by the emerging adult. Thus the case serves as a secure cocoon within which the pupa undergoes its transformations to the adult stage. The pupa in the season of 1937 was observed as early as May 5 in the laboratory and as late as July 16 few pupae were still found in the fields. The pupal stage lasts about three weeks.

In the rearing cages some moths emerged as early as May 27; the maximum emergence of adults took place between June 20 and July 20 and collections of larvae were made as late as July 15.

The little moths usually emerge at night and in the morning we often found newly emerged moths resting on their cases or on some small twigs. Apparently they feed but little on the juice of the leaves and do little damage.

Two or three days after their appearance the moths begin to lay their tiny yellow eggs singly with the under side broadly glued to the lower surface of the leaves.

The laying ability of the female varies widely.

There was a range of from a few to more than one hundred among the individuals in the cage. The duration of oviposition is observed to occupy from one to three days per individual. The average length of life of the female is about three or four days longer than that of the male which is about four or five days under laboratory conditions.

The embryonic development of the eggs lasts for about two weeks. At the approach of hatching the young larva within the egg is plainly visible under a hand lens. It curls in the egg shell with the head situated towards the margin next to the leaf. Upon hatching, the brown tiny larva emerges by way of a hole cut from the under side of the egg and enters the leaf directly between the two epidermis without being openly exposed at any time. It mines where it gets in and lives as do other lepidopterous leaf miners for a period of about two or more weeks, using the egg shell as a temporary case. After that it constructs a small irregular shaped case itself out of the two leaf layers by cutting through them along the margin of the mine, leaving a few strands uncut at the ends of the case to hold the skins in position while they are being neatly joined together with its secretion. When the work is complete it holds the leaf and manages to break off the case and carry it to some uninjured part of the leaf and thereafter it mines the leaf from the case. Most of the tiny

caterpillars complete their little cases during the latter part of August and the beginning of September. Figure 12 illustrates such a little case newly made attaching to the leaf, the egg shell from which the larva emerged, and an irregular shaped small hole out of which the case was constructed. Figure 13 shows a small case with the egg shell glued on, indicating that the case was made right from the portion around the egg. The injury produced by the young larvae in making the first cases is often mistaken to be that of the "shot-hole disease".

After the early hatched young larvae feed for about two or more weeks they soon find that their first or primary case is too small for them. They then come to the edge of the leaf and make one addition to their primary case in the manner as before stated. By September 9 we already found some small cases with one additional part (figure 14). However, many larvae also winter in simple primary cases.

Before the weather gets too cold and the leaves of the trees are preparing to fall the sensitive little caterpillars already half-grown begin their march from their feeding quarter to the bark and attach around the buds for over-wintering. In the season of 1937, by September 26 some caterpillars were already observed to attach their small cases to the twigs near the buds to hibernate. But the

majority of the wintering migration takes place in the beginning of October.

IV FOOD PLANTS AND INJURY

This insect has a rather limited list of food plants. It originally feeds on Prunus serotina (wild black cherry) which is the only host cited by Clemens (2), Packard (22), Braun (1) and Forbes (12). Prunus virginiana (choke cherry) was listed by Petch (23) as the second most important host. Within the last ten years for some unknown reason it has changed its feeding habits to include cultivated cherry and apple and developed into a rather serious pest of these two fruits. It has also been recorded that slight injury was done to Crataegus sp., cultivated plum, and pear. In Wisconsin it was also observed to feed on the leaves of paper birch (17). McDunnough (21) reported that a small number was found on Myrica in Eastern Ontario.

Cherries, both sour and sweet varieties, are attacked and immunity in any variety has not been observed. There is also no apparent correlation between the variety of apple and infestation.

In the special studies to learn the explanation for the heavy infestation of apple orchards by the case-bearers in Wisconsin when originally these insects were found largely on cherries, Lilly and Fluke (11) made two sig-

nificant discoveries which also have something to do with their distribution and control and are worth quoting here. First, the orchard spraying practices have much to do with the movement of case-bearers from cherries to apples. They claimed that bordeaux spray has something of a repelling effect on the egg laying female moths. Secondly, the egg laying females tend to oviposit most of their eggs on trees showing the best growth.

The caterpillars infest mainly the leaves but they may also be found on flowers and young fruits. Damage by them is caused by the feeding between the two epidermis of the leaves. The injury is readily recognized by the irregular shapes and sizes of the excavations in the affected leaves with a little clear-cut round hole near the center through one epidermis of the leaf. When collecting, if you find such injury on the leaves, you can almost be sure to find one or more workers nearby. The injured part of the leaf is devitilized and turns brown and dies. One large leaf may be entirely devitilized in one night by two of the little caterpillars.

In the spring as the buds begin to open they move to the expanding leaves and consume considerable portions of the new growth. Injury at this time of the season is naturally quite important as affecting both the vigor of the trees and the development of the fruits. It has been

already mentioned that one larva can make as many as five to ten excavations before reaching the pupal stage. This reduces greatly the functioning area of the leaves and consequently the tree fails to make adequate growth and is crippled in its effort to mature fruit or build reserves for the coming season. As the young larvae hatched in the summer are very active during the period when the plant is storing up food for the next season their damage to the trees is also potentially great.

Fluke and Lilly (8) reported that small areas of decay on apples in storage appeared under many of the eggs which had been laid by the adult cherry case-bearers and that a rot usually occurs around the small feeding areas of the older larvae upon the apple fruit. As the encased larvae, especially in the later instars, commonly do a limited amount of feeding on the fruits and the young ones which emerge from the eggs deposited on the growing fruits directly puncture the cuticle of the fruit it is not improbably that they may do some damage directly to the fruits in one way or another.

V NATURAL ENEMIES AND METHODS OF CONTROL

The cherry case-bearer is beset with many natural enemies among which the parasites are the most important. In 1931-1932, Fluke and Lilly (6) reported that at least

24 kinds of parasites have taken a part in preventing an epidemic of this species. M. H. Doner of Michigan (4), in a paper titled "Observation on the Biology of Microbracon pygmaeus (prov.), an Important Parasite of C. pruniella Cl.", reported that a total of 32 species of parasites of this insect were reared of which four species belong to the Ichneumonoidea and 28 to the Chalcidoidea and that of these M. pygmaeus Prov. was the most important natural factor in limiting the numbers of this pest in Door County.

In our cage two species of hymenopterous parasites, Eurydinota lividicorpus Gir.* (figure 15), and Microbracon pygmaeus (Prov.)** (figure 16), were reared during the larval stage of this case-bearer. Both of them emerged the latter part of June. They feed on the larva and when mature bore a hole on the side of the case of their host (figure 17) and emerge as adults. In our collections some vacant cases with a hole on the side have been found. It is apparent that the host caterpillars in them were parasitized and eaten up by their parasite enemy.

Because of the protective feeding habits of this case-bearer from hatching of the young larvae to the emergence of adults there is so far no artificial means of control

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* Determined by A. B. Grahan.
** Determined by C. F. W. Muesubeck.

having given satisfactory results without considerable risk of damaging the trees. The larvae feed between the two epidermis of the leaves and never expose themselves openly since they hatch from the eggs so the regular spray schedule adopted by the growers for controlling the other insect pests is ineffective. Foliage may be completely covered with the spray yet it cannot reach the insects which keep on feeding with the leaves unhurt.

In the South Farm of Oregon State College we, following the regular spray schedule in 1937, sprayed the apple trees with lime sulphur, arsenate of lead, and Black Leaf 40. It was observed that the well protected caterpillars were not injured by any of the poisons and moved from place to place as usual and some even bored into the leaves from the portions very heavily covered with sprays. Judging from the number of the young caterpillars which hatched this summer no noticeable reduction had been attained from either of the applications.

A full account of the results of the various spraying experiments will be found in the reports by Hutson of Michigan and by Fluke and Lilly of Wisconsin. Hutson (18, 19) claimed that cherry case-bearer is susceptible to control by dormant applications of rather high concentrations of oil emulsions, miscible oils, and tar washes,

and that nicotine and derrisol combined with lime-sulphur 1-40 can be used effectively if properly timed.

According to Lilly and Fluke's experiments (10, 11), a comparatively more recent work, control of the cherry case-bearer by dormant oil emulsion sprays has been quite successful on cherries but often failed almost entirely on apples and that dormant lime-sulphur was tried in an effort to control this insect without tree injuries and preliminary trials with it are most encouraging.

For the control of this pest in the Willamette Valley further investigation is needed.

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PART TWO: THE CIGAR CASE-BEARER

(Coleophora fletcherella Fernald)*

I HISTORY AND DISTRIBUTION

The cigar case-bearer (Coleophora fletcherella Fernald), like the cherry case-bearer (Coleophora pruniella Clemens), is also thought to be a native species of North America, feeding originally upon wild hawthorns. It is the more abundant of the two and is likely to be found in most apple sections since it is readily distributed on nursery stock.

It was first recorded to be injurious on young pears in 1889 by Dr. J. A. Lintner at Rochester, New York (50). In 1890 he gave an account of the insect before the Western New York Horticultural Society with a brief description of the insect and its life history and advised early arsenical spray for its control (51). The same account was repeated in Popular Gardening of the same year (52) and again included in his seventh report in 1891 (53). At about the same time the insect attracted attention of the entomologists in Canada. In 1889 Dr. James Fletcher received some larvae from Carlestown, Prince Edward Island (24). They were recorded to feed on plum, apple and pear. Further notes on this insect and some experiments of its

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* Determined by C. Heinrich.

control were given by Fletcher in his various publications from 1891 to 1897. In 1892 Prof. C. H. Fernald described it and named it fletcherella in honor of Dr. Fletcher (23). Lintner in his ninth report showed that the case-bearer referred to in his early reports was this same species (55). Prof. L. H. Bailey reported that it was one of the worst pests in Wayne and Monroe counties of New York state in 1894. (1). In the same year Slingerland published an extensive account of the insect, giving a detailed description of its various stages and of its life history. Webster of Ohio, gave a summarized account in 1895 (79). Cockerell reported its introduction into Santa Fe, New Mexico on infested nursery stock from New York in 1896 (11). In 1897 a hymenoterous parasite, Microdus laticinctus Ashm., was reported to be reared out from the cases by Fletcher (35). In 1898 E. E. Faville reported its occurrence at Manhattan, Kansas, with an account of its life history and mode of control (18). It was considered to be one of the principal insects liable to be distributed on nursery stock by Banks (4). In 1904 R. H. Pettit included it as an insect injurious to fruits at Port Hope, Michigan (67). In 1905 H. A. Gossard of Ohio gave an account of the insect and recommended winter applications of lime-sulphur wash for its control (40). A general program of spraying was outlined by him in 1908 and 1911

(41, 42). In 1909 A. G. Hammar gave a very extensive description and an account of its life history with illustrations and bibliography. He summarized its distribution as: "In Canada, Fletcher reports it from Ontario, Quebec, Nova Scotia, Prince Edward Island, and British Columbia. In the state of New York it has been recorded by Lintner, Slingerland, and others; at Manhattan, Kansas by Faville; at Santa Fe, New Mexico by Cockerell; at North East, Pennsylvania by the writer; at Port Hope, Michigan by Pettit, and at Douglas, Michigan by Braucher" (43). After this Johannsen recorded its occurrence near Monmouth, Maine in 1910 (44). H. J. Pack reported that it was fairly numerous in orchards at Granger, Utah and that cases were also collected on apples at Magna and on cherry leaves at Centerville of this state (63). Early in 1908 E. M. Ehrhorn of California warned that it was a new pest in eastern states which could be easily shipped in on nursery stock and it is apparent that it had not been found around there at that time.

Facilities were not available to make an extensive survey to determine the distribution of the cigar case-bearer in Oregon. It was found, however, that it is fairly numerous on hawthorns and neglected apple trees at Portland, Salem, Corvallis, Monroe and Eugene, and probably it also occurs in some other parts of the Willa-

mette Valley and other apple growing districts in Oregon.

II DESCRIPTION

THE EGG

The egg (figure 18) is a very minute object. But unlike that of the cherry case-bearer, is of oval shape, measuring about 0.3 by 0.2mm. It is of pale yellow color and the surface is marked with elevated ridges forming numerous small triangular depressions. It is usually loosely located among the pubescence on the lower surface of the leaves.

THE LARVA AND ITS CASES

The larva (figure 19) when newly hatched is a very tiny light brown object with a length of less than 1mm. When fully grown it reaches a length of about 5 to 5.5mm. The head and thoracic plates are black and conspicuous. Body setae are reduced. The thoracic legs are well developed, darker in color with segments distinct and armed with a single claw on the end of tarsus. The anal legs are with a single row of well developed crotches. The crotches on the first abdomenal legs are reduced and those on the other three pairs are rudementary.

The larva has two cases for protection during its

life time. The first one (figure 20) which is made in the fall about 15 to 20 days after its emergence from the egg is a minute curved structure. It is composed of the two epidermis of a mined portion of the leaves. It is about 2 to 2.5mm. in length. As the larva grows in the fall and the following spring, additions of fragments of leaves are added to the anterior end of the case which is consequently prolonged into a tube (figure 21). The addition may reach the same length as the primary case and sometimes even longer. When the larva grows still larger in the latter part of the spring, it abandons the old small case and constructs another new one. The second case (figure 22) is straight and cylindrical, resembling a miniature cigar both in shape and color, hence its common name. It is about 8mm. in length, slightly compressed laterally with a more or less distinct ridge both above and beneath. The anterior end is slightly curved with a round opening and the posterior end slightly tapering, terminates in three lobes which close the opening. This case is also made out with the two epidermis of the leaves and consequently one side of the case is hairy and lighter in color while the opposite side is almost smooth.

THE PUPA

The pupa (figure 23) is very much like that of the cherry case-bearer, obtected and cylindrical in form, tapering slightly at both ends. It is usually of brown color and about 4.5 to 5mm. in length.

THE ADULT

The moth (figure 24) is also a very delicate object, metallic gray in color, with the expanse of wings of about 11 to 12mm. and the body of about 4mm., smaller than that of the cherry case-bearer to which it is superficially very similar only the color is generally darker especially on the under side of the wings and the legs. When at rest it assumes a similar gesture as the cherry case-bearer moth with the antennae projecting straight forward from its head and the wings folded over the abdomen. But as the hind end is much wider the general form is quite like a seed of shepherd's purse.

III SEASONAL HISTORY AND HABITS

The life history of the cigar case-bearer is very similar to that of the cherry case-bearer. There is only one generation per year and most of its life time is spent in hibernation.

The little caterpillar awakes from its hibernating quarter in the first part of April when the buds begin to open. As the cherry case-bearer, it frees its case from the twig and migrates to the expanding foliage where it fastens its case to the lower surface of the leaves and bores through the skin to feed on the inner tissue. It continues feeding and growing till the first part of May and then it finds that the small curved case is too small for its body. But unlike the cherry case-bearer, it constructs another new case and discards the old one instead of depositing additions on it. It usually prefers to feed at the middle part of the leaf but before it begins to build a new case it often moves down to that part of the leaf next to the petiole. It first bites a small hole through the lower epidermis of the leaf and then begins feeding upon the inner tissue until a narrow elongate area along the margin of the leaf is consumed. It then cuts out its new case by cutting through both epidermis leaving a few strands uncut to hold the epidermis in position at both ends. Then it turns around with its head towards the entrance, projects its head against the margin of the leaf or its old case to remove its new work. We observed one larva making such an effort against its old case, but failing to detach its new case from the leaf, it turned round to cut more strands. After the

construction of the new case it moves away to find a new feeding place, leaving an elongate notch on the leaf with a small curved case (figure 25). Some larvae also make their new cases from some other part of the leaves between the margin and the midrib. Figure 26 shows a little caterpillar at work on its new case which was nearly completed but still attached to the leaf. This second case looks very much like a miniature cigar in shape with the upper edge either smooth or serrated as the part of the leaf out of which the case is made happens to be. The first cigar-shaped case was constructed at the end of April in our laboratory. It takes about one day to complete the work. After the construction of this case the larva continues to feed more greedily and this is the period of its greatest injury. It excavates the green tissue and skeletonizes the leaves in the same manner as cherry case-bearers. It attacks the young fruits as well as the leaves.

Toward the first part of June it ceases feeding, securely fastens its case to the upper surface of the leaves or a small twig and turns around to pupate in it. In about 20 days it transforms within the case through a light brown pupa to a tiny shining gray moth. It usually emerges during night time and is often seen sitting on its case in the morning. The females begin laying two or

three days after emergence. The minute yellow pitted eggs are deposited among the hairs on the under side of the young leaves. But they refuse to lay eggs within test tubes. Hatching takes place within about two weeks. The young caterpillars bore into the leaves directly from the eggs. They work as leaf miners for two weeks or more and then construct their little curved cases from their mines by cutting the two skins of the leaves (figure 27). They keep on feeding in their small cases till the last part of September and then they begin to migrate to the twigs where they attach their cases near the buds to spend their long winter.

IV FOOD PLANTS AND INJURY

Like the cherry case-bearer the cigar case-bearer has a limited species of food plants which are almost confined to the family Rosaceae. It originally fed on certain species of Crataegus and some wild crab apple and then it extended its food plants to some cultivated fruit trees. It was first noticed to be destructive upon young fruits of pears by Mr. P. Barry of Rochester, New York in 1888 (50). About one year later Fletcher reported them feeding on plum trees and soon after he found them upon apple and pear also (43). Banks recorded it feeding

upon pear and quince (4). It was reported to be a cherry pest by Quaintance (68) and was also reported to be very abundant on currents and gooseberries by Lockhead (58).

Most of our specimens were collected from apples and hawthorns. Some of them were collected from pears and quinces and a few were from cherries. In the fall of the season Mr. Rosenstiel found some young larvae with their small curved cases on Cotoneaster horizontalis, having very similar habits and appearance. It is not improbable that the cigar case-bearer also feeds upon Cotoneaster which is closely related with Crataegus.

The injury is done by the larval stage. Like those of the cherry case-bearer, the larvae of the cigar case-bearer infest mainly the leaves in the same manner (figure 28). They mine between the two epidermis of the leaves and exhaust all the green tissue as far as they can reach in every direction without letting go their cases, thus devitalizing plants by affecting both the vigor of the trees and the development of the fruits. In the spring and early summer they may also be found infesting on the young fruits (figure 29). The injury on apples may be usually recognized by the small round corky scars with depressed centers. The punctures appears as tiny holes opening into a small cavity and surrounded by a ring of

black dried skin. These resemble the "stings" of codling moth worms.

V NATURAL ENEMIES AND METHODS OF CONTROL

The first recorded parasite of the cigar case-bearer was Microdus laticinctis Ashm. reared out by Fletcher from the cases from Port Hope, Ontario (35). Another hymenopterus parasite, Habrocytus sp. was reared in considerable numbers at North East, Pennsylvania and it was recorded that about 10 per cent of the transforming insects were parasited (43). A. G. Hammar recorded the larvae of the lace-wing fly (Chrysopa oculata Say), a kind of minute yellow mite and various species of lady bird beetles as their predaceous enemies by attacking their eggs and larvae (43). Pack of Utah reported that several parasites were reared from specimens collected (63). In our cage one species of hymenopterous parasite, Microbracon pygmaeus (Prov.),* was obtained from the case of which the host was apparently parasitised during the larval stage. We also noticed that some larvae were attacked by some small spiders.

Unlike the cherry case-bearer the cigar case-bearer can be kept in check by thorough sprayings of stomach poison. D. Young of Adolphustown, Ontario, early in 1891

* Determined by C. F. W. Muesebeck.

carried out extensive spraying experiments with kerosene emulsion and Paris green and found that Paris green spray was very effective and that a spray of kerosene emulsion, diluted with nine parts of water, applied thoroughly in spring when the caterpillars are active, was still more effective. A full account of these experiments will be found in Fletcher's various publications (24, 25, 28, 30, 33, 34). H. A. Gossard of Ohio, reported that winter application of lime sulphur spray added with arsenical sprays in the spring were effective to check this pest (40, 41, 42). Lime sulphur spray should be applied after the leaves fall. In early spring as soon as the leaf tips appear in the buds spray with arsenical. Spray again in about a week or ten days, just before the blossoms fall. Slingerland and others claimed that strong sprays against the San Jose Scale in winter might reach the winter larvae (75, 76), and that arsenate of lead applied in early spring was effective in New York state. Quaintance and Siegler claimed (68) that a contact spray, as 10 per cent kerosene emulsion or nicotine sulphate (40% nicotine) in the proportion of one-half pint to 50 gallons of soapy water, may be employed instead of an arsenical. As the injurious caterpillars are protected by their cases skillful and thorough spraying is

needed to guarantee the effectiveness of the application.

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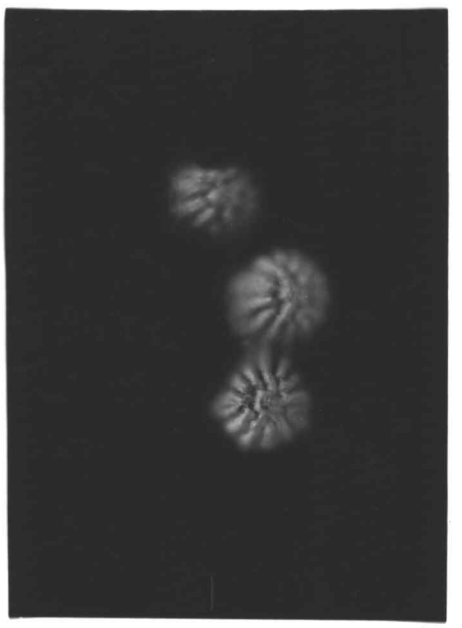


Figure 1. Eggs of C. pruniella. About x65.

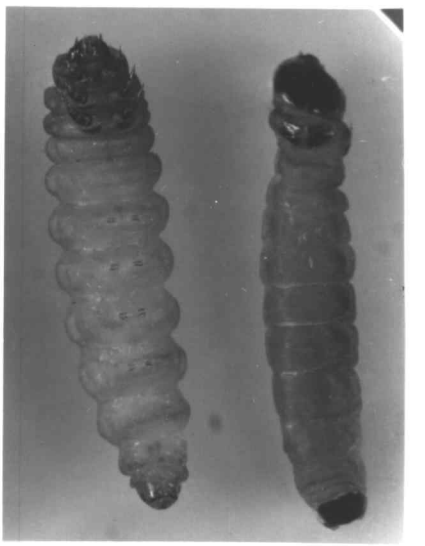


Figure 2. Larvae of C. pruniella. About x8.

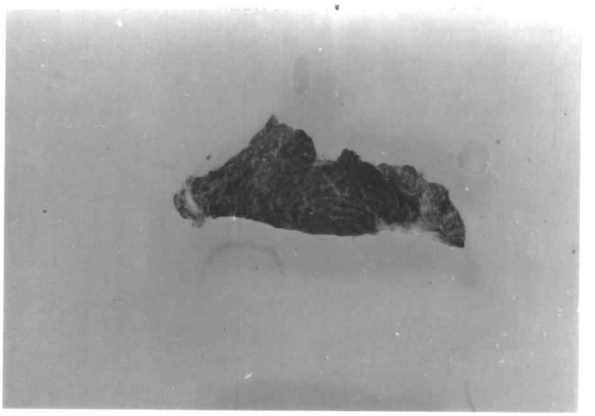


Figure 3. A complete case of C. pruniella. About x4.

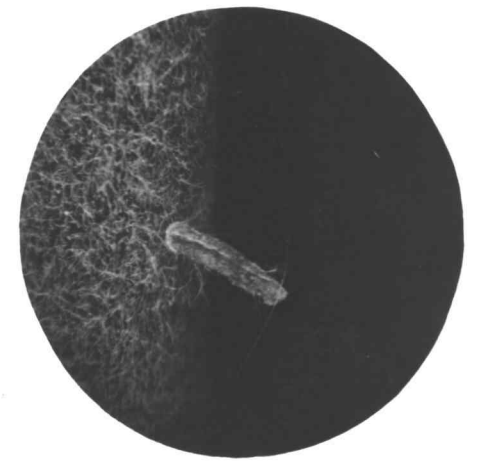


Figure 4. A primary case of C. pruniella attached to a twig. About x6.

Figure 5. Pupa of C. pruniella, lateral view. About x10.

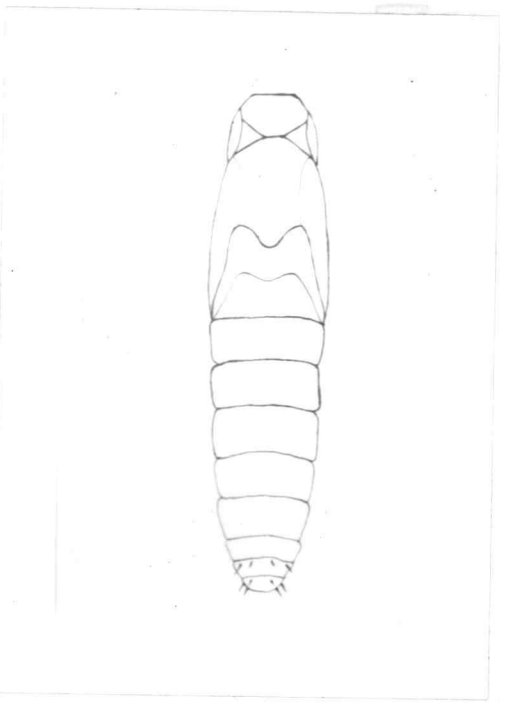


Figure 6. Pupa of C. pruniella, dorsal view. About x10.

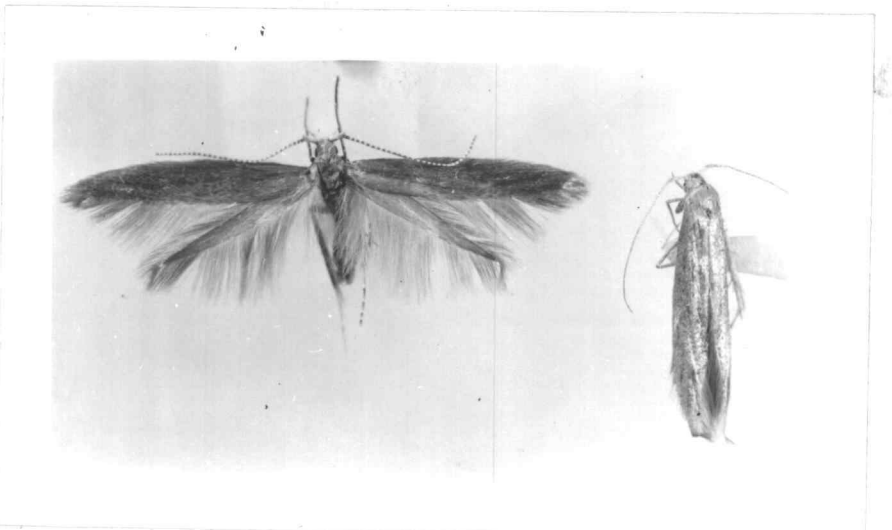


Figure 7. Adults of C. pruniella. About x4.6

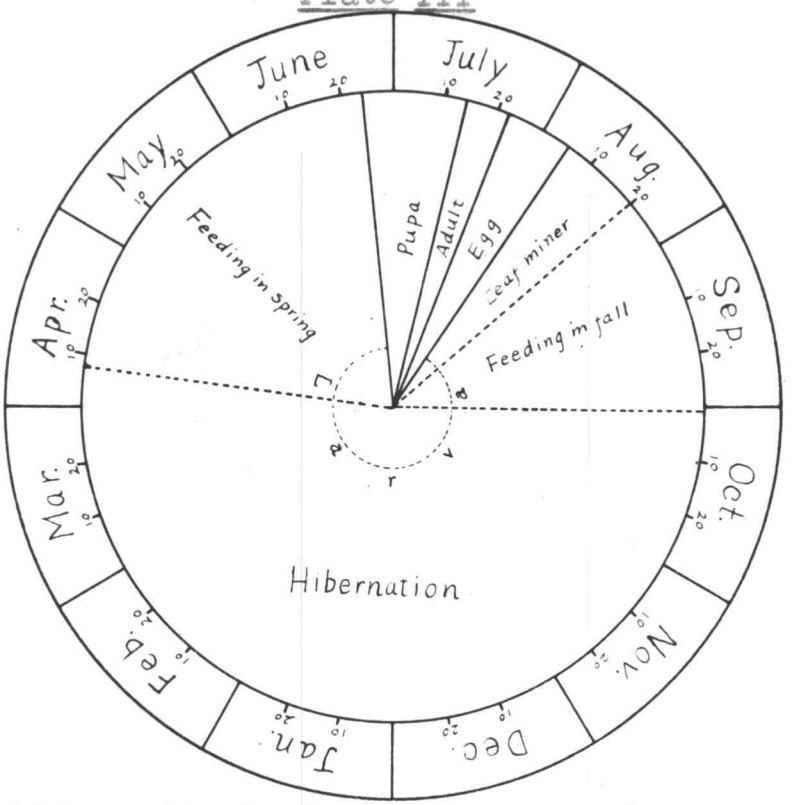
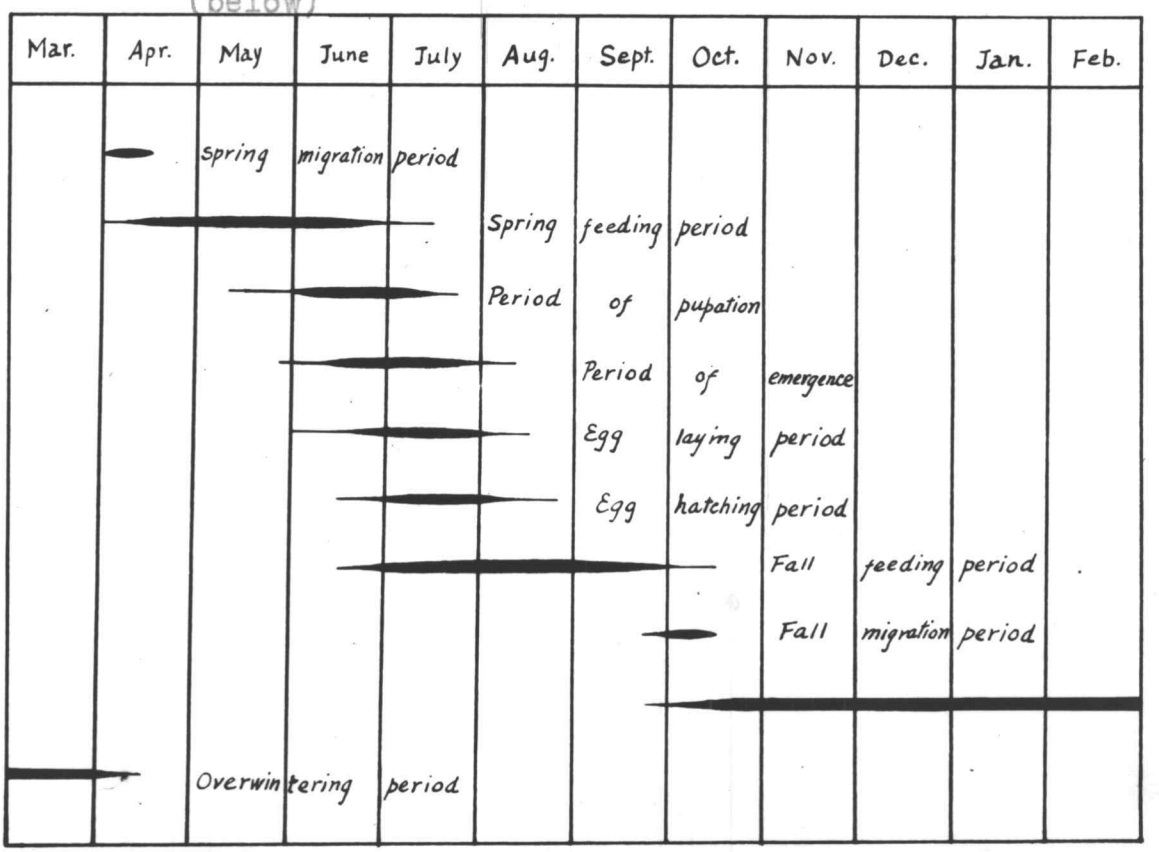


Figure 8. Life cycle chart of an average cherry case-bearer.
Figure 9. Seasonal life history chart of C. pruniella. (below)



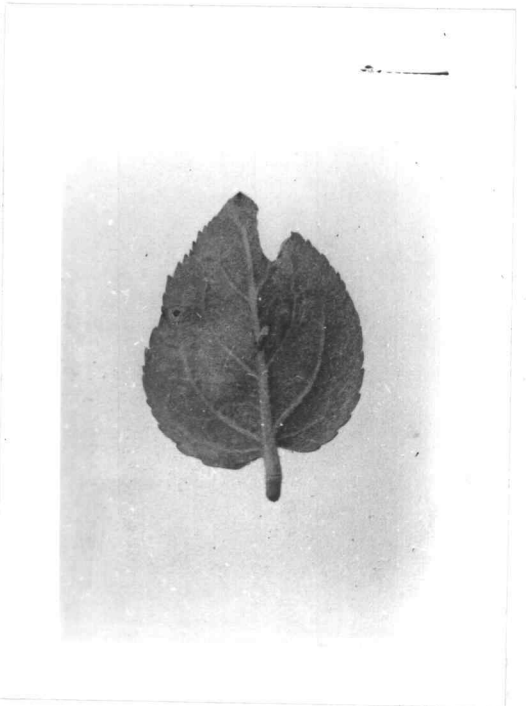


Figure 10. An apple leaf with notch from which an addition to a case was made.

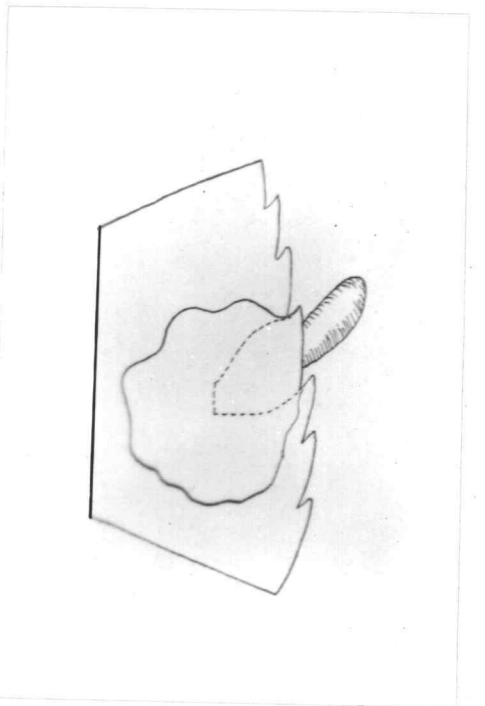


Figure 11. Diagram showing how the case-bearer makes the addition to its case.

Figure 12. Apple leaf with a case, an egg shell from which the larva hatched and a hole out of which the case was made.

Figure 13. A primary case of C. pruniella with the egg shell on its posterior end.

Figure 14. An over-wintering case of C. pruniella consisting of the primary case and one additional part.

Figure 15. Eurydinota lividicorpus Gir, a Hymenopterous parasite.

Figure 16. Microbracon pygmaeus (Prov.) a Hymenopterous parasite.

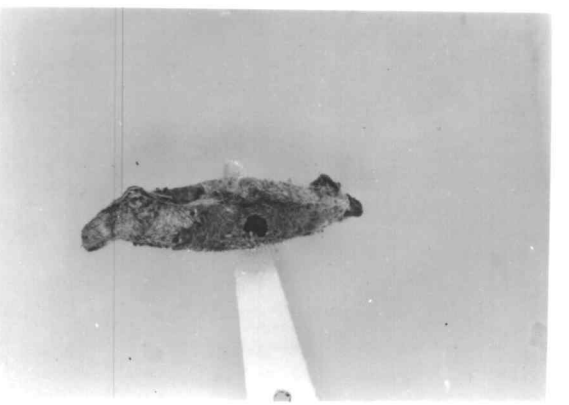


Figure 17. A case of C. pruniella from which E. lividicorpus emerged.

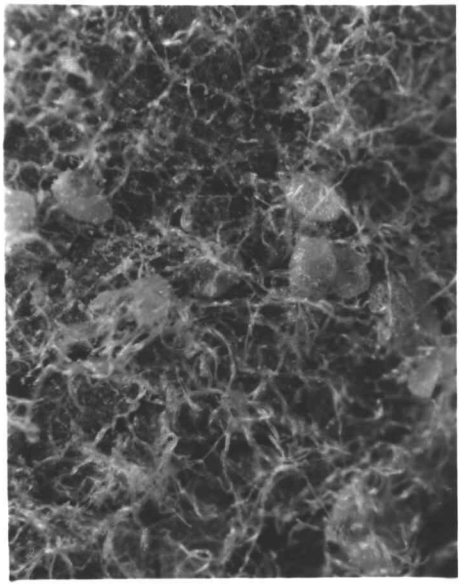


Figure 18. Eggs of C. fletcherella on apple leaf. About x30.

Figure 19. Larvae of C. fletcherella. About x12.

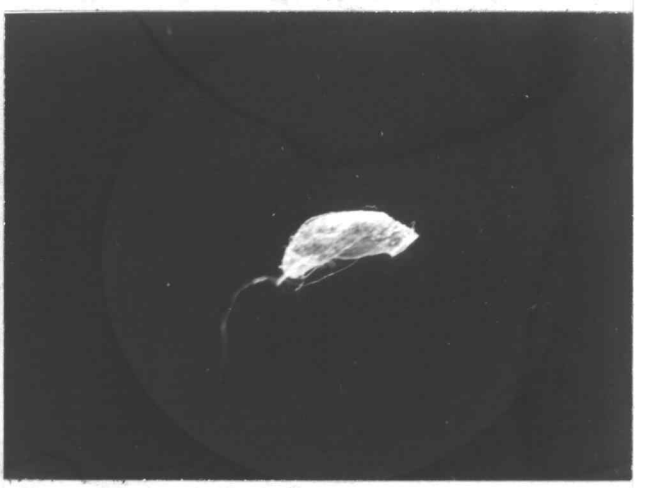


Figure 20. First case of C. fletcherella. About x8.

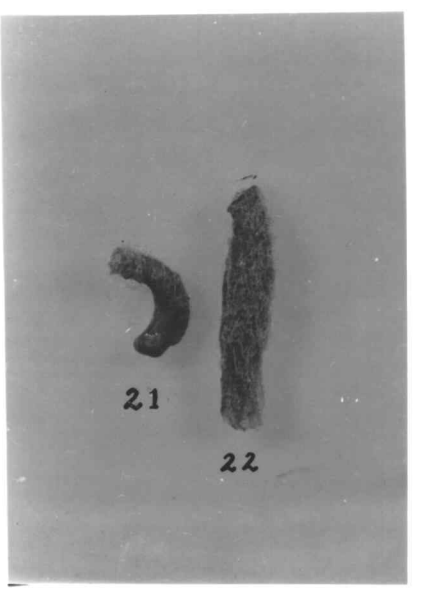


Figure 21. First case of C. fletcherella with spring addition at the anterior end. Figure 22. Case of C. fletcherella. About x4.

Figure 23. Pupa of C. fletcherella. About x12.

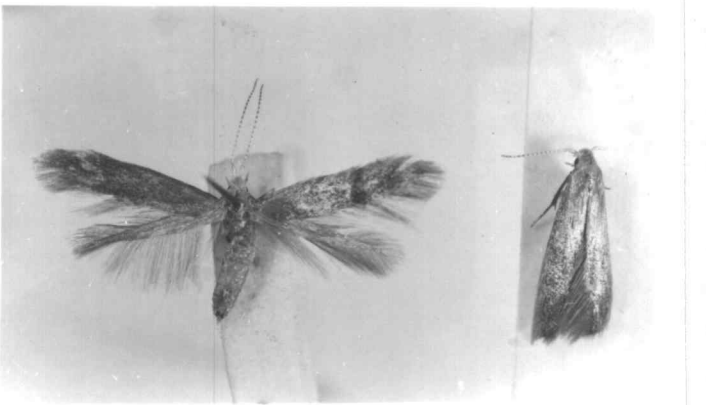


Figure 24. Adults of C. fletcherella. About x4.6

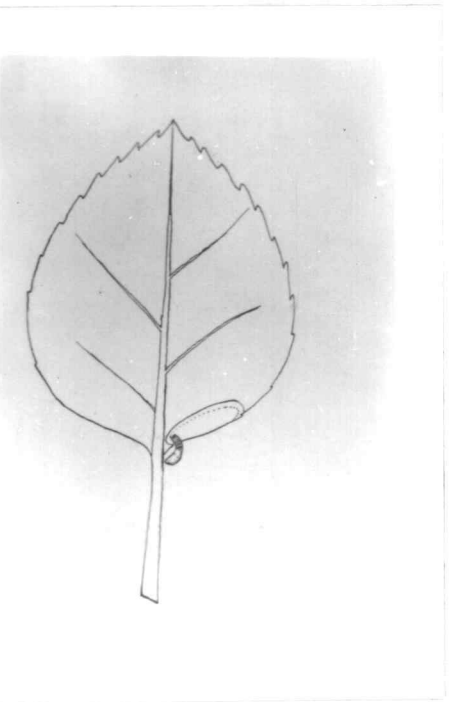


Figure 25. Diagram showing the making of the cigar-shaped case.

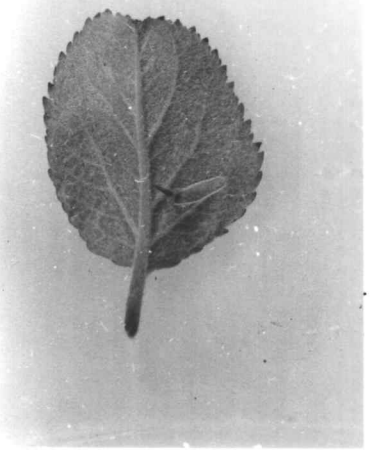


Figure 26. An apple leaf on which a caterpillar was making its cigar-shaped case.

Figure 27. An apple leaf on which a young larva was making its first case.

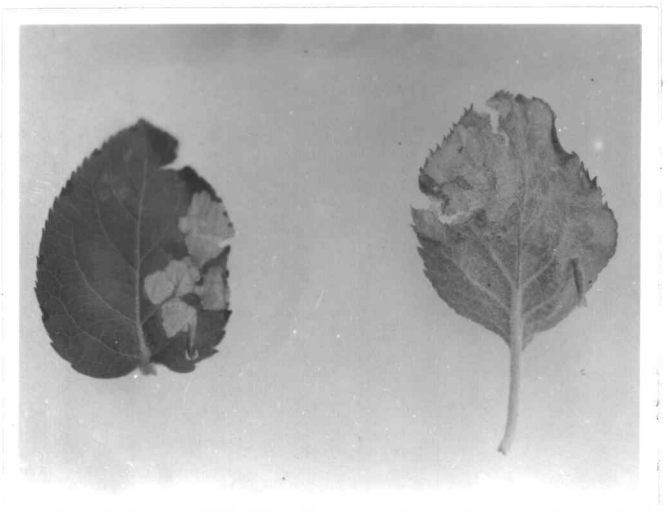


Figure 28. Damage of C. fletcherella on apple leaves.

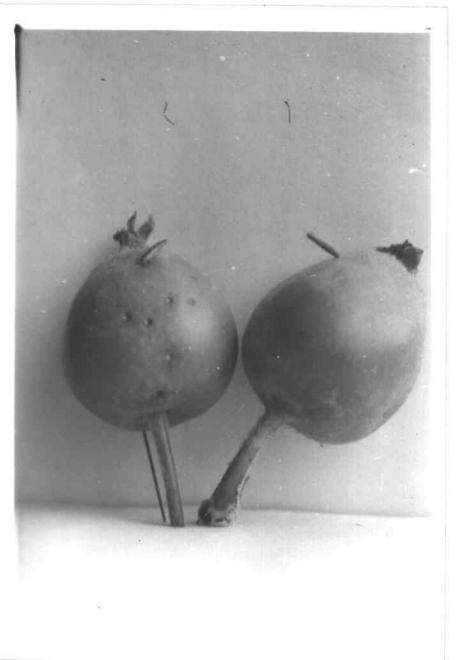


Figure 29. C. fletcherella working on young apples.