A CONTRIBUTION TO THE BIOLOGY OF SAWFLIES

By

W. G. Garlick.
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Approved by:

[signature]
Head of Department

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INTRODUCTION

The chief purpose of this paper is to bring together in an orderly manner a number of observations on the biology of sawflies made by the writer during the last four years. An attempt has also been made to bring these observations into line with those already known. Whilst no essay to cover the subject completely has been undertaken - indeed such would be almost a monumental task - it is hoped that sufficient data has been given to show the value and interest to be obtained from a study of this group of insects. Much might be written in favor of a study of sawflies but suffice it to say here that they are of interest to the systematist as representing an unique and somewhat conjectural group of the order Hymenoptera; to the economic entomologist on account of the many destructive plant-eating larvae; and to the general biologist as offering remarkable material for the study of many phases of parthenogenesis.

A discussion on the systematic status of sawflies would be out of place here but it might be well to make a few remarks relative to their position in the order Hymenoptera. In this paper the name sawfly is used by the writer to include rather a mixed group, namely the old family Tenthredinidae. Thus the horntails (Siricidae) and woodwasps (Oryssidae) are also classed as sawflies though they are not strictly speaking sawflies at all. According to Rohwer (1917) there are now two suborders in the group, Chalastogastra and

Idiogastra. Taking the order Hymenoptera as a whole the sawflies are probably rightfully placed as the lowest or most primitive forms though they do not seem to be the lineal ancestors of the other groups within the order. However, the venation of the wings is unquestionably primitive being almost identical with that of the hypothetical hymenopterous type of Comstock (1918). The structure of the abdomen, particularly its attachment with the thorax, is also probably nearer to the primitive. If the larvae are of any account in considering the primitiveness of insects they certainly place sawflies as the lowest in the order. To sum up it might be said that the sawflies certainly belong to the order Hymenoptera as known at present and of this order they are the most primitive members, but whether or not they represent the stock from which the rest of the order sprang is at present a debatable question.

The paper has been divided into three parts, the first part contains general notes on the whole sawfly group as noted by the writer while parts two and three each take up in detail the life history of one species of sawfly.

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PART I

GENERAL NOTES ON SAWFLIES

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In arranging these notes the method followed has been to take up the various details under the heading of the stage of the insect at which they occur. Thus the adults, eggs, larvae, and pupae will each be discussed in turn. Where a generalisation is made, that is to say where a statement is made applying to the sawflies as a group, it is to be understood to cover only those species known to the writer and therefore may not apply to all the known members of this family. Where observations are taken from other sources the name of the authority is given in all cases.

ADULTS

Habitat - It is safe to say that on the whole sawflies are shy retiring insects for they form but a small part of the catch - even amongst the Hymenoptera - brought in by the general collector. They have no protective weapon such as the sting of bees and wasps and their progeny usually require more or less hidden places in which to develop. A fruitful place to the collector is on the small bushy growth to be found round the edges of woods and even within the woods on the leaves of small shrubs and weeds. Comparatively very few are to be found round blossoms, instead they may often be seen in the spring sunning themselves on the leaves of shrubs and small trees. MacGillivray (1913) says they are to be found on and around their host plants and this has been the experience of the writer. In one case a specimen of the blackberry leaf-miner (see Part III) was taken at least a quarter of a mile from its host plant, possibly carried thither by the wind. In an uncared for pear orchard the common pear slug, Caliroa cerasi (Linné), was found to be quite abundant one spring. The coal-black adults were seen sitting around on the weeds - most noticeably on the broad leaves of the common milk weed - but on the pear trees themselves not a sawfly could be found. For two days this unaccountable state of affairs prevailed and then oviposition on the pear leaves began and the adults were common on the trees and not to be found on the weeds. Another place where adults can often be obtained is on the tall weeds and brush, such as raspberry and blackberry, growing along fence-rows.

Flight - When not in use the wings of sawflies rest upon the dorsum of the abdomen much as in the Heteroptera, the hind wings being more or less folded and the fore wings overlapping each other completely at the apex but separating toward the base. They are usually well developed and strong but in comparison with most Hymenoptera appear rather heavy and clumsy. The writer has never come upon any examples of sustained flight and though quite active on the wing these insects come to rest apparently after quite short flights. It is for this reason that weeds and shrubby growth along fence-rows (see under Habitat) often prove a good collecting place for though there may not be any host plants in such a situation the insect may merely have stopped there to rest on its seemingly erratic course. It is on account of this also that odd shrubs and small trees which form connecting islands as it were in the sea of ground between extensive woodlots, or that run out from an intensive grove of shrubbery, are often found to have sawflies resting on them. Another fact tending to show that sawflies are not strong fliers is to be found in their often intense dislike to take to the wing when it is at all windy. Even quite a slight breeze will keep them clinging to a support so firmly that they can be easily captured with the hand. Not only can they be taken with the hand at such times but they will cling to their support so that they must be pulled away forcibly. Considering that the same species will ordinarily drop groundward as soon as disturbed the above statement has more significance. It is true that the presence of wind usually implies a fall in temperature and that sawflies are very sensitive to temperature changes being quite inactive when it is cold but the writer believes that the dislike to take flight in the wind is largely due to inability to maintain flight under such conditions. The way a sawfly alights after a flight is quite characteristic though not readily described. It is as if the insect blundered on to its landing place rather than purposely chose a spot on which to alight. A distinctly audible buzz is emitted as if the wings continued to beat for a moment after landing and were therefore beating against the twig or leaf. This is quite common in many insects but not so common within the order Hymenoptera.

If then the power of sustained flight is not at all great how are we to account for the rapid spread of introduced species? The writer believes that the distribution of imported sawflies is about the same as the way in which they were imported in the first place which would almost certainly not be by flight. Some of the means of dispersal are discussed elsewhere (see under Means of Spread).

Activities - It is on bright sunny days that sawflies are most alert. They may be seen running actively over the leaves of various plants, the antennae nervously vibrating with an up and down movement. Short flights are indulged in from one plant to another the leaves being inspected often with methodical assiduity though they may not belong to the host plant of that species. On the contrary when cold they become quite inactive and seem to disappear altogether. At such times they are to be found sheltering on the undersides of leaves quite near the ground. It is here that they may be found during rains and as soon as it gets dark and cool in the evenings. Rau (1916a) records having seen the large Pigeon Tremex, Tremex columba (Linne), sleeping on the underside of the lower leaves of mulberry.

That they stay strictly around vegetation can be readily seen when one reflects that often the currant and gooseberry bushes in the back yard and the very roses trained against the porch may be the home of many generations of sawflies and yet how seldom are the adults ever seen within doors or on the woodwork of the porch even. The writer has only once captured a specimen on the inside of a window. There are species which may infest plants in greenhouses of which the coiled rose worm, Allantus (Emphytus) cinctipes (Norton), is an example but these are probably brought in as larvae or pupae in the plants or soil and rarely fly in on their own account.

As mentioned elsewhere (see under Flight) a sawfly if suddenly disturbed usually rolls off its support and falls toward the ground. Before the ground is reached, however, the insect takes to flight, by this means often escaping the most vigilant eye. Those species which do not "play possum" to any extent have a habit when disturbed of flying through the thicker parts of the plant they are on rather than out into the open rendering their capture with a net or the chance of following them with the eye quite difficult.

Rau (1916b) described what he aptly called the "Sun Dance of the Sawfly." Numerous adults were seen by this observer in a warm sheltered spot alternately flying low in the air or settling on the surrounding bushes. The writer has never seen anything comparable to this.

Feeding - This is one of the factors about which very little is known. In quite a number of rearing experiments carried on by the writer the inevitable conclusion seemed to be that food was not a necessity and that water was sufficient to supply all needs as far as egg laying is concerned. Oviposition usually takes place very soon after emergence and the eggs appear to be laid in a comparatively short time. For example a female of Pteronidea ribesii (Scopoli) laid her first egg sixty-five minutes after pushing up through the soil from her cocoon and had finished laying in less than two days. However, it has been the experience of Peacock (1922a) and Miss Chawner (1921) that certain species will not lay eggs unless fed. Miss Chawner whose long experience with rearing sawflies gives value to her report says that "all require food if they are to be kept alive for more than a few days" and also that egg laying takes place within a comparatively short time no eggs whatever being laid in the latter part of the life. Her observations cover the following foods; pollen of various flowers including pine, small insects, and the leaves of ash. Of other records Rohwer (1913) records two instances, one an adult eating a Perlid imago and the other an adult eating four stamens of an Umbellifer. Venables (1914) mentions an adult seen eating Diptera.

In the spring of 1923 the writer was fortunate enough to have the opportunity of observing the feeding of one species, Macroxyela ferruginea (Say), and this proved to be rather different to any previous records. This species appeared about the time the buds of elm were just lengthening but not yet opening and on these buds the insects fed ravenously. In most cases a hole was made in the bud just above the middle and this was deepened until the middle of the bud was reached. Then the inside would be eaten out right down to the base of the bud the external opening being enlarged as necessary. Often the bud was left a mere empty shell incapable of any further growth. The blossom buds of plum and pear were also attacked by this hungry saw-fly, though elm always seemed to be the first choice. The adults were observed for a period of twenty-five days in which time there were always some of them to be seen feeding.

Thus it is seen that there are carnivorous and herbivorous forms. Many more observations are needed in this direction before any generalisations can be made. Do carnivorous forms ever turn to a vegetable diet or vice versa, or is the diet definitely either the one thing or the other? In the case of _Tenthredo arcuatus (Foerster)_ Rohwer (1913) has observed an adult eating stamens as mentioned above. Rohwer further mentions that Morley (1913) notes the same species as having been seen masticating a female of _Empria pennipes_. Miss Chawner (1921) says that _Allantus arcuatus_, which is in all probability the same species, feeds on small insects. Thus we have one example of a saw-fly both carnivorous and herbivorous in its diet.

Mating - In all cases which have come under the writers observation this has taken place with the insects end to end so that mating on the wing could not occur. Rohwer (1915) shows that in the case of Xiphydria maculata Say mating takes place with the male above the female, both facing the same way. All other species mentioned in the same article mate end to end facing in opposite directions. The males are usually very assiduous in their attentions to the females and, as often seen amongst the Lepidoptera, the female may be attended by literally swarms of males. One female may mate more than once though such does not seem to be necessary. One male may mate with several females. Usually the female appears to be averse to mating which is seldom more than a few seconds in duration. She is the first to break away, pressing down on the abdomen of the male with her hind legs and probably with her ovipositor also. In many species no males have as yet been taken and in some others they are very rare.

Proportion of Sexes - A true average of the proportion of sexes in the field is a difficult thing to find out. For one thing it is the common experience of collectors that the proportion varies with the time of collection, that for example mostly males of a species may be caught one day and nearly all females the next. Again in captivity the abnormal conditions may affect the sex ratio through parthenogenesis. In some species no males have as yet been found and in others they are very rare. The writer has reared some hundreds of individuals of Caliroa cerasi (Linné) and caught many more in the field. So far only one of these has proved to be a male. No record of any males of this species is known to the writer for America though males have been described for the same species in Europe. In the case of Diphadnus appendiculatus (Hartig) only five males appeared out of two hundred thirty two individuals reared, no males at all showing up in the first two or three generations. From an average of over two thousand individuals in one season the sex ratio of Metallus bethunei MacGillivray (see Part III) came out at about 65% females and 35% males. In other species worked with the males have never been found to equal the females in number but as the results do not cover sufficient ground to be of value as yet no figures are given here.

Seasonal Appearance - It may be stated in a general way that the adults first appear when the plant on which their larvae feed is suitably advanced for oviposition or at least very nearly so. Thus Macroxyela ferruginea (Say) comes out quite early, when the elm buds are just beginning to lengthen. Pteronidea ribesii (Scopoli) and Diphadnus appendiculatus (Hartig) come out when the currant and gooseberry leaves are little larger than a ten cent piece. Metallus bethunei MacGillivray whose larvae are leaf-miners does not show up till the leaves have attained full size. At this time the host, blackberry, is coming out into blossom. April, May and June are the months when most sawflies seem to appear the exact date varying with the latitude.

Longevity - The only way to find out the length of life of adults is to hold them in confinement and while this gives a possible figure it hardly shows what the usual span of life is in the field. Some species are with difficulty kept alive in confinement for more than thirty hours, and the longest life the writer has note of in his rearing experiments is a female Pteronidea ribesii (Scopoli) which lived for thirteen days. Miss Chawner (1921) records a Macrophya which lived for five weeks, the species feeds on the leaves of ash. In the field the length of life probably largely depends on the length of the preoviposition and oviposition periods and these in turn depend on the weather. If such is the case then fine warm weather with no cold or rainy days would hasten the activities of the adult and shorten its life.

Relation of Feeding to Oviposition - The writer has successfully obtained the life history of several species without supplying the adults with any food beyond the plant on which they were to oviposit. Peacock (1922a) failed to induce certain species to oviposit unless fed a sugar syrup. The writer wonders whether in this case water would not have done just as well as the sugar syrup for in several trials, notably with Pteronidea ribesii (Scopoli), between water and sweetened water no preference whatever was shown. Water was found to be taken up greedily by the females and out of doors moisture from dew and guttation more than supplied these needs, whereas it seems quite likely that in a house the female would not have access to water unless it was purposely supplied. However, from careful watching of the Xyelid, Macroxyela ferruginea (Say), there seems little doubt that this sawfly is one that requires food before oviposition. Species such as P. ribesii (Scopoli), Monophadnoides rubi (Harris), Schizocerus zabriskiei Ashmead, Metallus bethunei MacGillivray, and others emerge from their cocoons ready to begin oviposition the abdomen being distended with eggs - especially in the first named species. With the Xyelid noted above the abdomen on emergence was gaunt and noticeably thin. It was only after the lapse of several days that the females, which had been feeding right along, showed signs of the developing ova within, their abdomens becoming distended markedly so that they looked more like the emergence stage of the species listed above. With M. ferruginea (Say) there must therefore be a fairly long preoviposition period.

Oviposition - Before proceeding to describe the way the female lays her eggs a few words on the structure of the ovipositor would not be out of place. Fortunately the main parts of the sawfly ovipositor can be readily compared with those found in many other insects so that a brief description should enable anyone to recognise the parts. The terminology here followed is that used by Walker (1919) who worked with Orthopteroid insects. There are three distinct pairs of valves (gonapophyses) in the make up of the sawfly ovipositor. These are the dorsal, inner, and ventral valves. They will be taken up seriatim.

The dorsal valves form the only part visible when the female is not using her saws. Typically they are two longitudinal narrow plates arising from near the caudal margin of the seventh sternite and running caudad to or beyond the end of the abdomen. Though tightly appressed along the median ventral line they are in no way united here but can be separated to allow of egress or ingress of the remaining pairs of valves. The dorsal margins (in the part not projecting beyond the abdomen) are fused or connected by a membrane which in a sense forms part of the body wall in this region. Where the valves project beyond the abdomen the dorsal margins may be fused as in _Tremex columba_ (Linné) or separate as in _Macroxyela ferruginea_ (Say). There is often an apparent division of each valve into a posterior and anterior portion. This is particularly noticeable in _T. columba_ (Linne) and seems to be comparable to the state of affairs found in the cicada (_Tibicina septemdecim_) among the Homoptera. The valves may project considerably beyond the tip of the abdomen as in _T. columba_ (Linné) and the small members of the genus Xyela, or they may appear almost on a level with the adjacent sclerites as in Abia americana (Cresson). All intergradations between these two extremes are to be found. The outline as viewed laterally is often used as a specific character there being convex and concave upper (where projecting beyond the abdomen) and lower margins and various forms of apices. The term 'sheath' is used by Rohwer to indicate these valves and is an appropriate word with reference to their function. MacGillivray uses 'saw-guides' to indicate the same thing. So far as known to the writer the dorsal valves never take an active part in oviposition, they seem purely to ensheath and protect the inner and ventral valves when the latter are not in use.

The inner valves in a large number of forms are usually readily separable from the ventral valves which they most resemble from the fact that their margins are not so frequently dentate and they are more heavily chitinised as a rule. The additional chitinisation is in direct response to the strain put upon these valves; thus the dorsal and ventral margins are thickened and running transversely between these two thickenings are many parallel braces. The thickened parts appear darker than the rest of the valve which is thus divided up into many window-like areas. In addition the basal portion is usually quite heavily chitinised. The general shape may be likened to a sickle with the attached part representing the handle. The point is usually turned ventrad but in Abia americana (Cresson) and Cimbex americana Leach the point is turned dorsad, the whole being rather S-shaped than like a sickle. The curve in the former cases may be of several kinds. It may be a regular arc, the base may be straight and the apex turned down or a short distance at the base may be straight with the remainder curving down with a rather abrupt turn. In width there is usually a gradual narrowing down from the base to a sharp point at apex but sometimes the change is not gradual. In Monophadnoides rubi (Harris) the middle is narrower than the more distal portion giving the valve a somewhat club-shaped appearance. The inner valves are convex on their lateral and concave on the mesal surface forming together a half circle or oval which is continued more or less, though not closed, by the ventral valves. The dorsal margins of the inner valves present all gradations of cohesion. Thus in Metallus bethunei MacGillivray they are quite free, in Cephus pygmaeus (Linné) they are united for half their length, and in Diphadnus appendiculatus (Hartig) and Pteronidea ribesii (Scopoli) they are united from base to apex. There are all variations between these. The ventral margins are of necessity always free and in each valve running ventro-laterally along its length is a tongue which is received in a groove in the dorso-mesal wall of the ventral valve on the same side. The function of the inner valves seems to be purely that of giving support to the ventral valves. The ventral valves are slid in and out and held in place by the tongue and groove arrangement. The name saw-guides would be more appropriate here it seems. Rohwer uses the term 'lance' to indicate an inner valve and in the older literature the name 'seta' is used.

The ventral valves - 'lancets' of Rohwer, 'spiculae' of older writers - constitute the saws proper and always consist of two separate plates. In general shape they resemble the inner valves but are usually broader. Dorsally they are connected with the inner valves by means of the tongue and groove arrangement mentioned above. This connection whilst holding the inner and ventral valve of each side firmly together allows the ventral valves perfect freedom to slide alternately cephalad and caudad. The characters presented by the saws or ventral valves are probably specific and though this fact has often been mentioned in literature no one seems to have made a definite study of them on a large scale in order to determine their taxonomic value.

A few of the variations may be mentioned here. The shape, number, size, and spacing of the teeth on the ventral margin constitute the most readily observable characters. The shape of the teeth varies from a slight undulation of the margin to quite prominent sharply pointed - Cladius isomerus Norton - or obtusely rounded - Monophadnoides rubi (Harris) projections. The rounded teeth may have their margins serrulate as in Caliroa cerasi (Linné) in fact numerous combinations and variations may be found in this respect alone. The number of teeth varies all the way from none as in Macroxyela ferruginea (Say) whose margin is entire to about seventy-two in Cimbex americana Leach. Pteronidea ribesii (Scopoli) is practically lacking in teeth but they appear to have been lost (perhaps through disuse) whereas in M. ferruginea (Say) they do not seem to have ever been present. The size varies from minute serrulations which are only visible with the aid of considerable magnification to quite large teeth as in the genus Priophorus. The spacing is quite distinctive the most common arrangement being a gradual decrease in the distance between teeth from base to apex the terminal ones becoming very close together and smaller in size. However, in Cimbex the spacing of the seventy-two teeth is more nearly constant throughout.

The lateral surface also presents some distinctive characters which in some forms are very striking. Morice (1913) has ably demonstrated some of the characters in the genus Dolerus and the closely related genus Loderus. There are groups of hairs or setae, and variously shaped thickenings of the chitin which usually run down in the shape of inverted cones from the dorsal to the ventral margins of the valves, their contiguous bases often giving the appearance of an arched aqueduct. There are in addition often quite prominent lateral teeth which point toward the base of the saw. Their location will be described below.

There is a structural peculiarity common to the inner and ventral valves which has not been hitherto mentioned. When well marked as in the ventral valves of the genera Priophorus and Cladius the valve appears to be made up of sections placed one within another. This may be likened to a side view of a number of ice cream cones placed one within another, the only difference being that there would have to be an increase in size toward the base to give the outline as a whole a tapering appearance. In this illustration it is easy to realise that the edges along the upper and lower margins (if the string of cones be laid horizontally) will appear more or less dentate according to the thickness of the cones and that there will be a series of vertical ridges connecting the teeth above and below. This structural peculiarity may be much obscured but is nearly always present. There is no trace of it, however, in Macroxyela ferruginea (Say) which, as mentioned above, is toothless, but it can be readily discerned in Pteronidea ribesii (Scopoli) which is very nearly toothless. In the genera Priophorus and Cladius the vertical ridges mentioned above bear the lateral teeth whose points face toward the base of the saw and whose bases rest on the ridges. These are also present in Loderus palmatus (Klug) where, however, they are quite inconspicuous on the basal half of the valve. As in the cone simile the vertical ridges end in the marginal teeth though these are seldom present on the dorsal margin of the ventral valves. Other points which might be considered are the shape of the apex, the relative widths of different parts of the saw, the proportion of width to length, the transparency, and the position of the groove which is not always exactly on the dorsal margin but may be a slight distance ventrad of it.

Having briefly outlined the structure of the ovipositor a description of its manner of use should be more easily understood. Before taking this up, however, it would be helpful to enumerate the parts of plants chosen by the female sawfly for oviposition. Since the larvae feed for the great part on the more tender leaves of various plants it is only natural to expect to find the eggs on or close to such places. Most sawflies known to the writer lay their eggs within the tissue of the leaf blade, some species choosing the marginal areas, others preferring the main veins and still others laying their eggs indiscriminately in any part of the leaf lamina. They may be laid from the upper surface, the lower surface, or the margin. The needles of pines are also included here. Of those species that do not lay their eggs in the leaf blades a few examples will suffice to give an idea of the variations to expect. Some eggs can hardly be said to be laid within the tissue of the leaf though they may be laid on the blade of the leaf. Pteronidea ribesii (Scopoli) is an example of this well known to most people and Chapman (1920a) notes that the same is true of Thrinax mixta (Klug). Janus _integer_ (Norton) oviposits in the stems of the young terminal currant shoots; an undetermined species of Priophorus in the petiole of raspberry leaves; _Emphytus serotinus_ in the twigs of the new growth of oak, Chapman (1919a); _Trichiocampus viminalis_ (Fallén) in the petioles of poplar leaves, Chapman (1918), Rohwer and Middleton (1922); and _Macroxyela ferruginea_ (Say) in the buds of elm. In the last named species the egg may or may not be in the plant tissue. It is variously in between the embryo leaves, within the folds of a leaf, or within the leaf tissue, always, however, being in the bud. The wood-borers including the families Xiphidriidae, Siricidae and Oryssidae are obviously not here classed with the plant-feeders.

The actual process of oviposition is probably best observed in _Pteronidea ribesii_ (Scopoli) for a description of which the reader is referred to Part II. The common pear and cherry slug, _Caliroa cerasi_ (Linné), is also a good species to make observations with because when held against the light the ovipositor (ventral and inner valves here) can be clearly seen through the leaf of pear. Further the saw can be seen from the upper surface of the leaf through the epidermis but not so well as by holding the leaf against the light. Marlatt (1897) figured the egg pocket and showed the position of the ovipositor therein. It is the habit of the female to first run over the upper surface of the leaf and when satisfied with this examination to go to the under side of the leaf and select a spot in which to start operations. When a suitable site is found the female bends the tip of the abdomen toward the leaf at the same time bringing the sawing mechanism (inner and ventral valves) out from the sheath (dorsal valves). The points of all four valves are first pressed vertically against the leaf surface and the saws (ventral valves) begin to work rapidly up and down. Soon the epidermis is pierced and the valves sinking more readily into the underlying tissue are turned to one side so that the part within the leaf is now parallel to the leaf surface. This is continued until nearly the whole of the sawing apparatus is within the leaf tissue just beneath the epidermis of the upper surface of the leaf. At this time the valves are nearly at right angles to the long axis of the female and as the latter does not turn on her side the valves must be bent sharply in the neighborhood of their entry into the leaf. From this position the point is swung forward through an arc cutting a pocket with the whole of the ventral margin of the saws as it moves. As the base remains practically stationary the original hole of entry into the leaf is enlarged but little. The point of the valves is continued forward until their long axis is not quite parallel to the long axis of the female. The valves are then moved back to their first extended position and as they go an egg is deposited in the cavity and the valves are finally withdrawn from the leaf. There are slight variations in the procedure, sometimes the valves when moved back remain a few seconds before the egg is laid; the angles between valves and insect at start and at finish of the arc stroke are also subject to variation; occasionally the valves are forced clean through the leaf and the insect, unable to withdraw them, is held until she dies. The question as to whether the ventral valves move out beyond their supports, the inner ones, is not easily settled. The writer hesitates to make any definite statement on this point. According to Chapman (1918) there is a variation, some saws in their outward movement passing well beyond the supports and others not going further than the end of the supports. Of <u>Cladius viminalis (Fallén)</u> he writes "...the two saws advance together and then retreat, but at one advance one saw is in front, in the next the other, and so on alternately. The sharp stiletto of the saws is thrust a long way beyond the support and then withdrawn, and there is a twinkling in the upper part of the saws demonstrating that they also advance and retreat alternately" From the latter part of the above extract the writer infers that Chapman means the inner valves move back and forth also, and if this is the case one can readily see how the ventral valves would appear to move far beyond the inner ones. The writer has not examined the ovipositor of this species but as mentioned elsewhere there are species which have the inner valves united dorsally from base to apex so that any back and forth movement in these species would be impossible.

In the species which lay their eggs in the petioles of leaves, at least with some of them, there is no necessity for the lateral bending of the saw apparatus because the saws are driven straight into the tissue which is considerably thicker than that of the leaf blade allowing more room to pierce downwards than sidewise. This is also largely true of certain species laying their eggs in the margins of leaves. It might be added that the inner valves usually bear on their dorsal extremity some kind of notch or notches (in some cases large teeth) which must help to prevent them from becoming withdrawn when the tissue is being pierced. The alternating movement of the ventral valves tends to bring about the same result for one side is, as it were, forced in at the same time as it is being used as a lever for the withdrawal of the other side.

The writer has never observed oviposition in either the Xiphydriidae or Oryssidae and the observations made on the Siricidae were only in connection with Tremex columba (Linné) and these were very general. In Tremex the inner valves are firmly united along their entire length and, with the ventral valves, are of practically the same size throughout. The ventral valves are distinct as in all the members of the Chalastogastra known to the writer. Tremex lays its eggs in the trunks of dead or dying trees and has repeatedly been seen ovipositing in the same tree from which it emerged.

When a suitable location is found the female raises the abdomen so that when the inner and ventral valves are extruded they are braced vertically between the abdomen and the wood surface. Then by muscular movements which involve the caudal segments of the abdomen the ventral valves are slid up and down appearing to travel a considerable distance. From observations made with the naked eye only it seemed as if the caudal portion of the abdomen were rocked from side to side pivoting in the centre on the fused inner valves. Owing to modification the ovipositor appears to arise from the centre of the venter but a careful examination shows that the sternite immediately cephalad of the origin of the ovipositor is still the seventh as in all the sawflies. The operation of drilling the hole for her egg takes the female a considerable time and quite often the valves are the cause of her death for they become so firmly wedged in the wood that she is unable to extricate them. As a device for boring into wood the ovipositor of Tremex does not seem very efficient and it is not easily seen just how the valves are worked into the wood at all. In the case of the ichneumon Megarhyssa lunator (Fabricius) whose larvae are parasitic on the larvae of Tremex columba (Linné) the wonder is even greater. It has been suggested to the writer that Tremex only lays eggs in wood that is already greatly softened by decay or fungus. A tree which appeared to be perfectly healthy and to have the normal amount of foliage was noted to be seriously attacked by T. columba (Linné). The trunk showed many exit holes of the adults and some twenty or more females were taken whilst in the act of boring into the wood. The deception was soon exposed by a strong gale which snapped the tree off some fifteen feet from the ground when an examination revealed the entire heart wood penetrated by the mycelium of some fungus and this had extended to the surface in some places though not sufficiently to cut off the peripheral sap supply.

Egg Pockets - The writer does not know of any species of sawfly laying more than one egg in a single pocket. It would not seem improbable, however, that one might find two pockets coalesced especially in the case of those species laying many eggs within one leaf. But this would not alter the fact that for every egg laid a pocket is made by the female. The shape of the egg or its size do not seem to be correlated with the shape and size of the pocket in any way except in so far as the obvious fact that the pocket must at least be large enough to contain the egg. For example Caliroa cerasi (Linné) oviposits from the lower surface of the leaf and the egg pocket shows only from the upper surface. In this case the pocket is quite large, roughly elliptical in shape though one or more of the edges may be nearly straight, and the much smaller egg occupies the centre with a clear free space between it and the limits of the pocket. Metallus _bethunei_ MacGillivray on the other hand lays its eggs from the upper surface of the leaf and the pocket can only be seen on the lower surface of the leaf. Here the pocket is circular in outline and tightly filled by the egg, so much so that the egg must be considerably bent out of its free shape to get into the pocket at all. In _Monophadnoides rubi_ (Harris) almost invariably and sometimes in _Diphadnus appendiculatus_ (Hartig), the female inserts the ovipositor in the edge of one of the main veins on the under surface of the leaf. In these cases the pockets appear as elongate swellings in the angle between the vein and the leaf surface. _Allantus (Emphytus) cinctipes_ (Norton) in a few cases observed laid its eggs from the upper surface of the leaf and the swelling caused by the egg within the pocket appeared about equally on both upper and lower surfaces it being impossible to tell with the eye which was most prominent. It would seem that the particular part of the plant chosen by the female and the nature of the tissue in which the pocket is made largely govern its shape.

Although a series could be chosen which would show all stages between eggs laid practically entirely exposed and those completely buried within the tissue yet the process seems to be rather a modification from enclosed to exposed eggs and gives us no clue as to how the pocket-forming habit originated. Thus _Pteronidea ribesii_ (Scopoli) might be said to lay its eggs on the surface (see Part II). As noted by

Chapman (1920b) Pteronidea pavida (Lepeletier) appears to lay its eggs in a similar manner but a careful examination shows that the epidermis of the leaf covers much of one side of the egg. From this to the complete covering of the egg would not be a very big step.

EGGS

The exposed eggs of Pteronidea ribesii (Scopoli) have a rather soft and flexible chorion so they are very easily crushed or otherwise injured by slight pressure. Many eggs of other species which are not exposed are far more delicate so that it is not a simple matter to dissect one of these eggs from its pocket without injuring or distorting it. As mentioned elsewhere (under Egg Pockets and in Part III) the eggs of Metallus bethunei MacGillivray must be pressed into a shape to conform with the pocket and it would seem that this flexibility of the chorion is in some ways an advantage in that the egg can easily be forced into the cavity without causing too much injury to it or to the surrounding plant cells. The shape of the free egg is generally somewhat cylindrical with the ends rather bluntly rounded and with the sides straight along one surface and convexly curved on the opposite side. The color is usually a pale whitish, often with a pearly lustre, but varies somewhat with the stage of incubation. All eggs seen by the writer bore no sculpturing of any kind.

The incubation period depends very largely on the temperature. In the same species the time may vary from three to eighteen days, *Pteronidea ribesii* (Scopoli), though some species do not seem to vary nearly as much as this. For instance in the rearing of *Caliroa cerasi* (Linné) the variation was between eight and ten days only, though doubtless under certain conditions these limits might be extended. No records for the incubation period in the writers notes are outside of the range quoted for *P. ribesii* (Scopoli) above. According to Chapman (1919a & 1919b) the egg is the overwintering stage of *Emphytus serotinus* and *Pteronus sertifer*.

Sawfly eggs seem to be absolutely dependent on a supply of moisture. When removed from their pocket or cut off from the surface they very quickly dry up and turn brown. Chapman (1920b) notes this in connection with *Pteronidea pavida* (Lepeletier) though he uses the word 'nutriment' instead of moisture, and the writer has often noted it in the case of *P. ribesii* (Scopoli) (see Part II) as well as in a few other species. It is probably true of most if not all sawfly eggs saving perhaps the wood-boring families.

An oft commented upon characteristic of sawfly eggs is that they increase markedly in size between the time they are laid and the time they are ready to hatch. This increase is of sufficient proportions to be readily seen by the naked eye. MacGillivray (1913) states that the eggs swell up to twice their natural size (linear measurement or volume?) and that the swelling commences at a time after they are laid varying with the species. It is a difficult task to get actual measurements from eggs laid within the plant tissue because as mentioned above they dry up and fail to develop when exposed. The eggs of Caliroa cerasi (Linné) have been seen to break the epidermis covering them so that they were exposed to a varying extent, and the eggs of a species of Priophorus to extend out beyond the pocket in which the female had placed them. In both cases the swelling of the egg seemed to be the cause. With Pteronidea ribesii (Scopoli) it is a simple matter to measure the eggs in situ. Some account of the measurements made by the writer with this species is given in Part II and all that it is necessary to say here is that with P. ribesii (Scopoli) neither of the linear dimensions of the egg is doubled and the increase in size varies from a gradual enlargement from first to last to spasmodic increases and resting periods. In either case the difference between first and last measurements is approximately the same. This increase appears to be due to the development of the embryo which can be seen through the shell wall. The moisture taken up is probably necessary for the development of the embryo and is not directly concerned therefore with the increase in size. As the eggs are quite commonly laid in tissue which is still growing it is possible that the swelling of the egg tends to prevent crushing of the embryo in these cases. It might be also that the expansion tends to prevent the surrounding tissue from forming a callous around the egg which might both jeopardise the escape of the larva and cut off the moisture supply. With either supposition P. ribesii (Scopoli) stands rather in the way unless explained by saying that the exposed eggs represent a modification more recent than the swelling of the eggs.

LARVAE

Sawfly larvae are most easily separated from other larvae from the fact that the former have usually more than five pairs of abdominal legs and only a single ocellus on each side of the head. There is much variation in the coloring of the body which is more often naked than not. Detailed characters are given by Yuasa (1922).

Hatching - As the chorion is transparent the movements of the embryo can be seen within the egg. Pigment areas such as the tarsal claws, mandibles, ring surrounding each of the two ocelli, and sometimes the whole head, enable one to watch the movements fairly closely. Unfortunately it is necessary to open the pocket for this examination so that it is not possible to ascertain the normal behaviour of the larva on emerging from the egg. MacGillivray (1913) says "the young larvae issue through the slit made in the leaf by the female in inserting the egg", and where the eggs are laid in the petiole of the leaf this is just what one would expect to occur. With Caliroa cerasi (Linné), however, the eggs are laid by the female from the under surface of the leaf and the young larvae escape by cutting a crescentic slit through the epidermis of the upper surface of the leaf. The female Allantus (Emphytus) cinctipes (Norton) lays her eggs normally from the upper surface of the leaf and the larvae cut their way out on to the lower surface. Monophadnoides rubi (Harris) inserts its ovipositor in the edge of a vein on the underside of the leaf and the larvae make their exit through a round hole in the side of the pocket. Caliroa aethiops (Fabricius) lays its eggs from the upper surface of the leaf and the larvae emerge on the lower surface. Diphadnus appendiculatus (Hartig) may lay its eggs in a manner somewhat similar to M. rubi (Harris) above or in the margin of the leaf. In either case the larvae do not normally escape by way of the hole made by the female in ovipositing. It would seem highly probable that many more examples could be found.

As noted for P. ribesii (Scopoli) and Metallus bethunei MacGillivray (Parts II & III) the larvae in these species seem at first to be incapable of feeding owing to the soft condition of the cranial chitin which is unable to withstand the requisite muscular strain. If this is true of other species a rest period would seem to be a necessity between the hatching of the egg and the escape of the larva from the egg pocket. A larva of Macroxyela ferruginea (Say) was discovered on the opening of a bud to be feeding on the leaf tissue while all of its body except the head and thorax was ensconced in the egg-shell. In this case the egg was not within the tissue but was held between the folds of a young leaf.

Habits - Some larvae develop within the pith of canes, in twigs, in solid wood, in galls, and in fruit; others are miners within leaves, whilst a distinct group (Oryssidae) are parasitic, Burke (1917), Yuasa (1922). The majority are external feeders on foliage of various kinds. Many are specific in their food requirements, others will feed on closely related plants and a few will feed on a diversity of plants. Some feed by skeletonising the leaves i.e. eating only the soft parenchyma and leaving the framework entire, others eat holes here and there in the leaf and still others feed on the margins. The larvae may feed together or be widely scattered. For a list of host plants the reader is referred to Cameron (1882), MacGillivray (1913) and Yuasa (1922)

The positions assumed by the feeding and resting larvae are very characteristic. To give a few examples Tomostethus bardus (Say) usually feeds with the body straight and at right angles to the margin of the leaf. Diphadnus appendiculatus (Hartig) often rests entirely on the margin of the leaf and may feed in that position so that its outline appears to be the outline of the leaf. Allantus (Emphytus) cinctipes (Norton) rests on the under surface of the leaf coiled in a helix and apparently only holding on by the thoracic legs. Cimbex also assumes the spiral resting position but the whole body may be resting on the leaf. Many larvae when moving on and around the margins of leaves have a habit of holding the end of the abdomen to one side, the thoracic legs doing most of the work. When disturbed the abdomen may be shaken from side to side in the air the thoracic legs meanwhile maintaining the hold. The progression of Macroxyela ferruginea (Say) along the smooth twigs of elm is a truly comical sight. Presumably there is great danger of being shaken off by passing gusts of wind for the larva first encircles the twig forming a ring around it, the head either just touching the tip of the abdomen or lying closely alongside the caudal segments according to the length of the larva and the diameter of the twig. From this position two distinct methods of progress can be watched. In one of these the larva goes round and round the twig always keeping the head close to the end of the abdomen and thus describing in its advance a spiral similar to the threads of a screw. No slower or safer way could easily be imagined. The other method is considerably faster and consists in a lateral movement of the head and thorax which is continued all along the body until the end of the abdomen is once more against the fore part of the body the latter being moved forward again and so on. As a rule the larvae cling quite tenaciously to their support but some species drop off as soon as touched and others even before this.

As mentioned above some larvae mine within the leaf. These are modified in structure to suit the peculiar conditions and they bear little superficial resemblance to their relatives feeding on the surface. The writer in rearing Schizocerus zabriskiei Ashmead was surprised to find that the larvae of this species whilst mining in leaves do not develop entirely in a single leaf but pass on to mine other leaves never stopping to feed on the surface. This had been previously noticed by Webster and Mally (1900) who, however, do not seem to have been struck by the fact that other species of sawfly larvae which develop entirely within a single leaf are quite helpless when out of their mine. The writer, Garlick (1922) noted that the larvae of S. zabriskiei Ashmead seem to be intermediate in character between true mining and surface feeding larvae.

Wheeler and Mann (1923) found sawfly larvae travelling en masse which though previously noted in Lepidoptera has not been before reported for sawfly larvae.

Molts - A few observations on Macroxyela ferruginea (Say) seemed to indicate that these larvae molt four times. Metallus bethunei MacGillivray, Pteronidea ribesii (Scopoli) and Caliroa cerasi (Linné) molt five times normally though there is a variation (as discussed for the first two in Parts II & III). Webster (1912) shows very clearly the variation in the number of molts in C. cerasi (Linné). Although his rearing conditions were rather abnormal the observations illustrate a possible variation of from five to eight molts and they further show that molting is not necessarily accompanied by an increase in size. The writer noted six molts in this species with the larvae practically under field conditions. In connection with the ultimate molt of Tenthredinid larvae Marlatt (1890) says "this molt is not accompanied, as in the earlier ones, with an increase in the size of the head". MacGillivray (1913) says there are five to seven instars in sawfly larvae the number being different in the different groups.

With one noteworthy exception the instars are all more or less alike in general appearance. This exception occurs in a certain group in the last instar or after the larva has molted for the last time and is ready to seek for a suitable spot where it may form its cocoon. So completely may the larvae differ in appearance before and after the ultimate molt that many persons have thought they were dealing with a different species. For example the common currant worm, Pteronidea ribesii (Scopoli) before the ultimate or final molt has a black head, the dorsum and pleurae are covered with many shiny black setae-bearing tubercles, the thoracic legs are largely black and the area in front of the anal cerci is more or less black. After the final molt the larva is a pale green all over. Monophadnoides rubi (Harris) at the ultimate molt loses its protective coat of formidable spines. An undetermined species noted by the writer lost its black spine-bearing tubercles and became a dull bluish color. Tomostethus bardus (Say) exchanges a black head and thoracic legs and a pale waxy-yellow body for a pale head and legs and a somewhat blackish body. Cameron (1882) explains this peculiarity on the ground that it is a protection to the larvae as at this time they leave their host plants in search of a place to make their cocoon and therefore if colored the same as when on the plant they would be unduly exposed on account of the lack of harmony with their surroundings. Marlatt (1890) does not agree with Cameron and suggests that it is on account of the long period spent as a larva within the cocoon, especially in species having but one brood per year. He further states that the final molt may be analogous to the one before pupation proper in insects and has no counterpart in any other family of insects. Whatever the color significance may be it is obviously advantageous for a larva that is going to remain many months at a stretch within its cocoon to be first rid of tubercles and spines. Not only would such structures be a hindrance to the larva in its cocoon but they could often prevent it from making a cocoon at all, especially where this is done in the soil. It should be mentioned here that no feeding takes place after the ultimate molt. Not all sawflies exhibit this peculiarity which will probably be found to be limited to a definite group. In Macroxyela ferruginea (Say) the larvae are the same in color pattern after the final molt as they were before it.

It is of interest to note that in this last example the color pattern which consists of white markings on a green background changes gradually after the final molt. The white markings fade away till they are quite unrecognisable and the larva assumes the green color all over.

Cocoon - When through feeding, which is just before the ultimate molt in those species which exhibit this phenomenon, the larvae may rest awhile motionless. Sooner or later, however, they become quite active and imbued with the 'wanderlust'. The writer has often noticed that all through the feeding period the larvae in the cages might be quite sluggish even when pulled off their food plant and set free to return thereto. But as soon as the 'wanderlust' develops these same larvae were overcome with a feverish haste to 'get somewhere' reminding one of the larvae of the common Isabella Tiger-moth. Probably most sawfly larvae spin their cocoons in the soil and as examples of how this is done the reader is referred to Parts II & III where the process is taken up in some detail. The wood-boring species remain in their burrows where pupation also takes place. Allantus (Emphytus) cinctipes (Norton) normally tunnels into the pith of rose stems (rose being the commonest host plant of this species) where it spins a somewhat flimsy cocoon. An undetermined species of Priophorus seemed to prefer cavities in rotting wood. MacGillivray (1913) states that some tunnel into rotten wood. Although in cages many larvae will not spin a cocoon unless supplied with the material requisite for the species there is, nevertheless, a certain amount of adaptation. For instance Diphadnus appendiculatus (Hartig) and Pteronidea ribesii (Scopoli) normally spin their cocoons in the soil but they will also spin up between leaves on the ground and even on the bush itself. This has been observed to take place in the field as well as in the cage. The writer one season found many larvae of Allantus (Emphytus) cinctipes (Norton) feeding on strawberry leaves in a large field some distance from rose bushes. Some of these were collected and caged being supplied only with strawberry plants and soil. In spite of this some adults were reared from these larvae though the mortality was high. In another experiment with the same species dry raspberry canes were broken into suitable lengths and placed in the cage and into the pith of these the larvae tunneled with no noticeable hesitation. The tunnels were slightly curved along their length which ran from two to four and a half centimeters. The resting cell was usually slightly larger than the remainder of the tunnel. Species making their cell in the soil or in wood usually line it with a material which is given off from an opening in the labium and the thickness of this lining varies with the group. It is usually thickest in soil forms.

One would naturally expect that once its cocoon was finished the larva would assume the pupal form but this does not seem to be the case with most sawfly larvae. Pupation seems to take place always very shortly prior to the emergence of the adult so that the larvae will only pupate soon after spinning a cocoon in those cases where emergence as a new brood the same season takes place. Sinee, however, many sawflies are single brooded and that in the case of those having more than one brood these are often only partial a larva as such may remain in its cocoon nine or ten months normally, or up to about twenty-two months in exceptional cases where a whole season is passed over. If at any time during this rest period a cocoon is opened the larva will be found within little changed with respect to color but much contracted cephalo-caudad and in general appearance like a short fat grub. The head is usually bent very slightly ventrad, the thoracic legs are all close together on each side and project vertically away from the ventral surface and the abdominal segments are telescoped towards the thorax. One may find in Pteronidea ribesii (Scopoli) the tip of the abdomen turned against the venter much as in white grubs though the abdomen is not at all enlarged in the case of the sawfly. In cages where suitable material is not supplied the larvae will, after a shorter of longer period of wandering around, contract and assume the typical appearance they take on when in the cocoon. The writer has never succeeded in getting such contracted larvae to spin a cocoon when supplied with the requisite conditions though it is possible but difficult to keep such larvae alive if careful attention be paid to light and moisture requirements. The writer has also removed larvae from their cocoons and tried to induce them to re-spin but without success. They remained alive so long as moisture conditions were carefully watched but soon perished otherwise. MacGillivray (1913) says of certain larvae that "just before they are ready to cast their larval skins and become pupae they may leave their cocoons or earthen cells or their tunnels in rotten wood and force themselves to the surface of the soil where they will remain as if dead, only wriggling the body when disturbed. Such larvae may pupate on the surface of the soil and produce adults or they may die".

PUPAE

The pupa is of the usual hymenopterous type lying free within the cocoon. The question as to the time spent in this stage is not readily settled. If the time from the spinning of the cocoon to the emergence of the adult (in species of more than one brood) could be taken as the pupal period the calculation would be simple enough. However, for reasons pointed out above this method will not work. The shortest time between cocoon formation and the emergence of the adult that the writer has note of is eight days. That the time is quite short at least for certain species there can be no doubt. Harukawa (1921) says of a peach sawfly that the pupal period is from four to five days, and Maxwell-Lefroy & Ghosh (1908) give for Athalia proxima (Klug) five to six days. It would seem that there is plenty of room for careful work on this point. For instance it would be of interest to know whether the pupal period bears any relation to the time spent in the dormant larval condition. Also as to whether the changes within the larva take place over a long period of time, in other words are gradual, or whether they happen more or less rapidly.

Young (1899) records an interesting observation on the pupae of Macroxyela ferruginea (Say). He says "A few days before the appearance of the adult the larva......changes to an active pupa, which bursts its cocoon and comes forth without shedding its skin and exists then as an active pupa at the surface of the ground from twenty-four to forty-eight hours. It then sheds its skin and becomes the true imago". This would seem to explain satisfactorily why the writer noted many of the adults of this species with parts of their pupal skins adhering to them. Thus some had quite large portions stuck to their tarsal claws, others to the wings , and one was noted with the pupal case still covering one antenna. It would be a task for this insect to get clear of its pupal skin when it is merely lying unattached to anything on the ground.

The adults gain their freedom by tearing out one end of the cocoon, by cutting a circular piece out neatly at one end, or as described by Fabre (1891) in the case of Sirex augur Klug by chewing some distance through solid wood. In the same place Fabre recalls the incident of the adults in their effort to escape piercing the lead of bullets in the arsenal at Grenoble, France, the species in this case being Sirex gigas (Linné).

BROODS

If anyone will take a hasty survey of the literature on the economic forms they will find quite a difference of opinion on the number of broods of the same species. There are several reasons for these discrepancies the most important being the overlapping of broods and the variation with season. As the season advances broods tend to overlap so that it is impossible to correctly name the brood one is dealing with when all stages of the species are present at one and the same time. Of the variation with season the writer feels reasonably sure that with some species the number of broods varies with the season. Some species are unquestionably one brooded. Macroxyela ferruginea (Say) which lays its eggs in the buds of elm in the spring could hardly have more than one brood unless it had two ways of ovipositing. Monophadnoides rubi (Harris) is generally conceded as having only a single brood. The adults of this species appear in Ontario at the latter part of May and in 1922 larvae were found in the field up till August 9th, so that if the species is one brooded the adults must continue to emerge over a very long period. The adults are not easily seen and the point has not yet been definitely cleared up so far as the writer knows. Pteronidea ribesii (Scopoli) is usually given as being two brooded in this country and this is probably in general correct (for further details of this species see Part II). Diphadnus appendiculatus (Hartig) is given by Sanderson and Peairs (1921) as being two brooded yet the writer reared six generations of this sawfly in one year in cages kept out of doors. Metallus bethunei MacGillivray (see Part III) seems to be normally two brooded but in 1921 a third brood appeared in parts of Ontario. Caliroa cerasi (Linné) has apparently but two broods in Ontario.

In stating that a species of sawfly has two, three, or more broods it should be born in mind that not all of one generation may emerge as a following generation. In other words the broods are usually only partial. There is room for much experimentation here for probably many variations occur of which we are at present quite ignorant. D. appendiculatus (Hartig) and at least two other species when reared in the insectary showed complete broods, but with others as P. ribesii (Scopoli), C.cerasi (Linné) and others only a small percentage of the first generation emerged as a second. This system of partial broods seems to be a wonderful adaptation to assure the continuation of the species and is in the writers opinion a forerunner of the now well known fact that some insects instead of emerging the season following their activities as is normal miss out a season and appear one year from the time one would ordinarily expect them. This has been shown to occur in certain Diptera, O'Kane (1914), in Lepidoptera, Riley (1893), and some sawflies, Chapman (1919c) also Maxwell-Lefroy & Ghosh (1908). It should not be necessary to add that where a whole year is missed the number doing so is only a part of the original generation.

A partial brood system may be illustrated somewhat as follows. Suppose A represents the adults of a species of sawfly that appears in the spring. In this hypothetical case all the overwintering forms in this species appear as adults at the same time. Only a part of brood A will appear as a second brood B so we will suppose for illustration that a quarter of A emerge as B and three quarters stay in the soil (resting stage). This can be written thus:- $\frac{1}{4}$A emerge as B, and $\frac{3}{4}$A remain in the soil. In like manner brood B will be producing brood C, again only partially, so that $\frac{1}{4}$B will emerge as C and $\frac{3}{4}$B will stay in the soil. If C is the last brood all of it will stay in the soil. In the following season then we shall have emerging all at the same time in the spring $\frac{3}{4}$A, $\frac{3}{4}$B, and C. Thus if any of the generations after the first fail to survive there will still be some of the first left to carry on the race. The passing over of a whole year seems to be an attempt to overcome the possibility of even this first generation failing completely.

PARTHENOGENESIS

It has long been noted that sawflies among other hymenopterous insects are parthenogenetic. In spite of the many allusions in literature to the parthenogenesis of this or that species no one seems to have gone into the subject at all deeply. Peacock (1922b) points out the lack of data and lists some of the kinds of parthenogenesis. In rearing experiments the writer noted that unmated females of Pteronidea ribesii (Scopoli) produced only males and that when mated both males and females appeared. An unmated female of Diphadnus appendiculatus (Hartig) produced several generations of females only and then both females and males in subsequent generations. Caliroa cerasi (Linné) yielded only females (though males are known in this species). An undetermined Priophorus yielded only females. The few examples given show what diversities are likely to be met with and as yet the field is almost untouched.

Concerning C. cerasi (Linné) Ewing (1917) suggests that in connection with a high mortality of the second brood where he made his observations the trouble was caused by the lack of vigor due to the absence of fertilisation for this brood, parthenogenesis being normal for the first brood only. For reasons which it is not necessary to go into here the writer thinks that other causes will explain this failure of the second brood in a much simpler way.

MEANS OF SPREAD

Since many of the injurious species of sawfly have been imported into this country from Europe it might be interesting to note how this transfer might take place. Without doubt most species are carried as larvae in their cocoons in the soil. In shipping plants, particularly nursery stock, much earthy material is often used. Evergreens are often 'balled' to use a nurserymans term which implies that the plants are dug up with a 'ball' of earth round the roots which is held in place by a wrapping of burlap. Not only species living on the evergreens might thus be imported but if the plants were grown near to where other sawfly larvae were feeding on some other host the larvae might crawl into the soil round the evergreens to spin their cocoons. Almost any inspector of imported plants can recall finding live larvae and adults of different insects so that the conditions must often be suitable for the transportation of sawfly cocoons. Indeed one would expect that in many respects the requirements of the plant and insect would be fairly alike.

It has already been mentioned that Allantus (Emphytus) cinctipes (Norton) burrows in the pith of rose stems to make its cocoon and it requires no imagination to see that a ready means of transport is thus provided even were there no soil shipped with the plants.

Scattered through the literature there are records of some of the wood-borers (Siricidae) emerging from lumber and even from furniture. There is thus always the chance of some individuals being carried long distances in timber, in fact the passage of the Atlantic has already been made in this way.

PART II

LIFE HISTORY OF THE IMPORTED CURRANT WORM

Pteronidea ribesii (Scopoli)

Index

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PART II

Index

(continued from page 53)

Introduction - Of the history, synonomy and distribution of this species the writer intends to say very little here except to refer to the literature. The history dates back many years. Scopoli descibed the female in 1763 and Reaumur (1740) figured the larvae eggs and adult. Since then it has been known under various names and for the synonomy and references the reader is referred to Dalla Torre (1894) for the European, and Marlatt (1896) for the American literature. Dalla Torre gives the distribution as Europe boreal and central, Canada, and United States. Marlatt gives simply Canada to Missouri for America.

Since there is scarcely a bulletin, circular, or periodical treating of injurious garden insects which does not mention the Common Currant Worm or Imported Currant Worm, Pteronidea ribesii (Scopoli), and since the literature treating of the life history or various stages of the life history would fill many volumes it would seem that any further writing on the subject would be superfluous unless indeed the writer had made some new discovery not yet recorded. At the very beginning the writer wishes to make it clear that he has no startling discovery to disclose, that while he believes much of it may duplicate what has already been written yet some of it is new and all of it is original. If the complete life history of any insect (see Hayes,1922) has ever been written the writer is not aware of it. He believes that if the present incomplete collection of notes and observations does nothing else it will at least show what a little we know about this very common insect in comparison with what there is yet to be learned.

The notes and observations were made in three different places and in three different years. In 1919 at Burlington, Ontario; in 1921 at Vineland Station, Ontario; and in 1923 at Lawrence, Kansas. The first two places are within fifty miles of each other and are on the western shores of Lake Ontario. The third locality is some eight hundred miles south and west of the first two.

This part of the paper is divided for convenience into three sections. Under the first will be taken up a detailed life history, pieced together from insectary and field observations. The second section will deal briefly with the seasonal life history as seen in the field, and the third section will be devoted to a few notes on injury and control.

Before diving into a maze of intricate details it would be well to outline very briefly the essential points in the life history of this sawfly so that with a firm framework at the start it will be easier to place each detail in the mind and to relate it to the rest of the structure.

Beginning with the early spring when the leaves of its host are still quite small the adult escapes from its cocoon in the soil. All winter long is has lain as a larva within this cocoon only pupating a few days before emergence. In a short while the sexes pair and egg laying commences. In about a week the larvae hatch out from the eggs which are laid along the main veins underneath the leaves. They feed on the leaves for about two weeks when they become full grown and about three quarters of an inch long. They then seek the ground, make a cell an inch or so beneath the surface and line it with a silky material spun from the mouth. In this cocoon they may either pupate in a short while and emerge as a new brood or they may lie dormant till the following spring when they will pupate and emerge as adults to carry on the cycle. Such is a very sketchy outline of the life history of the common currant worm. Some of the details will now be filled in.

ADULTS

Description - Female. Length 6 to 7.5 mm. Robust.

Head - Black; with the following parts luteous, clypeus, labrum, mandibles at base, triangular spot between antennae extending to or nearly to clypeus, ventral surface of antennae except two basal segments, variable spot extending from malar space round inner margin of compound eye not quite to level of antennae, variable spot extending round dorsal margin of compound eye which may extend down to level of frontal crest on inner and outer margins and may be expanded on the supra orbital area. Ocellar basin with low but distinct walls interrupted at middle by frontal crest; median fovea circular, distinct; antennae tapering, longer than head and thorax, third and fourth segments subequal or fourth slightly longer than third, blackish above; clypeus shallowly roundly emarginate at centre; labrum slightly narrower in front with rounded corners. Finely and evenly punctate.

Thorax - Black; with the following parts luteous: most of the pronotum, tegulae, more or less of lateral lobes at sides (most marked on the outside), scutellum, scutellar appendage, metanotum, and upper half of mesoepisternum. Finely and evenly punctate.

Abdomen - Luteous except tip of sheath and more or less of posterior margin of basal plates which are blackish. Cerci long, filiform.

Legs - Luteous with the following parts blackish: spot above on tips of anterior and intermediate tibiae and tarsi (sometimes below also), ring round hind tibiae at apex and all of hind tarsi (sometimes there is a variable amount of lighter coloring in the middle of one or more of the tarsal segments); claws cleft, rays about equal.

Wings - Stigma about twice as long as broad, veins of fore wings except base of costa usually dark and shiny.

Male. Length 6 mm. Abdomen quite slender in comparison with the female.

Differs from the female as follows: there is no triangular spot between antennae; light areas round compound eyes often hard to make out; antennae evenly colored above and below, blackish, third segment distinctly shorter than fourth; whole of thorax, except most of pronotum and tegulae, black; abdomen with all of dorsum, except last one or two segments, black; hind coxae usually black at base.

Host Plants - As previously pointed out (Caesar and Garlick, 1920) it is commonly stated that the currant worm feeds on currants and gooseberries. Sanderson and Peairs (1921) quoting Lugger states that it "feeds indiscriminately on all kinds of currants and gooseberries". In England Theobald (1909) says "the red currant is frequently attacked, the black currant but rarely". The writer has yet to record the black currant as a host plant of this species. In one instance eggs were discovered in the spring on an odd black currant bush growing amongst the red varieties. These eggs hatched but the larvae died before they had more than tasted the leaves. In this case the black currant bush in question being somewhat more advanced than its neighboring red currants had probably attracted the attention of some early emerging female anxious to deposit some of her burden of eggs (see under Preoviposition Period). When quite small the leaves of black currant probably do not give off the pronounced odor which marks them later on and perhaps renders them unsuitable food for the larvae. Many attempts were made to force the females to lay on black currant by confining them with only black currant leaves. Success was attained in but one instance and, as noted in the field, the larvae succumbed soon after hatching. That the females experimentated with were normal was proved by supplying them later with red currant or gooseberry on which they laid freely, the larvae arising therefrom being reared to maturity. Other factors being equal no preference could be seen between gooseberry and red currant either in the field or in cages. Saunders (1870) reports the finding of larvae on black currant and plum leaves and adds that they all died.

The red currant does not seem to grow wild though it may often be found round old gardens long since deserted. The gooseberry on the other hand is represented by several wild species some of which are the host plants of the native currant worm, Diphadnus appendiculatus (Hartig), which also has the cultivated gooseberries and red currants on its host plant list. The writer has no record of the currant worm, P. ribesii (Scopoli), on wild gooseberry away from any garden. White currants, which are more nearly related to the red than to the black varieties, are also host plants of the currant worm. It is therefore suggested that until future records disprove or alter it the list of host plants be as follows:- Cultivated varieties of gooseberries and red and white varieties of currants. This may sound somewhat of a quibble but it amounts to dollars and cents in the pockets of the growers when it comes to artificial control measures.

<u>Period of Emergence</u> - By this is meant the number of days during which adults of any one brood will continue to emerge. It is important in that on it depends whether there will be overlapping of broods or whether one can tell with any degree of certainty what brood he is dealing with in the field. For if the spring adults continue to emerge over a long enough period there will be eggs from these adults on the bushes at the same time as eggs from the new brood of adults. In the writers experience this is about what happens in broods other than the first though not enough work has been done with the first brood to be at all sure about it. In the Lake Ontario region eggs were never found at the time the larvae from the spring adults were mature. However, at Lawrence, Kansas, eggs which had been recently laid could be found alongside nearly full grown larvae. An explanation of this can hardly be given until the writer is more familiar with the normal activities of this insect in Kansas. In the north spring adults were seen in the field for about four weeks which, allowing that the length of life is a week, would put the emergence period for the spring at three weeks. In the south adults were noted over a period of three weeks though they were undoubtedly present for a longer time. Experiments in the insectary showed the peak of emergence to be on the second day, the curve falling rapidly to zero on the twelfth day and thereafter running low until zero was reached again on the twenty-fourth day. There were a very

few emergences between the thirty-fourth and thirty-eighth days and a little calculation from Table I, page 86, will show as high as seventy days for cage 2. Experiments seem to indicate that there is a general emergence period covering about two weeks after which time stragglers may continue to emerge at long intervals over a considerable time. This seems to be fairly true for all the broods, though, omitting the stragglers, the spring emergence surely lasts longer than the others on account of the greater variations in temperature which are normal for this time of the year.

Activity - The adults are fairly shy creatures or perhaps it would be better stated that they are so intent about their business that they seldom cross our path. They are most active on hot days when there is little wind, becoming almost dormant if it should turn cold. The females are somewhat slower, clumsier fliers in comparison with the males owing to the burden of eggs they carry. The adults fly freely from bush to bush often settling on any plant that happens in their path but always seeming to keep near the ground. The only time their activities are likely to come under the attention of the ordinary onlooker is when they are mating and the vicinity of the female is alive with males. The writer has often seen a gooseberry bush which showed no signs of any insect activity whatever until with the head near the ground the bush was viewed from below. Then a dozen or more females might be seen either busily ovipositing or resting from their labors on the undersides of the leaves. How far the adults will fly in search of fresh host plants and whether they will cross wide stretches of cultivated land on which no sheltering plants are growing the writer does not know.

Feeding Habits - No solid food was ever seen to be taken by the adults either in the field or in the cages. Water seemed to be a necessity in the cages and adults were noted apparently taking up greedily the liquid from condensation and guttation of the leaves. This source of moisture where the cages were kept out of doors and shaded from the sun proved sufficient. In an attempt to prolong the life of caged adults water solutions of honey, sugar, and molasses were supplied both in turn and altogether. So far as could be observed water was just as good for the insects as the sweetened solutions for which no preference was shown. Miss Chawner (1921) mentions the use of dandelions or buttercups in the rearing cages for the genus Pteronidea. The writer has not tried either of these with the currant worm adults but it would be interesting to find whether it is liquid or solid refreshment they take from these flowers. Certain it is that dandelions are not the resort of this species all hours of the day for the writer has noted the dandelion bloom in the vicinity of gooseberry bushes when the adults were flying but not one was seen to visit a blossom. There is no reason, however, why a short repast should not be taken on some flower which would be sufficient for all needs for a day or more. The writer would suggest that a great deal may depend on the weather and the availability of suitable plants for oviposition. Thus, where all conditions are favorable for the female to go ahead and oviposit without having to travel far or to suspend operations during cold weather, it may be that a little water will supply all her needs. On the other hand if, for some reason or other, she finds herself some distance from any host plant or the weather is inclement, thus protracting the oviposition period, some kind of nourishment may be required to sustain activity until the adult functions are performed. Observations covering many consecutive hours and dissections of the alimentary tract would no doubt elucidate the question.

Longevity - The length of life of the adults can only be determined by confinement in cages and the somewhat unnatural conditions thus imposed upon them may give us results which would not obtain in the field. The maximum by cage experiment for the females was thirteen days and for the males one day less. The average for the females was was seven days. Much seemed to depend on the oviposition period in the case of the females for they seldom lived very long once the eggs were laid. If for any reason the oviposition period was protracted the females usually lived longer. As already noted males are much more active than the females. They do not seem to survive mating very long.

Proportion of Sexes - The writer has not sufficient figures on the sex ratio to give anything like a reliable average. It would seem altogether likely that the ratio would vary with the brood and that this factor would have to be reckoned with in calculating an average. Cages give rise to somewhat abnormal conditions, especially in the case of this species, for the confined females are averse to mating with the result that their progeny are all males. From cocoons collected in the field the females invariably outnumbered the males, sometimes as much as twenty to one. There is another factor in connection with the collection of field cocoons which should not be lost sight of, namely the extent of parasitism. The larvae that will eventually give rise to males do not generally attain the size of those that will give rise to the opposite sex and their exposed life is often shorter. Therefore it may be that the parasitism will be far more on the female than on the male side. Owing to this and other factors as well as to parthenogenesis any average sex ratio should only be computed from figures obtained for the different broods and covering several seasons.

Mating - This takes place in the way common to most sawflies namely with the insects end to end facing in opposite directions. Usually the time taken is but a few seconds though occasionally a pair may remain together up to a minute or slightly longer. In all cases noted it was the males that sought out the females, the latter not appearing anxious to mate at all. In the spring a swarm of males can often be seen hovering round a gooseberry or red currant bush where, if search be made, one or more females are sure to be found. For some reason or other caged females in the writers experience are always averse to mating. No matter how assiduous the male might be in his attentions to the female she almost always managed to dodge or avoid him. An attempt was made to get around this difficulty by caging a female with a large number of males and though by this means mating was effected yet it brought about another difficulty. The females so mated either refused to lay at all or else laid about one quarter of the usual number of eggs. It looked as if the females were injured in some way though they were removed from the company of the males as soon as pairing had taken place. One mating is probably sufficient if one can judge from the progeny of many females taken mating in the field and caged without a male. In one or two cases a caged male was seen to mate with more than one female. Mating shortened the life of the males. Was this in part due to lack of food in the cages?

Preoviposition Period - As the female comes out from her cocoon in the soil her abdomen is seen to be distended with ova. There is therefore no need of a long wait in which the ova may be developed sufficiently to be deposited on the host plant. Even with this knowledge it was somewhat of a surprise to the writer to find that a female could commence laying within sixty-five minutes of her emergence from the soil, Caesar and Garlick (1920). In this instance the female was seen getting clear of the soil in a pot in which was a currant shoot. Up this shoot she crawled and rested for nearly an hour when she became active and ran around on the plant. No mating took place and in sixty-five minutes the first egg was laid. In several other instances periods of two and three hours between the time of emergence and the laying of the first egg were recorded. It seems altogether likely that in the field when the female emerges from the soil she will crawl up on or fly to the nearest bush or plant and rest for a time and that while thus resting the males will gather round her until there may be quite a number of them. Sooner or later a male will succeed in pairing with the female and the latter will fly off and, escaping the males, commence egg laying. Males were not noticed frequenting the vicinity of a female busy ovipositing.

Oviposition - This sawfly differs from most of the other species in that its eggs are concealed in the tissue of the host plant but are plainly visible on the surface of the leaf. They are nearly always laid on the underside of the leaves and in regular chain-like rows along the prominences of the main veins. The female is by no means indiscriminate in her choice of leaves and with few exceptions selects the leaves near the ground and preferably in the very centre of the bush. Here she can oviposit more or less unmolested and not subject to the disturbance caused by every gust of wind that may make the footing precarious on leaves higher up. It is for this reason that the larvae are seldom noticed until they are quite largely grown when, the centre of the bush being more or less denuded of its foliage, they move to the outside of the bush in search of food and are noticed for the first time. It is not uncommon to hear growers and others remark that the "worms eat up the bushes in the night". Where, as is often the case in neglected gardens, the bushes grow so that the canes of adjacent bushes are interlacing eggs may be found not always in the centre of a bush but still near the ground. In exceptional cases the writer has found eggs on the upper surface of the leaves, apparently scattered promiscuously, and occasionally they are not on the veins though on the under side of the leaf. Seldom they may be found on the leaves near the top of the bush.

In ovipositing the female straddles a main vein on the under surface of the leaf her long axis parallel with and directly under the vein. The tip of the abdomen is then curved up toward the vein so that the extruded sawing apparatus will project vertically or nearly so on the prominences of the vein. With the points of the inner and ventral valves pressed against the tissue the saws (ventral valves) are worked rapidly up and down until the epidermis is pierced. As soon as this is accomplished and without going any deeper in the tissue the slit thus started is continued toward the head of the creature, the abdomen being doubled more and more as the cut progresses. As the slit is worked forwards the united dorsal margins of the inner valves rest in the slit thus keeping the two sides apart. Often after the epidermis is pierced the valves will be turned sharply to one side and the cut continued in this way much as described for Caliroa cerasi (Linné) (Part I) only in this case the tip of the valves alone is in the tissue. When the slit is of sufficient length a slight pause is made and following this the egg can be seen travelling down the channel formed by the inner and ventral valves. As soon as the tip of the egg reaches the vein the abdomen is slowly straightened bringing the valves backward. The egg is thus pressed into the slit immediately in the wake of the inner valves as they are drawn backward. Only an exceedingly small portion of the egg is gripped by the slit but it is nevertheless held very firmly. If the description has been followed it will be noted that the last laid end of the egg is facing caudad in relation to the insect. The female next moves forward a little and lays another egg in a similar way the last laid end of the second egg usually not quite touching the first laid end of the first egg. The female may face either the base or the marginal extremity of the veins so that by turning round a vein may be covered with eggs almost from one end to the other. Several eggs are usually laid in this way before the female passes to another vein or leaf. Often every large vein will be crowned with eggs the writer having counted as many as seventy-five on a single leaf. The number quite commonly met with is about twenty-five though only one or two may be found on some leaves. Where eggs are not laid on the veins the leaf tissue is cut in the same way. Without this connection the eggs will turn brown and die.

Number of Eggs Laid - Figures taken from caged females show a maximum from any female of one hundred and forty-four and an average from ten females of ninety-five. This gives an approximate idea of the possibilities in the field and is probably a little on the low side. No attempt was made to count the eggs by dissecting the abdomen of the female though this could readily be done. Before any eggs are laid the abdomen of the female is much distended and as oviposition progresses the abdomen caves in as it were, becoming finally somewhat shrivelled and distorted.

EGGS

Description - More or less canoe-shaped, the surface next the leaf convexly rounded and the surface away from the leaf flat. Ends bluntly rounded. Surface smooth; color pale white with more or less of a pearly lustre. Length when first laid 1.13 mm. Width 0.38 mm.

Attachment to Leaf - It has been shown above how that a part of the egg is gripped by the edges of a slit made in the leaf tissue and it was mentioned that without this organic connection the eggs turned brown and died. A few eggs were found placed on the top of others so that they had no connection with the leaf except through the eggs on which they rested. Unfortunately in handling the leaves these eggs became detached so that the writer has no idea whether they would have dried up or not. That the plant supplies moisture to the egg seems highly probable for if the egg-bearing leaf dries up the eggs will not hatch unless they are very nearly ready to do so before drying up begins. moreover if a cut shoot or leaf be placed in water with a little eosin the pigment will penetrate all the veins of the leaf and will show as a distinct red collar around the junction of leaf and egg, showing clearly that the plant has not modified the tissue round the slit to prevent the escape of water. A strip of leaf tissue bearing eggs was torn from a leaf and placed in a covered watch glass. On the drying of the tissue the eggs dried up also. Another strip was removed in the same manner and dropped in water. Though submerged all the time except when removed for examination the eggs hatched and the larvae got clear of the eggshell before they were drowned. The relation of the absorption of water to the increase in size of the egg is not known to the writer. There is room for a great deal of experimentation to shed some light on this interesting phase of development.

Incubation Period - This is subject to a wide range of variation and roughly seems to vary inversely as the cumulative temperature. In the notth the spring range was between eleven and eighteen days inclusive and later on in the season ran from three to eight days. In the hot weather three and four days was quite normal for the incubation period. The average in the south would probably be lower and the maximum of eighteen days given for the north would probably not be reached so often in the south. It would not seem that the lower limit, three days, could be much reduced though the writer has tried no heat-controlled experiments to determine this.

Increase in Size - A few measurements were made with the compound microscope using a 0.5 mm. squared glass in the eyepiece in an attempt to determine accurately the amount of linear increase and also whether the increase was spasmodic or gradual. Only forty-eight eggs were measured and not all of these were carried through to hatching so the results leave much to be desired though they are of interest. It was early noticed that as the hatching time drew near the eggs might decrease in one dimension and increase in another a greater amount than usual. This was thought to be due to the movements of the embryo within the somewhat plastic membrane representing the eggshell. Measurements were taken from end to end (length) and from side to side (width) when looking vertically on the leaf surface. The width was taken at the widest part which is not usually at the centre. Owing to the movements of the embryo causing perhaps a certain amount of 'distortion' the writer feels that a third measurement should have been made of each egg, namely the depth. This would have to be taken from the side.

In one experiment seventeen eggs, the product of a single female, were first measured about four hours after they were laid and were subsequently measured every twenty-four hours till they hatched which was on the fourth day about six hours after the last measurements were taken. Three of these were injured just before the last measurement was taken and two others did not develop from the start. The following facts were noted. The increase in length from the first measurement to the last varied from 0.18 mm. to 0.29 mm. with an average of 0.22 mm. The width increase ran from 0.20 mm. to 0.25 mm. with an average of 0.22 mm. Thus in this case though the increase in length and width are the same the relative increase is much greater for the width because the egg is much longer than broad. As referred to in Part I neither of the linear measurements are doubled but the actual volume (making no allowance for a change of depth) is very nearly tripled. If the figures are reliable for this species MacGillivray (1913) when he says the eggs swell to "twice their original size" is incorrect if he refers to linear size and underestimating if he refers to volume. The increase was not found to be spasmodic. The first twenty-four hours showed a slight increase in length and width, The second twenty-four hours showed an acceleration in the rate of increase. The third twenty-four hours the increase was greater than the second but the last showed an increase of about the same as the first. The figures are not all arranged this way but the above represents their general trend.

The next experiment showed only too clearly the need for further work. In this the variation was so wide as to preclude the possibility of drawing any definite conclusions. In the first place the eggs at the initial measurement showed great variation is size and thereafter the increases were erratic and in the total less than those of the first experiment. As the female did not behave in the usual manner it is possible that she was not normal. A batch of eight eggs brought in from the field were nearly of one size as were those of the female in the first experiment but the former were not carried through.

Visibility of Embryo - It is worth noting that many of the changes going on within the developing egg can be watched from without. Anyone who will take the trouble to examine the eggs from time to time as they are developing will soon be able to judge the stage of development of an egg when seen for the first time. When first laid the eggs are fairly homogeneous soon taking on a granular appearance. Later there is a white band across the middle of the egg and the ends are clear. From one to two days before hatching certain pigment spots appear. These are, a dark brown ring around each ocellus, the reddish brown mandibles, and the tarsal claws. These landmarks are useful in following the movements of the embryo within the egg, the rest of the body being so transparent as to be made out only with great difficulty. Just before hatching the embryo usually rests with the ventral surface next to the attached part of the egg. The head occupies practically the whole of one end of the egg, the thoracic legs are pointed caudad and the last segments of the abdomen are turned forward on the venter so that when straightened out the embryo is longer than the egg which contains it.

LARVAE

Hatching - For some hours previous to the rupture of the egg the head may make many movements chiefly from side to side. The mandibles are alternately opened and closed and the thoracic legs are moved. It looks as if the acutely toothed mandibles made the first tear in the eggshell though they are very weakly moved. As soon as the egg is ruptured the head bursts out as it were from one end of the egg and the emerging larva commences its struggle for freedom. The time taken to get clear of the eggshell in a few cases noted was from three to six minutes, the egg collapsing as the larva left it.

Early Feeding - As the larva escapes from the egg it crawls down from the vein on to the leaf and there rests for a varying length of time. This first move does not take the larva far from the eggshell, in fact it often rests on the leaf with the tip of its abdomen still on the vein near the eggshell. From time to time the mandibles will be worked and at the same time parts of the head capsule will be indented as if the cranium, not yet hardened, was being pulled from within by muscles attached thereto. Perhaps this resting stage is necessary to give the chitin time to harden so the mandibles can be worked to some effect. The limits of this resting period in a few timed cases were from a minimum of thirty-five minutes to a maximum of one and one half hours. The rest at an end, the larva starts to feed often without altering its position though when crowded a short distance is traversed. With the mandibles the surface (underside of the leaf) is rasped away over a small area and this saucer-shaped depression is gradually deepened till a funnel-shaped hole is pierced through the leaf. The hole is enlarged until the larva can get its head in it and feed on the edge which later is gripped by the thoracic legs the three legs of one side being on the upper surface and the three of the other side on the lower surface of the leaf. It is these small perforations, looking like so many shot holes, that first proclaim the presence of the larvae to a careful observer.

Later Feeding - When the leaf on which the larvae hatched out is reduced to a few of the main veins the larvae crawl off in search of other leaves. When these are found the larvae at once commence to feed on the margin, holding on to upper and lower surfaces of the leaf with the thoracic legs and usually holding the rest of the body slightly curled under the edge of the leaf. In no case was a larva observed to commence feeding on a new leaf by chewing a hole through as noted for the hatching larva. If a hole was already present in the leaf a larva might make use of it but the margin was the place sought. The leaves are reduced each time to a few veins and the larvae work usually outwards and upwards until the whole bush may be defoliated. Theobald (1909) states that the fruit of gooseberries may be eaten but the writer has not seen this even on gooseberry bushes which had been stripped of all foliage and on which there were still immature larvae. The variety of gooseberry would probably have much to do with this.

In the cages the same larvae were given alternating meals of gooseberry and red currant leaves and no objection was noticed at this treatment. Attempts to substitute black currant leaves on the other hand failed always and larvae could not be starved into eating them. As mentioned elsewhere Saunders (1870) found larvae on black currant and plum leaves, but failed to rear the larvae on these diets.

Larval Period - In rearing experiments the maximum and minimum periods were twenty-six and eight days respectively. The duration would depend on temperature, availability and succulence of the food supply.

Instars - Isolated larvae molted from four to six times five being the usual number. On hatching the larva is about 2 mm. long and is all pale whitish except for the pigmented areas previously noted. Very shortly after feeding commences the green coloration from the leaf tissue can be seen to permeate the body, starting from the alimentary tract. Gradually the head darkens and the black spots so characteristic of the later stages show up and are brownish in color. After the first molt the larva is about 4 mm. in length and the spots and head are becoming blackish. After the second molt the larva is about 7 or 8 mm. long and after the third and fourth about 14 and 19 mm. respectively. After the fifth or ultimate molt there is little or no increase in size, but a great change in external appearance, and a cessation of feeding. Up to the last instar the only noticeable change is an increase in the intensity of the black areas, but after the fifth molt the larva might be mistaken for that of another species. A description of the fifth and sixth instars will give an idea of this change.

In the fifth instar the body is cylindrical, tapering slightly in the last three segments of the abdomen. Segments clearly defined. Head shiny black with scattered short stout setae. Body bluish-green with a faint transverse band of orange-yellow in the prothoracic region and near the tip of abdomen. On dorsum and pleurae of each segment, except the head, are very conspicuous shiny black spots symmetrically arranged in transverse rows and bearing setae which are not readily seen. The three pairs of thoracic legs are black except the distal portion of the coxae which are light colored. Each thoracic leg bears at its distal end a single hooked claw. The seven pairs of abdominal legs are concolorous with the body. The last segment of the abdomen bears on its dorsum two small black protuberances. Length when ready to molt 13 to 24 mm.

The sixth or final instar can be tersely summed up as follows. Head pale brownish to pale green, ocelli ringed with black, mandibles reddish brown. Body including thoracic legs all pale green except for the orange-yellow markings on the prothorax (sometimes parts of mesothorax also) and on the eighth and part of the tenth abdominal segments.

It is of interest to note in passing that there is often a decided difference in size between mature larvae which will eventually produce male imagines and those that will be female imagines. The former are much the smaller of the two.

Cocoon - When the larvae reach the sixth instar they often rest for several hours close to where they escaped from their cast skins. After this they crawl or drop to the ground and at once search for the easiest place to get into the soil. Advantage is taken of some unevenness in the soil to push the head down and force a passage into the soil. As soon as a layer of soil is reached which will stand moulding the larva makes a cell for itself and commences lining this in a short while. At first this lining is very coarse but as the wall thickens from the superimposed layers the lining material is spun out finer and finer till it is quite like silk. The process of lining the cell may be completed in twenty-four hours or even less. Sometimes it is done with quite long periods of rest interrupting the work.

What time of day the larvae choose to leave the host plant the writer does not know. If no particular time of day is chosen then many must perish under certain conditions. These conditions are where the sun can strike the soil all round the bushes for much of the day. Larvae coming in contact with such sun-heated soil almost always die before they can get into the ground or escape to some friendly shade. If a particular time is chosen the early morning would seem to be most propitious.

Not all of the cocoons are made in the soil. A few may occasionally be found spun between leaves on the host plants, on twigs of the host plant and among trash on the ground round the plant. How far the larvae will travel along the ground in search of suitable ground to bury themselves in the writer does not know. In searching for cocoons round the bases of red currant and gooseberry bushes more were found within a radius of one foot from the trunk than slightly beyond this. Many were found fastened to the trunk just below the surface of the soil. Most cocoons were found within the first two inches below which very few were found. The depth would depend on the dampness of the soil and its physical condition.

When removed from the earth the soil adheres firmly to the cocoon so that to the unpractised eye the cocoons are not readily picked out from other small lumps of soil. The general color is thus that of the surrounding soil. Where the cocoon is spun clear of the soil it is often at first pale greenish, later brown and finally almost black. Sometimes it will remain brownish. The cocoons are cylindrical with rounded ends and are fairly symmetrical as a rule. They are of two distinct sizes the larger containing females and the smaller males. The larger ones are about 9.5 mm. in length and 4.8 mm. in width. The smaller are 7.8 mm. long and 4.0 mm. wide. It will be noted that the cocoon is short for the length of the larva. The larva within is much contracted and may have the end of the abdomen turned round upon the venter.

It is in these cocoons that the larvae pass the winter not pupating till the following spring shortly before the emergence of the adults. The writer thinks it quite likely that under certain conditions the larvae, or rather a very small percentage of the larvae, miss over a whole season and do not pupate till the spring following the one they would normally be expected to pupate and emerge in. In support of this two facts might be noted apart from what has already been stated in Part I as to certain sawflies passing over a whole season. The first point is with regard to the durability of the cocoon. Even when opened to admit liquids to the inside the cocoon showed no change after immersion for forty-eight hours in xylol or chloroform. When immersed unbroken in water for several days the water did not penetrate to the interior. Cocoons exposed to drought on the surface of the soil have been noted to keep their contents in good condition for long periods. There seems to be little question that the cocoon is sufficient to take care of a larva for such a length of time. The second point is as follows. The writer collected some field larvae in July 1922 and these were caged and fed till all had entered the soil which was about the end of July. Some of these pupated and emerged as adults in August of the same year but the majority remained in the soil. In September the cocoons were removed from the soil and placed in a small tin box without any soil. They were kept in a drawer indoors all winter and occasionally a drop or two of water was put in the tin. At time of writing, June 1923, the cocoons still contain perfectly healthy larvae which will probably not pupate till the spring of 1924 and then only if exposed in the winter to the action of frost. It would be of interest to know how long such a process could be kept up and how much frost is needed before pupation will take place.

PUPAE

The pupa is a pale greenish in color, with orange-yellow markings similar in position to those of the larva though more extensive. It lies free within the cocoon and is of the usual hymenopterous type. Of the duration of the pupal stage the writer has no data. The shortest time noted between the spinning of the cocoon and the emergence of the adult was ten days but how much of this was spent in the pupal state was not ascertained. Two weeks was the usual length of time elapsing between the disappearance of the larvae into the soil and the appearance of the new brood of adults arising therefrom.

The adults seem to effect their escape from the cocoon by tearing and cutting a hole in one end of it. They then have to force their way through the soil to the surface and in doing so their struggles usually fill the vacated cocoon with soil so that the cocoons are seldom found quite empty when dug up. The sense of direction when escaping through the soil seems to be a negative geotropism.

PARTHENOGENESIS

It has long been known that this species is parthenogenetic. The writer has never had the least trouble in inducing unmated females to lay, in fact, as noted above, the reverse was always the case in the cages. In a large number of rearings covering two seasons the progeny of unmated females without exception were males. Cameron (1882) states that most of the eggs laid by unfertilized females yield only males, but females are occasionally bred from virgin females. One should be cautious about contradicting such an authority but if his statement is correct the case should prove of great interest to the genetecist, besides making parthenogenesis among sawflies more than ever 'mixed', to borrow a term used by MacGillivray. Since both males and females result from fertilized females it follows that the species is not dependent for its males on unfertilized females. The males are essential for the perpetuity of the species but the function of parthenogenesis here is not quite obvious. Possibly careful work on the sex ratio would indicate its usefulness.

BROODS

As mentioned elsewhere the first brood is fairly easy to follow in the field, at least in the north. Later the broods cannot be separated and insectary experiments must be resorted to. In 1919 and 1921 two broods were reared and the adults of a third appeared (see Table II page 86) but from these latter no larvae were developed to maturity. The reason for this failure on the part of the third brood the writer ascribes to the host plants which had by this time finished their summer growth, or very nearly so, and the leaves were all tough and leathery in texture a state of affairs distasteful to any sawfly and fatal to all young sawfly larvae. Theobald (1909) says that four broods may occur in England, that this fourth brood is unusual but that three frequently occur. In America three broods are probably unusual and two broods quite regular, but this statement is not above question in exceptional seasons. What determines the number of broods? How do the larvae in their cocoons beneath the soil find out whether the foliage in the daylight above them is suitable for another brood or not? The writer is inclined to believe the stimulus to be largely that of moisture conditions. Warm rains not only soften the

TABLE I

FIRST BROOD LARVAE

Cage	Date From	To	Numbered Emerged	Number Unemerged	% Emerging as 2nd Brood
1.	June 14	July 27	12	44	21.4
2.	May 17	July 26	11	25	30.5
3.	May 17	June 24	25	7	78.1
4.	June 17	June 30	9	72	11.1
5.	June 16	June 22	24	42	36.3
6.	June 14	June 22	26	47	35.6

TABLE II

SECOND BROOD LARVAE

Cage	Date From	To	Number Emerged	Number Unemerged	% Emerging as 2nd Brood
7.	July 21	Aug. 6	21	43	32.8
8.	July 25	Aug. 3	8	34	19.0
9.	July 19	Aug. 1	24	68	26.0
10.	July 20	Aug. 11	42	58	42.0
11.	Aug. 2	Aug. 15	43	165	20.7

soil and make escape therefrom easier but they usually imply plant activity which will be manifested in the new growth so essential to young sawfly larvae. The writer has noted among species the large number which seemed to emerge a few days after a heavy rain. If it is true that without the rain these same adults would have been unable to make good their escape through the soil there must be a high mortality in dry seasons from this cause. Be the stimulus what it may the broods, saving perhaps the first, are only partial ones in this species. The 'perhaps' is put in here in connection with the first brood because the writer has no definite proof that such is the case. It is improbable that the overwintering larvae pupate and emerge with the different broods in a periodic fashion but it is possible that some may miss over a whole season as is mentioned under the paragraph Cocoon.

It has just been stated that the second and subsequent broods are only partial ones, it should therefore be of interest to find out what percent of each brood emerges as a new brood. Tables I and II (page 86) show the results of a few experiments. Cages 1 to 10 inclusive are each the progeny of one female and are for the year 1921. Number 11 represent some larvae which were gathered in the field in 1922 when about full grown and put into a cage with food. If the results are not too distorted by abnormal conditions to be of any value one fact stands out rather clearly namely that there is considerable variation. Between the lowest and highest there is a difference of 67% but it is noticeable that with the exception of these two extremes the percentage runs fairly evenly between 20 and 40. The tables show plainly that to obtain an idea of the real average far more experiments must be conducted. It should be mentioned in passing that to check up on the number in the 'unemerged' column the cocoons were taken from the soil in all cases in September of the experimental year and that each was opened and the contents examined. All such cocoons contained healthy larvae and in no case was a pupa found.

LIFE HISTORY IN THE FIELD

The correlation of the life history of P. ribesii (Scopoli) with the season has been purposely left till now because with the knowledge of the first section it will be easier to follow and the reader will appreciate the difficulty of interpreting the field findings even when observations are made systematically from start to finish throughout the season. The year 1923 indicates southern notes and all other years northerly or taken from the Lake Ontario region.

Contrary to what one would expect the spring adults do not wait till the leaves are fully expanded but begin to emerge and commence egg-laying when the leaves are about the size of a ten cent piece. Here one sees the necessity for the long incubation period of the spring for if the eggs were to hatch in the shorter time, three or four days, there would be danger of the larvae developing faster than the food supply. In 1919 eggs were first seen on the bushes towards the end of April. At this time the leaves of red currant were just expanding, many of the buds being merely swollen. The eggs began to hatch the second week in May and by June 6th a few larvae were full grown and some were leaving the bushes to spin up in the soil. The fruit at this time (red currant) was well set and increasing in size. The adults were noted until the third week in May when a few red currant blossoms were just opening. By June 16th all of the first brood larvae had gone into the ground and the second (presumably) brood adults were first noted about two days later. After this no track of broods could be kept. It should be mentioned here that the criterion that one is observing the emergence of the second brood is by the numbers emerging. There is danger of weather conditions bringing about a rather large emergence of stragglers but by watching closely it is hoped the error has in this case been eliminated. Red currants were ripe about the second week in July.

The season of 1921 was about two weeks earlier than that of 1919 and eggs were first noted in the field early in April and the adults were seen until the first week in May. The eggs began to hatch the last week in April. It is unnecessary to follow the season further as it was similar to that of 1919 save as noted above that it was earlier.

In 1922 but few observations were taken. Eggs were noted in the field as well as a few larvae on May 27th, these were probably the first brood. The fruit of red currants was at this time well set. By June 14th only a few well grown larvae were to be found. On visiting the field again on July 18th many larvae were noted some of which were collected and caged. From the cocoons thus obtained a small percentage emerged as adults in August. These may have been third brood adults.

In 1923 (south) no systematic observations were made. Adults were first caught on April 12th though how long they had been out on that date the writer does no know. However, as an ordinary but not thorough examination revealed no eggs and as the foliage of both red currants and gooseberries was quite small it seems probable they had not been out for much more than a week. On April 27th eggs, recently hatched eggs, and about half grown larvae were noted. Currants were starting to bloom. On May 4th nearly full grown larvae and fairly recently laid eggs were found on gooseberry the fruit of the latter being about one quarter of an inch in diameter. On May 7th full grown larvae were noted. A cursory examination of bushes on June 13th showed a few larvae about three parts grown. Neither adults nor eggs were seen.

INJURY

It is in the larval stage that the injury is done. Complete defoliation is by no means an uncommon sight and is the source of many troubles. Without foliage the crop of the current year cannot be properly ripened and will often have a bitter taste. The crops of succeeding years are bound to be affected. Also the bush receives a set-back which may result in late fall growth and injury to the unripened wood from frost. Relatively unimportant, though of some account, is the unsightly appearance of defoliated bushes

Most damage is done by the first and second broods and of these two the first is the worst offender, often being sufficient to strip the bushes so that there is little remaining for the second brood.

CONTROL

Natural - No close study of the natural control was made. Every stage of the insect is subject to depletion by some means or other. Pentatomids and spiders have been seen feeding on females they had captured and no doubt quite a number are killed in this way as they are somewhat slow and unresponsive to danger when ovipositing. The eggs are subject to the depredations of Chrysopid and Coccinellid larvae, to an undetermined species of large red mite(numbers of these were noted in the south) and are parasitized by the Chalcid, Trichogramma minutum Riley. The larvae are attacked by Pentatomids and doubtless other predaceous Hemiptera, and are parasitized by many species of Hymenoptera and Diptera. The larvae also may be killed trying to get into the ground to make their cocoons owing to the heated soil. One was noted that had failed to get clear of the old skin at molting and had thus died. The cocoons are probably subject to soil predators though none were ever seen at work. Many cocoons were found with small openings in the side but these may have been the exit holes of parasites. In spite of all these controlling factors the species holds its own from year to year in a rather remarkably constant manner.

Artificial - Fortunately for the grower the larvae are very easily destroyed. So susceptible are the larvae to arsenicals that one wonders why this pest is permitted year after year to divert the red currant and gooseberry foliage to its own purpose. Various dilutions of lead arsenate were tried and it was found that as little as half a pound of the paste in fifty gallons (U.S.) of water killed the small larvae in a day or less but took nearly four days to kill those largely grown. A bush on which only eggs could be found was sprayed with the above mixture. The eggs hatched five days later and in spite of a shower of rain in the interim there were no live larvae left two days after the eggs hatched. At this strength it was practically impossible to tell sprayed from unsprayed bushes so light was the covering of spray material. However, lead arsenate is not dear and there is therefore no necessity to be so sparing with it.

The writer would give the following recommendations. See that all dead wood is removed in the dormant season and do not allow the centre of the bush (red or white currant, or gooseberry) to become too crowded. This facilitates both spraying and observation as well as being helpful to the bush. In the spring watch the lower central leaves and as soon as these become perforated with 'shot holes' spray the bush with lead arsenate at the rate of one pound of lead arsenate powder to fifty gallons (U.S.) of water. See that the leaves on the inside of the bush get wetted with the spray. Be on the lookout in good time in the spring because when the injury is visible to the casual observer it means the damage is already extensive. The poison can be used with Bordeaux or Lime Sulphur (summer strength) where it is desired to check leaf spot. In the writers experience in the Lake Ontario region the Bordeaux is the better for the summer spray. A second spraying may be necessary as soon as the crop is off. If the bushes have not been watched and the larvae are seen stripping the leaves at a time when the fruit is nearly ready for picking and the use of lead arsenate not advisable, hellebore may be used at the rate of one ounce per gallon of water.

PART III

LIFE HISTORY OF THE BLACKBERRY-LEAF MINER

Metallus bethunei MacGillivray

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(continued on page 95)

PART III

Index

(continued from page 94)

Introduction - This pest of blackberries is probably the one referred to under the name of Scolioneura capitalis by Caesar (1909) and was described as a new species by MacGillivray (1914). Of its distribution the writer knows but little. It is found in Ontario on the south shore of Georgian Bay but seems to be most abundant in Ontario along the Niagara Peninsula. This would indicate that its range extends much south of Ontario. The injury is caused by the larvae which mine the leaves. They are often present in sufficient numbers to make a blackberry plantation look as if all the leaves had been scorched by fire.

Anyone who has attempted to work out the life history of this or allied species will appreciate the difficulty of the task. Many phases of any life history can only be worked out by means of cages and this species refuses to do anything at all except die under all ordinary cage conditions. If therefore there are many gaps in the following pages it is hoped the reader will bear this in mind.

ADULTS

Description - The description given here is copied in toto from the original which appeared in the Canadian Entomologist, Vol. 46, 1914, pp. 366 & 367. There are one or two obvious misprints which the writer has corrected. Any changes from the original have been underlined to show where they occur.

Metallus bethunei, n. sp.

"Female - Body black, with the two basal segments of the antennae more or less, the trochanters, and the legs beyond the knees, white; the distal half of the posterior tibiae sometimes more or less infuscated; the ocellar furrow adjacent to the median ocellus; the interocellar furrow wanting; depressed area behind the median ocellus broad; median fovea a broad, deep pit; lateral fovea distinct from antennal fovea: body polished with sparse setigerous punctures; the front not punctate around the base of the antennae; the stigma twice as long as broad; front wings with the free part of M_4+Cu_1 joining the cell M_4 at middle; the saw-guides straight above, somewhat oblique below, broadly obliquely rounded to a point at apex above. The antennae of the male are longer and the segments broader and compressed.
Length, 4 mm.

Habitat - Jordan Harbour and Saint Kits, Ontario, Canada.

Received from Mr. Lawson Caesar, who bred it from a leaf-mining larva on blackberry. The species is named for the Rev. C. J. S. Bethune. It is closely related to rubi, but readily separated from that species by the more oblique and blunter saw-guides".

Saint Kits (Saint Kitts) is an abbreviation for Saint

Catharines which, with Jordan Harbour, is in the Niagara Peninsula, about twenty miles from Niagara Falls.

Variation in Size - As this has rather a direct bearing on the life history besides being of ordinary interest it is given a separate paragraph here. The size given in the original description is probably a fair average but an idea of what is often found can be gained from the following figures. Males were found to vary from 2.5 mm. to 4.5 mm. in length and in width from 1.0 mm. to 1.5 mm. Females showed a variation from 3.5 mm. to 5.0 mm. in length and 1.0 mm. to 1.9 mm. in width. The distance the folded wings projected beyond the tip of the abdomen also varied greatly but no measurements of this were taken. The above will indicate that some of the adults looked twice as big as others which was quite often the case.

The significance of this variation in size is that larvae are capable of transforming even though not nearly the mature normal size. As will be understood later this is of great importance to the species for when a leaflet is eaten out the larva cannot crawl to another leaflet but must either spin its cocoon in the ground or perish.

Host Plants - Until the summer of 1922 the writer believed blackberry - both wild and cultivated - to be the only host plant of this species. In many cases where several acres of infested blackberries were growing next to raspberries the latter were not affected even though the distance between blackberry and raspberry plants was no greater than that between the rows of blackberries (usually about eight feet in plantations). It was noted, however, that an odd leaf-miner was rarely located in raspberry leaves but so scarce were they that no attempt was made to rear the adults. It was thought they might possibly be M. rubi Forbes. But in 1922 quite a number of raspberries had their leaves mined by a sawfly larva and accordingly adults were reared from leaves taken from several different plantations. The emerging adults could not be separated from M. bethunei MacGillivray moreover they readily oviposited in blackberry leaves. Doctor MacGillivray kindly consented to examine some of these for the writer and in reply stated "I am unable to find that it (the writer's material) differs from my specimens of bethunei". There is little room for doubt then that blackberry and raspberry are both host plants of the species and other hosts may be found when more is known of the insect. There seems to be a slight difference in susceptibility of varieties in blackberries but the varieties are so mixed even in the nurseries that no accurate information could be obtained in this field. So far as it could be traced a variety called 'Wilson' seemed to be most resistant. With raspberries no immune varieties were noted neither were any plants found as badly infested as those of blackberry. Should this pest spread to raspberries it would be a serious menace to raspberry growing in localities where M. bethunei MacGillivray is abundant.

Activities - The adults first appear about the time the blossom buds of blackberry are just showing white. At this time the lower leaves are fully expanded and quite large. During the hot sunny hours of the day they are very active flying from leaf to leaf and from plant to plant but never seeming to go very far at a time. They are somewhat timid and it is hard to get near them thoughwhen present in large numbers it is easy enough to watch them fairly closely. When cold or wet none are to be seen unless one looks on the undersides of the leaves near the ground. The writer has seen them present in enormous numbers so that they were "thick as flies" from one end of a row of blackberries to the other. They may be found flying round isolated blackberry plants and in one case an adult was seen at least a quarter of a mile from any blackberry plant that could be found. They do not strike one as capable of long flights for their wings seem too big for them, looking untidy and clumsy when at rest. On this account they would be more easily carried by slight winds one would think. On two or three occasions it was noted that large numbers of adults were hovering in the air above the leafless stumps of some blackberry canes which had been cut down a few days previously. Although there were healthy plants not very far distant yet they continued apparently for some hours to hover over the stumps.

Feeding Habits - The writer has never seen the adults take nourishment of any kind unless water can be so called. They were observed to be interested in drops of water and appeared to take some up. However numerous they might be in the field they were seldom seen to alight on the blackberry blossoms although these latter were the resort of numerous insects. Like P. ribesii (Scopoli) they emerge from the soil ready to oviposit and it would seem that water could supply all their needs.

Proportion of Sexes - The figures were obtained by collecting mature larvae and allowing them to spin their cocoons in a limited area of soil which was caged over so as to entrap the emerging adults. In 1921 only first brood larvae were collected so the emerging adults would be the commencement of the second brood. Out of 708 adults 486 were females and 222 were males giving a percentage of 69 for the females and 31 for the males. In 1922 figures were taken from the first brood the larvae having been collected the year before. Out of 2,294 individuals 1,492 were females and 802 were males, giving females 65%, and males 35%. Averaging the two years one would get in whole numbers, females 66%, males 34%, out of a total of 3,002. The similitude of the two years and the large number taken count of should make these figures reliable.

Mating - This could be seen to take place any time the adults were active. It did not differ in any way from the procedure followed by most sawflies, that is to say the pair would be end to end facing opposite directions. It nearly always was seen to take place on the leaves of the host plant. Quite often four or five males would surround a female at one time all attempting to mate with her at the same time. In such cases more than one male seemed to mate with a female but this may not really have taken place. Mating was of only a few moments duration.

Preoviposition Period - Experiments in the insectary carried on with adults emerging from first brood larvae showed no preoviposition period unless three hours and a half can be so called. No tests were made with the first brood adults. On emergence the abdomen of the female is packed full of eggs many of which seem to be ready for discharge from the body. There is thus a striking resemblance between this species and P. ribesii (Scopoli) in this respect though they are not at all closely related within the sawfly group.

Oviposition - Without an observed exception the eggs were laid by the female from the upper surface of the leaflet and appeared as swellings just beneath the lower epidermis. The method of using the ovipositor is similar to that described for Caliroa cerasi (Linné) in Part I and will not be given here. In two cases females were found which were held fast by their saws and had died thus on the leaflet. The usual spot sought by the female is close to one of the larger veins for she can rest on one side of the vein-formed valley and insert her ovipositor in the other side thus reducing the bending down of the tip of the abdomen to a minimum. Although the above is the place more commonly sought the eggs may be laid anywhere else on the leaflet except perhaps right in the main veins. At first only the larger and more mature leaves are chosen but in severe infestations any and all of the leaves are used. Having deposited her egg in the leaflet the female passes on to another not laying more than one egg per leaflet intentionally. It seems that she might accidentally visit the same leaf a number of times without being aware of previous visits. It was not difficult sometimes to find as many as sixty eggs on a single leaflet in badly infested plantations.

Number of Eggs Laid - The writer has only note of one count worth mentioning and that is of an unmated female which laid 112 eggs. A count by dissection gave an approximate total of 175 eggs.

Longevity - As mentioned at the beginning of this life history adults will not live under ordinary cage conditions. The longest record that the writer has note of is forty-eight hours. It is almost certain that many must live longer than this in the field especially when the weather is not suitable for oviposition but the writer has not yet found any way of proving it.

EGGS

These are whitish in color and almost transparent. The exceedingly thin and delicate chorion is readily broken allowing the thin and watery contents to escape. The shape is that of the pocket which contains it and is commonly somewhat hemispherical or flattened ovoid. Since it is only with great difficulty the egg can be exposed at all without breaking it and that even when exposed the shape is at once changed if an attempt be made to move it the measuring thereof is no simple task. In dissecting the eggs from the body of the female it was found they were almost exact miniatures of the eggs of P. ribesii (Scopoli), (see Part II), that is to say they were elongate, cylindrical, with rounded ends and with one of the sides convexly rounded and the other somewhat flattened. A measurement gave length 0.59 mm. and width 0.23 mm. Measurements taken from an egg in the leaf tissue which was exposed as carefully as possible gave length 0.54 mm. and width 0.40 mm. This shows that the egg is altered in shape to fit the egg pocket. As with other saw-flies the eggs increase in size after they are laid. When first laid the tiny blister-like swellings on the underside of the leaf are visible but not nearly so readily seen as when later, due to increase in size of the egg, the epidermis is raised considerably, and the blisters look as if they were going to burst, so tightly is the epidermis stretched over them.

The incubation period in the insectary varied very little and was nearly always seven or eight days.

LARVAE

Hatching - This cannot be observed without removing some of the leaf tissue which puts a stop to further development. Eggs which were all laid as nearly at the same time as possible were dissected out at times to find out the course of events. There is room for error here because it is necessary to presuppose that all the eggs will hatch at the same time. In removing the leaf tissue it is a very delicate operation if the chorion is to be left intact. The embryo being well developed for some time prior to hatching it means that if the chorion is broken when dissecting out the egg the embryo will look like a recently hatched larva. The first external signs of larval activity are brown spots about the size of a pin head showing on both sides of the leaflet. Attempts were made to find the time elapsing between the hatching of the egg and the first external sign of activity. As nearly as could be made out about fourteen hours was the usual time though as there are so many places where errors might have crept in the time may not represent the true average. It was noted that the larvae on hatching remain for some time coiled round within the leaf tissue and it would seem likely that the embryo is also coiled within the egg due to the latter having to conform to the shape of the egg pocket. Even on hatching the larvae never come to the surface of the leaf but remain within the tissues as leaf-miners until mature or the failure of the food supply.

Description - The mature larva is typical of the saw-fly leaf-miners. The general color is pale whitish; the mouth is directed forward and the head much flattened dorso-ventrally; the thoracic legs are present but small and the seven pairs of abdominal legs are rudimentary. Viewed ventrally there are some black markings around the mouthparts and on the meso- and meta-thorax, but these were not present in all larvae and where present varied in extent. Perhaps they are lost in the final molt. The length is about 7.5 mm. Yuasa (1922) describes the larva in detail but he gives for the length 10.0 mm. which the writer thinks must have been taken from preserved specimens as the larvae are prone to become elongated when preserved in liquid. This is further shown by the fact that he gives the length of rubi (a closely related species) as 11.0 mm. to 12.0 mm. whereas Houghton (1910) quoting Forbes gives a length of 8.5 mm. for rubi, the latter measurement being in all probability taken from the live material as was that of the writer.

Molts - The process of molting was not observed but since the cast skins along with the excreta are retained in the mine it is possible to count the former and thus determine the number of molts, always supposing, of course, the larvae do not devour them. The usual number found was five but occasionally six could be counted.

Larval Period - In the insectary this varied from 12 to 21 or 22 days the usual time being 14 days. In all experiments the majority came within the limits of from 12 to 15 days inclusive.

It should be explained that by the larval period is meant the time the larvae spend in feeding prior to their descent into the ground. Strictly speaking there are two larval periods an active and a passive one. The former is the one given above. The latter would include the time spent in the cocoon and not above ground at all, this for the overwintering forms would run up into months duration.

Habits - Most of the observations on the larvae deal with what can be made out from the outside of the leaflet containing them, for when freed from their mines they are incapable of feeding. Much can be seen by holding the leaf against the light. When commencing to feed the larva usually makes a narrow mine for some distance which is then enlarged considerably developing finally into a large blotch mine of no particular shape. The path of least resistance is followed at the beginning though later even the largest veins are severed without an opening being made to the outside of the leaf. So wonderfully and completely is the leaf often mined that it is hollow from end to end including the marginal serrations. In other words the upper and lower epidermis are held together only by a narrow margin of the leaflet. As is discussed later it takes more than one larva to completely mine out an average sized leaflet. In feeding the larva makes itself the radius of an arc swinging its head from side to side on the curve as the tissue is eaten.

When full grown the larvae under observation remained for various periods up to a day or two within the leaf. At times they would move around a little but for hours would stay in the same position. After wandering around for some time one full grown larva searched the margin of the mine at the lower extremity of the latter. Finally it forced rather than ate its way out and, placing its mouth against the outside margin and levering its body in an upward curve, forced itself clear of the mine dropping directly to the ground on which it landed in a curled up position. In the field the mines are often torn and punctured from the wind beating the leaves against thorns which are present on the canes, petioles, and central veins on the undersides of the leaves. It is probable that mature larvae escape by these holes but that they are not dependent on them is shown by the description given above.

Once on the ground the larvae are quite active and able to move fairly rapidly if the soil is not too rough. They cannot, however, climb any steep slope which is a little longer than their length. On soft ground and where there is no hard crust over the surface they soon burrow down out of sight.

It was noted that where the plantations were not kept clean and grass and weeds allowed to grow round the canes the infestation did not seem to be as heavy as in those plantations kept free from all weeds and well cultivated. Possibly the ground matted with weeds is not so readily penetrated by the larvae but more probably the grass harbours predaceous forms which would be ready to pounce on larvae while the latter were hunting for a suitable place to enter the soil.

Cocoon - To obtain uninjured cocoons from the soil and to get any accurate data as to their exact position is an almost hopeless task. Unlike that of P. ribesii (Scopoli) the cocoon is very easily crushed and whilst one is putting pressure on a shapeless lump of soil in order to find out if it is merely soil or contains a cocoon one is almost sure to crush any cocoon and its contents into a shapeless mass. Some information was gained in the insectary by the use of several devices such as glass plates, glass tubing, capsules etc. It was found that under such conditions the vertical depth to which the larvae went varied from just beneath the surface to one and one eighth inches, most being around three quarters of an inch. The greatest distance traveled through soil was three and seven-eighths inches, the larva in this case being restrained from assuming its normal spinning attitude by the confines of a glass tube.

Once a suitable depth is reached the larva by turning round fashions a cell in the soil. This it commences at once to line with a silky material spun from an opening in the labium. For a short while the process could be watched but soon the material was too dense to see through and the use of a strong light disconcerted the spinner. The whole process was usually finished within twenty-four hours. An interesting fact noted was that none of the cells were made in a horizontal position all being at angles varying from about forty to ninety degrees. The long distance through the soil traveled by a larva as noted above was one which the writer tried to force to make its cocoon in a horizontal position.

The size is subject to variation running from 3 to 6 mm. in length and 2 to 3 mm. in width. They are firmly attached to the surrounding soil which cannot be entirely removed from them. One larva was confined in a small glass vial (ampoule) which though quite small was several times larger than an ordinary cocoon. In this the larva literally spun itself to death as it attempted to line the whole interior with the secretion from the labium. Before it died it had spun an enormous amount of material.

In common with other species M. bethunei MacGillivray winters in the larval stage in the cocoon.

PUPAE

The pupa is free within the cocoon and a pale white in color. How long the pupal period lasts was not ascertained but the time elapsing between the descent of the first brood larvae into the ground and the emergence of the second brood adults ran from 19 to 22 days. It is not likely that all of this time was spent in the pupal stage.

The adults emerge by making a hole in one end of the cocoon. Over caged areas note was taken of the hours of emergence and it was found that very few adults emerged before 8.00 A.M. and that most had come out by noon. None were observed to emerge after 6.00 P.M. and very few came up as late as 4.00 P.M. As these observations were carefully taken and covered the emergence of hundreds of individuals over a period of several days it would seem that the habit is a normal one. If stimulated by the rise in temperature it would be interesting to see if any would emerge in the night if the soil were in some way heated.

So far as could be seen through the glass plates the adults force their way through the soil to the surface by a series of energetic struggles. The head is roughly pushed upwards as if it were the point of a drill while the legs are kept in constant motion in order to prevent the insect from sliding back again, and to make fresh headway.

PARTHENOGENESIS

It was found that unmated females would lay eggs and that the larvae hatching therefrom grew to maturity. Unfortunately the soil in which these larvae spun up was neglected so that only one adult emerged and it proved to be a male. That the species is parthenogenetic seems clear enough but what sex the progeny of unmated females may be remains to be worked out. It is likely that they would all be males because as can be seen from the sex ratio the species is not normally parthenogenetic.

BROODS

There are two broods and probably a partial third in certain seasons. There is yet doubt in the writers mind as to whether the second brood is a complete one or not. From caged soil the emergences of the first brood were as follows:- June-2,178, July-112, August-4, September-1. This shows clearly the distribution of emergence of the first brood (i.e. from overwintering larvae). It will be seen that practically all came out in June, the percentage coming out after this being too small (5%) to be mistaken for a second brood. In the field the second brood adults did not appear to be nearly so numerous as those of the first brood, a rough estimate placing the second at 75% less than the first. If then (as experiments seem to indicate) the second brood is a complete one it must be the only one from which the next spring adults will arise (saving the exceptional partial third brood). This at once begs an answer to the anomaly of why the spring adults should appear to be so much more numerous than the second brood. Observations covering several seasons are needed to check up on this point.

The second brood experiments gave results as follows. In July 1921 thirteen flower pots were filled with soil and most of them were submerged in the ground. Into each pot one hundred larvae (judged to be mature) were placed, these being collected in the field and unquestionably belonging to the first brood. For some reason or other the mortality was very high and the most emerging from a single pot was thirty-four, and the least twelve. But all of these emerged in 1921 and though the pots were left submerged till late in 1922 not a single one emerged in that year. In other experiments cages were placed over the soil and no pots used. No count of the larvae put in was made but the emergence record showed that from all cages into which larvae were placed in July 1921 no adults emerged during 1922.

Next ten pots were filled with soil and set in the ground. Into each one of these two hundred larvae were placed in August 1921. There is little doubt that most of these larvae if not all were second brood larvae. The year 1921 being exceptional a partial third brood appeared both in the field and in the insectary. Adults emerged from nine of the pots from September 22nd to October 1st, 1921. In 1922 adults emerged from all pots from June 15th to July 20th. As in the previous test the mortality was high only 9.5% emerging from the minimum pot and 43.5% from the maximum. Adults emerging in 1922 came only from cages where larvae were introduced after the middle of August 1921. The high mortality mentioned above is probably largely due to the somewhat unnatural conditions of the experiments and to the fact that the larvae counted out may not all have been mature enough to spin up, though they all buried themselves in the soil.

Thus the experiments suggest that the second brood is a complete one but, carefully as they were performed, the writer is not convinced and more experiments and checks will have to be carried out. Since partial broods are always more troublesome to deal with in control measures the point merits further consideration.

LIFE HISTORY IN THE FIELD

As noted at the beginning the observations were all made in the Niagara Peninsula where all work in connection with this insect was undertaken.

In 1921 a blackberry plantation was first examined on May 30th. At this time an odd blossom was to be seen here and there on the canes but most buds were not showing any white. A few adults were noted in one corner of the field. On June 6th some canes were about half out in bloom whilst others were not so far advanced. Adults were plentiful, were mating freely and apparently were egglaying. Three days later the adults were very numerous and the canes were about half out in bloom. June 10th the adults seemed to be very busy ovipositing but no eggs were located. No eggs were found until June 15th on which date a single initial mine was also located. It is difficult to account for this apparently long preoviposition period which did not occur the following season nor in the insectary experiments. The one mine would indicate that an egg was laid about June 3rd or 4th but what were the others doing at that time? The adults were particularly plentiful about June 21st but by June 30th they were becoming scarce. On July 7th only two adults were seen and up till the time they began to increase in numbers again (second brood) one or two were noted each day. These may have been belated firsts or early seconds. The fruit was well set by June 21st.

Adults began to be plentiful again on July 26th about the time of fruit picking. As noted elsewhere they were never apparently as numerous as those of the first brood. Adults were seen up to August 19th on which date only a single specimen was taken. Observations were discontinued about the first week in September but when adults began to emerge in the insectary on September 22nd the field was again examined on September 23rd. Two adults were noted and many eggs were found. Judging by the time these eggs hatched later the adults probably came out about September 18th. Comparing these notes with the insectary experiments the writer has no doubt that most of these, perhaps all, represented a partial third brood.

In 1922 the first adult seen was on some wild plants in the bush on June 4th. As this solitary individual escaped capture there is room for doubt as to its identity. The wild blackberry plants were in full bloom, but it was difficult to find a single blossom in the tame blackberry patches. On June 8th four adults were seen on one patch two of which were caught and identified. In this patch the buds were beginning to show white and a very few blossoms were open. At this same date in another plantation adults were fairly numerous and eggs were to be found, some plants were half out in bloom whilst others were scarcely showing white in the flower buds. A solitary mine which was not more than two days old was found on June 6th but it was not until June 21st that mines began to show up in any number. By July 5th some larvae were full grown and adults and eggs were still to be found, though with difficulty. The last adult was observed on July 13th, and on July 25th a few berries here and there were ripe. On August 2nd adults were appearing again (probably the first of the second brood), larvae of the first brood were scarce and the new growth of the plants had largely hidden the initial injury. A few mines of the second brood were showing on August 14th the adults being fairly scarce at this time although there were plenty of eggs. However, in another plantation adults were fairly plentiful three days later. The last adult was seen on August 22nd when some of the larvae were about two-thirds grown. It is probable that a few adults appeared later than this since a few small mines were found on September 5th. By September 11th many larvae had left the mines those remaining being mostly nearly full grown.

In comparing the two seasons the following points stand out. (1) A great decrease in the extent of the injury. (2) A distinct gap between the first and second broods in which time the plants were able to hide the injury made by the first brood before the second brood injury made its appearance. (3) Eggs were noticed coincident with the appearance of the adults.

In the two seasons the first brood adults appeared at the same time with respect to the stage of growth of the plants, which in point of time was about a week later in 1922 than in 1921.

INJURY

It was briefly noted in the introduction that the leaf-miner is sometimes present in sufficient numbers to cause a whole plantation to appear as if scorched by fire. Nearly all of the leaves on the canes will be like so many paper sacs, nothing being left of them save the upper and lower epidermal tissue. Even the very small leaflets which the early emerging adults will not oviposit in are later, on the exhaustion of the larger ones, well supplied with eggs. Furthermore the plants have not recovered from the first brood injury when the second brood appears to make use of every available leaf. It is a disheartening sight for any grower who has spent time and money in starting a blackberry plantation to find the whole field looking brown and dead. One would expect that a single year of such treatment from the leaf-miner would kill out or permanently injure the blackberry canes but such does not seem to be the case. Soil which is unsuitable for blackberries is usually unsuitable for the leaf-miners also so that in general poor plantations are not so severely attacked. Where the soil is suitable blackberries make a very rank growth, especially when there is the right amount of moisture, so that it is difficult to estimate the actual loss to the grower from this pest. The berries seem to be of a poorer quality but how much of this is due to the leaf-miner and how much to other causes the writer does not yet know. It is manifestly impossible that the canes can suffer so much loss of foliage without being injured in some way or other but the actual amount of the injury is not easily gotten at. Perhaps if severe infestations followed one another year after year the canes would be weakened and killed, but so far as the writers experience goes the severe infestations are followed by less serious ones in a more or less periodic manner.

SOME FACTORS IN NATURAL CONTROL

Metallus bethunei MacGillivray seems to be a native species and the writer has many times noted it upon wild blackberry plants which were either solitary or growing in small clumps. It was found often on small clumps in the bush about one quarter of a mile from any cultivated patches and in some cases the distance was well over a mile. No wild plants, with the exception of those growing along the fence-rows round an infested plantation, were ever seen to be as badly affected as those in the regular plantation. Why the factors which control this pest on wild plants have not yet apparently come to bear on the cultivated plantations is not clear. The balance of nature is truly upset when one finds, as in this species sometimes, the larvae so numerous that they are more inimical to each other than their enemies are to them. To briefly illustrate this last point the question of food supply might be appropriate. The area of fourteen mines was carefully computed and was found to average 1.39 square inches. The largest mine was 2.04 square inches and the smallest 1.03 square inches. These measurements were taken from leaflets which had but one mine, in which the larva had grown to maturity and had finally made its escape. Next a very large leaflet was measured and found to be 6.87 square inches in area whilst average sized leaflets were found to be 4.50 to 5.00 square inches in area. From this it is a simple matter to calculate how many larvae a single leaflet will support and it can be seen that a leaflet of 5.00 square inches area would at most support only four or five larvae under favorable conditions. As stated earlier there may be forty or fifty eggs on a single leaflet and ten mines per leaflet was commonly met with. Since there is no migration from leaflet to leaflet enormous numbers must be starved to death. It is realised that larvae in all probability can grow to maturity on a smaller area of leaf than the measurements given above indicate for how else are we to account for the extrordinary difference in size of the adults. In spite of this fact, however, it is manifestly impossible for a single leaflet to bring even ten larvae to maturity. Examinations of numerous leaves in the field tend to show that many over-populated leaflets bring but a single larva to maturity. Much will depend on the times the eggs hatch as the earlier ones would naturally have advantage over the others.

In view of the facts above stated in connection with the larvae it is obvious that whatever control factors were working against the adults their effects were too insignificant to be appreciable. Spiders and other predators no doubt get a few adults and two were noted held fast to the leaflets by their ovipositors. In spite of the fact that they will hardly live in a cage they are fairly hardy in the field and have been known to survive heavy downpours of rain even though beaten off the canes sometimes.

No eggs were found to be parasitized though there is no reason why Trichogramma minutum Riley should not be at work in some places not observed by the writer for it is known to be present in the locality. On the whole very little mortality amongst the eggs was noted in the field and for the few cases observed no specific cause was assignable. In the insectary 99% to 100% of the eggs hatched.

It is in the larval stage that a high mortality occurs,, both from starvation as noted above and from parasites. No particular study was made of the larval parasites though they give promise of some very interesting material. All, so far as noted, were hymenopterous and several species were involved. Nearly all of the species seen were ectoparasites their larvae feeding externally on the leaf-miner larvae and their mouthparts usually attached to the host in the intersegmental regions. How do the parasites get their eggs into the mines? If the eggs are deposited loosely in the mines how do the parasite larvae issuing therefrom get to the host and attach themselves? One wriggle of a large leaf-miner larva (and they are quick to move when frightened) would surely kill a helpless parasite larva long before it could attach itself. In examining a number of mines it was not difficult to find two or three eggs loose in the mine or to find a single egg attached to the larva. Perhaps the loose ones had been shaken off. Some of these loose eggs were very large, one which was measured being 1.26 mm. long and 0.27 mm. wide. Most were much smaller than this. One fairly large ichneumon was seen apparently ovipositing through the leaf in the region of a larva beneath but no egg was found on opening the mine. Possibly the female was disturbed prematurely. Two adults were reared from eggs. One emerged fourteen the other thirteen days after the hatching of the egg. In both cases the larval period was seven days. Professor Caesar informs the writer that he has observed the adult parasites run quickly over the mines and if a tear in the leaf tissue was found would immediately crawl into the mine by this opening. They would also tear at the leaf tissue with their mandibles in order to gain entrance to the mine. That this is not always the case with some species is shown by the fact that parasitized larvae were found in mines to which no external opening was apparent. All the observed parasites pupated in the mines, some appearing as free pupae and others spinning cocoons between the roof and floor of the mine thus firmly fastening the upper and lower surfaces of the leaf together at that point. Some of the parasite larvae were of a beautiful blue color, others were brownish and most were whitish. It would seem altogether likely that at least one or two species leave the mine and pupate in the ground.

It is somewhat strange that in several seasons noted the parasites were never abundant till late in the season. The last leaf-miner larvae of the season were heavily parasitized whereas it was difficult to find a single parasite larva early in the season. Does it mean that most of the parasites are facultative ones, that they are not specially adapted to this host and appear in the spring too soon before the leaf-miners to attack them? The writer has noticed in the spring large numbers of small Hymenoptera flying round the lower leaves of the blackberry canes sometime before the blackberry leaf-miners appeared. However, as none of the parasites have been identified yet the point will have to remain in abeyance.

As noted elsewhere the insectary experiments gave a very high mortality for adults emerging from what were gathered as mature larvae. It is possible that such a condition exists, though to a lesser extent, in the field. The writer feels sure that the season, especially very heavy rains which pack the soil followed by bright sunshine forming a hard crust on the surface, is responsible for the failure of many adults to effect their escape.

THE PROBLEM OF ARTIFICIAL CONTROL

A common method of arriving at a control measure is to work out the life history of the species causing the injury and with this knowledge attack the insect at its weakest point. Often by this means an effective remedy is discovered which would not have been found had the life history not been taken into account. With Metallus bethunei MacGillivray the life history as worked out by the writer only perplexes rather than helps one in finding a means of control. It is to be hoped that when the gaps in the life history are filled in that some weak point will be found but for the present the problem is truly a serious one.

In the first place the adults do not seem to feed or to require food so that they cannot be poisoned. Even were it possible to do so it is probable that many would lay eggs before they took the poison as the preoviposition period is so short. The eggs are laid within the tissue of the leaflets and the larvae on hatching have already a small mine (the egg pocket) started for them so they do not come to the surface at all. It was thought that possibly some spray such as nicotine sulphate would kill the larvae in their mines but owing to the tender nature of blackberry foliage any spray that was effective against the larvae killed the leaves also. The removal of infested leaves by hand before the larvae are full grown is not practicable. When mature the larvae straightway drop to the ground where they bury themselves as soon as possible. Once in the soil how can they be gotten at? In the field continuous cultivation did not appreciably lessen their numbers and as everyone knows who has tried the job it is no pleasant task trying to cultivate close up to a row of healthy blackberry plants. It is possible to plow up the soil against the canes and leave it that way until the time of emergence in the spring is past. In the cages, however, the adults worked their way out through eight inches of loose soil. Soil insecticides might be tried but with those experimented with by the writer the cost is prohibitive when used in effective quantities. Thus there seems to be no loophole in the life history, no weak point at which this species can be controlled.

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