9-1-1920

The Webspinning Sawfly of Plums and Sandcherries

H.C. Severin

Bulletin No. 190 September, 1920

The Webspinning Sawfly of Plums and Sandcherries

H. C. SEVERIN

Web of plum webspinning sawfly enclosing plum twig

AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS

Brookings, South Dakota

STATION STAFF

T. W. Dwight ---------- Regent Member
J. W. Campbell ---------- Regent Member
Willis E. Johnson ---------- President of College
James W. Wilson ---------- Director and Animal Husbandman
N. E. Hansen ---------- Vice-Director and Horticulturist
C. Larsen ---------- Dairy Husbandman
A. N. Hume ---------- Agronomist and Supt. of Sub-Stations
Harry C. Severin ---------- Entomologist
J. G. Hutton ---------- Associate Agronomist
Howard Loomis ---------- Agronomy Analyst
Matthew Fowlds ---------- Assistant Agronomist
Arthur H. Kuhlman ---------- Associate Animal Husbandman
T. H. Wright, Jr. ---------- Assistant Dairy Husbandman
Horace Jones ---------- Assistant Dairy Husbandman
George Gilbertson ---------- Assistant Entomologist
B. A. Dunbar ---------- Station Chemist
C. F. Wells ---------- Assistant Chemist
Paul W. Kieser ---------- Bulletin Editor
R. A. Larson ---------- Secretary
P. W. Hansen ---------- Bulletin Clerk and Stenographer

SUMMARY

The plum webspinning sawfly is distributed generally over South Dakota but it is the eastern half of the state that suffers most severely from the ravages of the larvae of this pest. The larvae are gregarious and live and feed in webs which they spin about the leaves and twigs of their food plants (see illustration on cover). The foliage of plum trees and sandcherry bushes constitutes the preferred food of the pest and such trees and bushes may be entirely defoliated during June and July (Fig. 2).

The adult insects make their appearance during the latter part of May or early June (Fig. 9). After mating, each female lays 46 eggs on an average and these, after a period of five to seven days, give rise to larvae or "worms". The "worms" feed for 13 to 23 days and at the end of this period they fall to the ground, enter it to a depth of 1 to 10½ inches and hollow out cells, inside of which they pass the remainder of the summer, and all of the fall, winter and early spring. With the approach of warm weather in the spring, the "worms" change to pupae and these give rise to adults or sawflies in 7 to 10 days. Thus it is seen that there is but one generation of this pest per year (Fig. 9).

While there are several very effective parasites and predaceous enemies of this insect, they do not keep down the numbers of the Neurotoma larvae to the point where their presence upon plum trees or sandcherry bushes is negligible. Consequently, spraying or dusting must be resorted to. If spraying is practiced, 1 pound of lead arsenate in paste form or ½ pound in the powdered form should be used for each 50 gallons of water, but if dusting is adopted, then 1 pound of powdered lead arsenate should be diluted with 15 pounds of air-slacked lime or powdered sulphur before it is applied to the foliage. The spray or dust should be applied to the fruit trees or bushes while the webs of this pest are still small.

THE WEBSPINNING SAWFLY OF PLUMS AND SANDCHERRIES

by

H. C. SEVERIN, Entomologist

Contents

INTRODUCTION

Because the plum webspinning sawfly* is the most destructive enemy of the foliage of plum trees and sandcherry bushes and because these are among the most important of the fruit producing plants in South Dakota, a study of this pest was undertaken. As a result of this study, the distribution of the insect has been fairly well determined and its life history and the behavior of the various stages in its life cycle are now known. The plants upon which the larvae feed and the injury done by them was also investigated. The most important of the natural enemies of this pest and their influence as checks upon the increase of the Neurotoma larvae were studied and, finally, satisfactory control measures for the pest were worked out.

An abbreviated account of the work done with this sawfly is given in the following pages while a detailed report will be found in Technical Bulletin Number 1 of the Office of the State Entomologist of South Dakota.

* Neurotoma inconspicua (Norton) MacGillivray: order Hymenoptera, family Pamphiliidae.

HISTORICAL

SYNONYMY

The plum webspinning sawfly was first described by Norton in 1869 as **Lyda inconspicua.** In 1882 W. F. Kirby listed this insect as **Pamphilius inconspicuus** in British Hymenoptera. Dalla Torre (1)* * in 1894 synomymized the genus Lyda with Pamphilius in his Catalogus Hymenopterorum but this had already been done by Curtis in 1831 in British Entomology. In bulletin 48 of the South Dakota Agricultural Experiment Station, T. A. Williams (8) in 1896 published an account dealing with this pest and called the insect **Lyda spolina.** In this publication he writes that specimens of the sawflies were submitted to Dr. C. L. Marlatt for identification and that he pronounced them as being a new species and described them under the name Lyda rufipes. In 1909, Dr. A. D. Mac Gillivray transferred this sawfly to the genus Neurotoma so that at the present writing it is known scientifically as **Neurotoma inconspicua** (Norton) Mac Gillivray.

INJURY

Although the plum webspinning sawfly is a serious enemy of plum trees and sandcherry bushes in South Dakota, but few references to it are to be found in literature. In 1896, T. A. Williams (8) called attention to the presence of this pest in South Dakota, published an account of its life history, and described the injury done by it and recommended measures for its control. In the same year J. Fletcher (3), of the Dominion of Canada, reported that the insect was doing considerable harm to plum trees in southern Manitoba. H. T. Fernald (2) found the pest in Massachusetts in 1902 and 1903 and from his studies concluded that, should it become abundant, it would rank as a serious enemy of the fruit-grower. The writer of this bulletin began a study of this pest in South Dakota in 1915 and three years later published a short popular account (5) dealing with the life history of the insect, the injury done by it and the most practical measures for its control.

* * Numbers in parenthesis refer to "Literature Cited" on page 251.

DISTRIBUTION

This insect is distributed generally over South Dakota but it occurs most abundantly in the eastern third of this state. The writer has found the pest in the neighboring states of Minnesota, Iowa, Nebraska, Montana and North Dakota. It has been reported as occuring in Massachusetts and is a serious pest in Southern Manitoba, Canada. Undoubtedly the insect will be found in states other than those mentioned.

INJURY

The principal injury done by the plum webspinning sawfly is brought about through the feeding activities of the larvae. However, some damage is also caused by the webspinning habits of the "worms", while a negligible injury is done by the female sawflies at the time of egg-laying.

The larvae are gregarious and live in colonies in silk webs which they spin. These webs are large or small depending upon the age of the larvae and upon their numbers. Each web consists of many sheets of silk threads, each sheet being spun by a larva. The sheets are fastened to each other or to leaves, branches, fruit, etc. and may enclose twigs, leaves and fruit of the host plant. Inside of these nests the larvae live and they feed here or at the edges of their webs by devouring the foliage. Movement through the webs by the worms is possible by going through the chambers formed by adjacent sheets of silk threads. In this fashion every nook in the nest can be entered by every larva. When the worms are young the nest occupies but one leaf and only the softer parts of this leaf are eaten, the veins, midrib and petiol being left untouched, but as the pests become older, more and more leaves are added to the nest and all the leaf tissue is devoured except the petiol, the base of the midrib and the stubs of the larger veins (Fig. 1). Occasionally the fruit that is enclosed in a web may also be attacked and its soft pulp eaten. When food is no longer available on a branch, a migration by the larvae to another branch takes place.

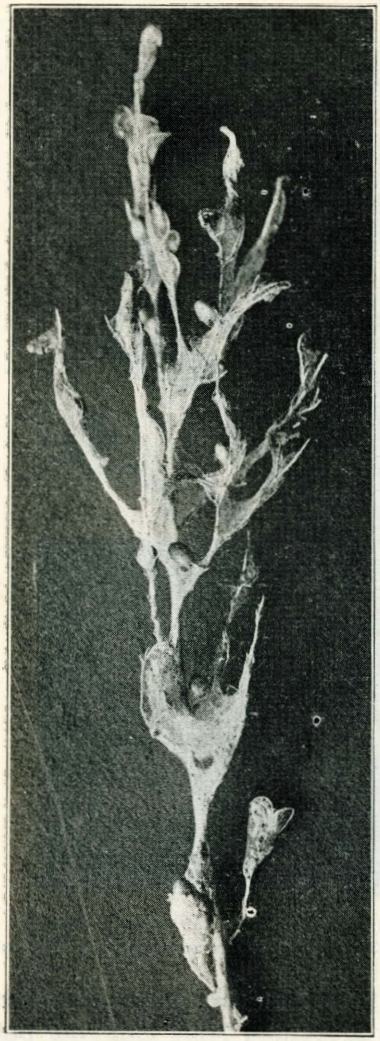

Fig. 1. Plum branch defoliated and webbed by larvae of plum webspinning sawfly.

A branch that has been deprived of its foliage is usually surrounded by a continuous matting of silk threads extending from its base to its tip. This matting encloses also the smaller branches, the petiols of the leaves, the remains of the veins, the uneaten portions of the leaf blades, many particles of black excrement and the cast skins of the larvae. The webs are not large, loose and bulky, but are elongated and compact and follow more or less the outline of the principal branches, their side shoots and the remains of the uneaten leaves (see cover page and fig. 1).

In case of severe injury, a tree may be entirely defoliated during the latter part of June and early July (Fig. 2). It is not unusual to find as many as 25 webs on trees 6 feet high and 5 feet across the top. As many as 53 webs were found on a tree 8 feet high and 7 feet across the top while 69 webs were counted on a tree 10 feet high and 8 feet across the top. The presence of such a large number of larvae on a tree or bush results in a destruction of all of the leaves on that tree or bush with a consequent reduction in the yield as well as size of the fruit. Should this defoliation be repeated several years in succession, the tree or bush becomes weakened and ultimately dies.

Fig. 2. Plum tree entirely defoliated by larvae of plum webspinning sawfly

Leaves that are enclosed in a web and not eaten are often killed or if not killed, they are prevented from carrying out their proper functions. Their death or weakened condition may be due to the fact that they are rolled up, tied and covered by a matting of silk and that this matting may contain the damp and water-soaked excrement of the larvae. Rains, dews and winds may mat the silk threads of the nest so as to exclude air and sunlight from the leaves. This may suffocate the leaf or it may prevent the evaporation of water. The damp or water-soaked excrement in the web injures the

leaves in a similar manner but in addition serves as an excellent medium in which molds grow and these molds may attack the weakened leaves.

The female sawfly at the time of egg-laying cuts small slits in the midrib of a leaf and in these slits lays her eggs. As a consequence, the leaf tissue does not grow as rapidly here as it does elsewhere, with the result that the leaf curls. However, since each female sawfly has but one egg-laying period during her life and since all of her eggs are usually laid in one batch on one leaf, the injury produced in this fashion is negligible.

FOOD PLANTS

The larvae of the plum webspinning sawfly were found feeding upon the foliage of the following plants:

Common wild plums (**Prunus americana** March)*
Common garden plums (**Prunus domestica** Linn.)
Canada plums (**Prunes nigra** Ait.)
Hybrid plums
(**Prunus besseyi x P. triflora**)
(**Prunus americana** x **P. simonii**)
(**Prunus americana x P. triflora**)
Western sandcherry (**Prunus besseyi** Bailey)
Compass cherry(**Prunus besseyi x P. americana**)
Common wild, red, bird or pin cherry (**Prunus pennsylvanica** Linn.)
Choke cherry (**Prunus virginiana** Linn.)
Sour or morello cherry (**Prunus cerasus** Linn.)
Russian almond (**Prunus nana Stokes**)
David's Chinese wild peach (**Prunus davidiana** Franch)

The common wild plums, the common garden plums, the Canada plums, the hybrid plums, the western sandcherries and the compass cherries suffered the largest amount of damage from the destructive work of this pest, while the pin cherries, choke cherries, sour cherries and Russian almonds were not seriously injured. David's wild peach is grown in South Dakota only locally on the horticultural experimental plots at Brookings and since even here it does not produce fruit, the severe harm that is done to this species of plum need not be considered.

*The common and scientific names of the plants mentioned above were taken from L. H. Bailey's Standard Cyclopedia of Horticulture, vol. 5.

DESCRIPTIONS

To complete its life history, the plum webspinning sawfly must pass through the egg, the larval, the pupal and the adult stages. The cycle in which these stages occur are in the order given, the adults starting a new generation by mating and laying eggs (Fig. 9).

THE ADULT OR WINGED FORMS

The adults are four winged insects known as sawflies (Figs. 3, 9, 10). They are thus called because the females are furnished with a saw on the under side of the back end of the adomen and with this saw they cut egg-slits in the midrib and petiol of the leaves.

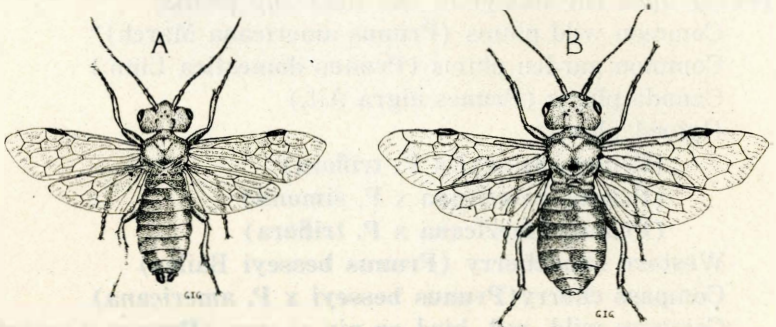

Fig. 3. Plum webspinning sawfly: a, Adult male; b, adult female. Enlarged 3¼x.

FOLLOWING IS A DESCRIPTION OF THESE INSECTS BY S. A. ROHWER:

Female: Length 7.5 - 9.5 mm. Clypeus gently rounded and medianly convex, shining with large separate punctures, supraclypeal area broadly ridged, punctured like the front; lateral supraclypeal area smooth, shining, impunctate; front with close almost confluent punctures; vertex and posterior orbits shining with sparse distinct punctures; a small depression in front of anterior ocellus; postocellar area longer than wide, rather well defined laterally; antennae normal for group, 19 - 21 jointed; mesonotum shining, sparsely punctured; apex of scutellum depressed medianly so as to appear notched; abdomen with shining surface finely reticulate; black with a faint bluish tinge to abdomen; spot in middle of clypeus (often wanting) and tegulae pale yellow; mandibles testaceous to rufous; trochanters, femora and tibiae rufous, tarsi blackish wings hyaline, iridescent, slightly infuscated below stigma.

Male: Length 7 - 8 mm. The male agrees well with the female but has the depression in front of the anterior ocellus somewhat deeper.

THE EGGS

The eggs of this pest are glued in a conspicuous mass in slits made on the under surface of the midrib or petiol of a leaf (Fig. 4). Such eggs as were deposited one, two or three hours ago are more or less broadly elliptical when viewed from beneath, but when examined from the side they are flattened or even concave where they are attached to the leaf and con-

vex on the side opposite. Each egg measures from 1.05 to 1.15 mm. in length and from .41 to .5 mm in breadth. The color of the eggs is cream-white, while the shell or chorion is smooth, shinning and more or less smeared with a yellow, sticky secretion. It is this secretion that glues the eggs in place.

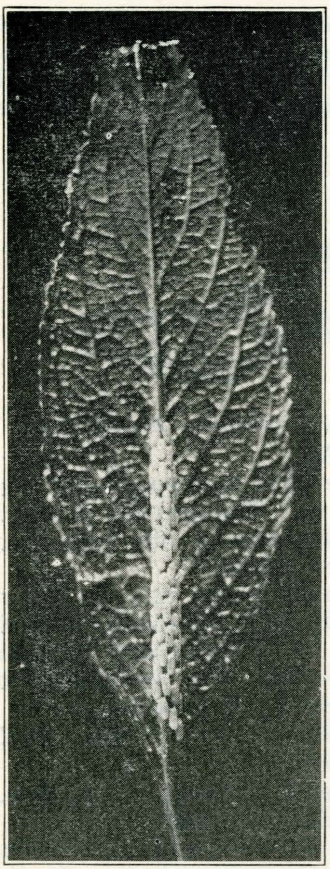

Fig. 4. Egg mass of Neurotoma inconspicua on plum leaf. Enlarged 2½x.

THE LARVAE

The larvae when hatched from the eggs are surprisingly large but they must feed and grow considerably before they become full-grown. At more or less regular intervals in their life they molt or shed their skins, this process taking place six times in the males and seven times in the females.

The "worms" vary somewhat in size and structure in all instars but it is possible to describe typical specimens and to include the variations in size in our figures of measurements. All larvae, whose measurements are recorded, either hatched from the egg one-half hour previous or molted one-half hour before their measurements were taken.

Following is a table in which are recorded the length of the body and the breadth of the head of the larvae in the various instars through which they pass.

Table 1

Length of body and width of head of larvae in their various instars

	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Sixth instar	Seventh instar of female
Length of body	2.3 to 2.5mm.	4.5 to 4.8mm.	5.9 to 6.5mm.	6.9 to 8.5mm.	10.5 to 11.8mm.	13 to 15mm.	16.5 to 17.5mm.
Width of head	.4 to .5mm.	.57 to .65mm.	.7 to .81mm.	.9 to 1.03mm.	1.25 to 1.3mm.	1.53 to 1.62mm.	1.8 to 1.85mm.

Because of lack of space none of the larval instars are described in this bulletin. Descriptions of these may be found in Technical Bulletin Number 1 of the Office of the State Entomologist. An excellent reproduction of a larva in its last instar is shown in figure 5 of this bulletin.

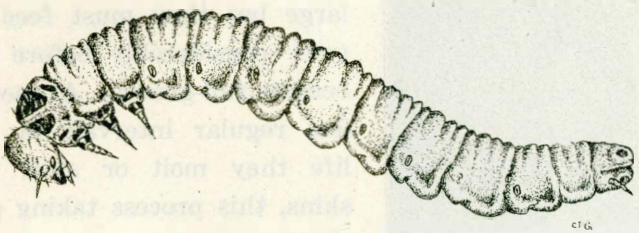

Fig. 5. Plum webspinning sawfly; female larva, full-grown. Enlarged 4x.

THE PUPAE

The pupae are of the free type with the appendages free but held close up to the body (Fig. 6). The position in which these appendages are held with reference to the body may readily be determined by glancing at figure 6.

Fig. 6. Plum webspinning sawfly; female pupa enlarged 4x.

Male and female pupae may be distinguished not only by a difference in their sizes but also by a difference in their structural characters. The measurements of the two sexes are as follows:

Male pupae: Length 9 to 10 mm.; width of head 2 to 2.5 mm.

Female pupae: Length 10 to 12.5 mm.; width of head 2.5 to 3 mm.

The structural differences are to be found mainly in the external genitalia. In the male pupa a pair of short swollen claspers are attached near the posterior end of the body and between these are to be found a pair of small knob-like structures. In the female pupae, a short ovipositor is found near the posterior end of the abdomen on its under side (Fig. 7).

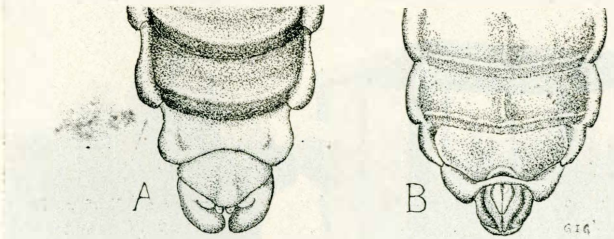

Fig. 7. Plum webspinning sawfly; A, ventral view of posterior end of abdomen of ♂ male pupa; B, ventral view of posterior end of abdomen of female pupa. Enlarged 12x.

LIFE HISTORY AND BEHAVIOR

The life history and behavior of the plum-webspinning sawfly were studied both out-of-doors and in the laboratory. Where cages were necessary out-of-doors, two types were used, large ones to cover plum trees of medium size, and many small cages to cover plum seedlings (Fig. 8).

ADULTS

Time of emergence: The time of emergence of the adult sawflies depends largely upon weather conditions. Ordinarily they make their appearance during the first three weeks in June, but this may be hastened or delayed by a warm or cold spring. The period during which the sawflies emerge may occupy a month or more; a few forerunners are to be found during the the first week or ten days, then follows the great body of the insects during the next week and finally the season is ended with the arrival of the stragglers (Fig. 9).

General behavior: The sawflies are only fairly active during the warmest days (80 - 90 degrees F.) and when the temperature becomes cooler (65 degrees F. or below) they become correspondingly more sluggish. Should the weather be exceptionally hot, the insects seek the shade and rest. During cool weather the sawflies may be approached, picked up and dropped without causing them to fly, but when the temperature is higher, they readily take wing. The insects are pugnacious at all time, not only toward each other but also

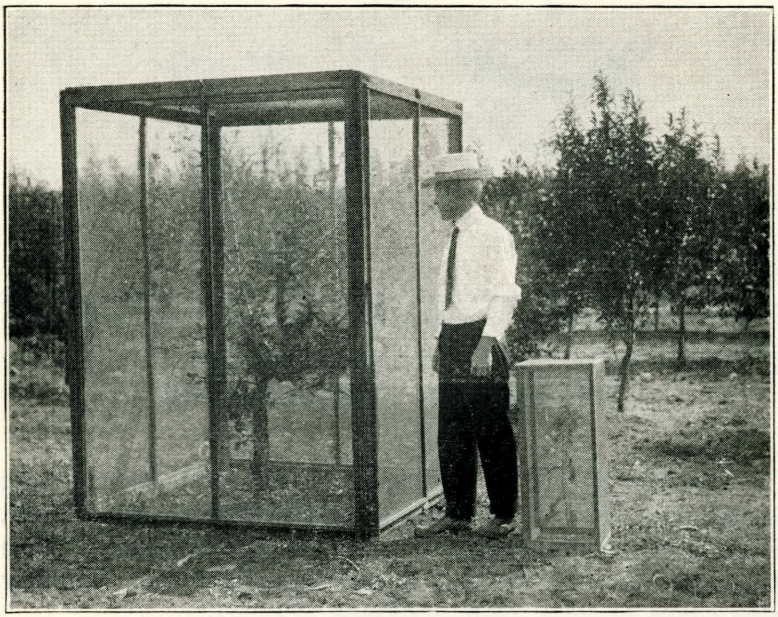

Fig. 8. Types of cages used in studying the life history and behavior of the plum webspinning sawfly.

toward any approaching object. The adult sawflies were never found eating foliage of any kind but they would drink dew and rain out-of-door and would feed upon diluted molasses, sugar water and nectar of various species of flowers indoors.

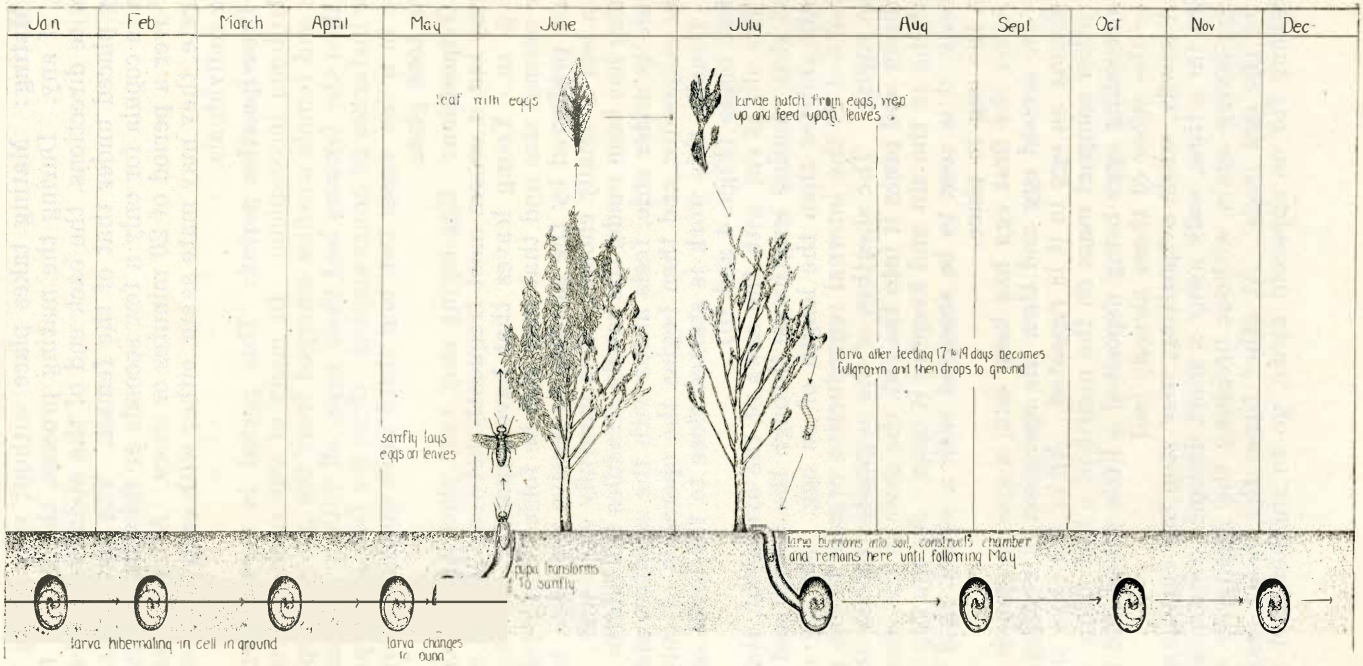

Fig. 9. Diagram illustrating the life cycle of the plum webspinning sawfly

Mating: Mating takes place without very much courtship, if any. During the mating process, the insects face in opposite directions, the back end of the abdomen of the male being placed under that of the female. The sawflies may remain in copula for only a few seconds or this process may extend over a period of 20 minutes or more. After the sawflies separate, they may mate again, either with each other or with other individuals.

Preoviposition period: This period is very short with Neutrotoma inconspicua. In many of our cage experiments, male and female sawflies emerged from the ground, copulated and then the females laid their eggs, all within 12 hours. In other instances 24 hours elapsed before the females oviposited, while in a few cases two and three days passed before egg-laying took place.

Oviposition: Egg-laying may take place at any time of the day but it occurs most frequently between 9:30 a. m. and 4:30 p. m. Young leaves that have expanded 1-5 to 1-3 of their normal size and that may still be folded along the midrib are preferred by the sawflies to receive the eggs, but before a leaf is finally chosen, it is carefully examined. After a choice has been made, the sawfly straddles the midrib of the leaf on its under side, feels about with the sensitive sheathes of her ovipositor and then begins the operation of cutting a slit. Usually this work is started close to the basal edge of the leaf blade (Figs. 4 and 10).

The slit is cut with the saws of the ovipositor, the completed slits running lengthwise through the midrib and being slightly shorter than the length of an egg. An egg is now worked out of the internal reproductive organs to the mouth of the vagina. The sheathes of the ovipositor receive the egg and direct and press it into the slit, the saws in the meantime remaining in the slit and keeping it open. As the egg leaves the body, it is seen to be smeared with a yellow fluid which glues the egg in place.

After the first egg has been laid, a spot is chosen to receive the second egg and then the operation of cutting a slit and placing an egg in it is repeated. All of the eggs are laid in a rather compact mass on the midrib of a leaf (Figs. 4, 10), the succeeding eggs being deposited a little ahead and to one side or the other of those already laid.

A sawfly, while ovipositing, may stop her egg-laying activities for a time, walk away a short distance, return and begin egg-laying again without breaking the regularity of the plan of the egg mass. At other times the insect may stop ovipositing for no apparent cause, go to another part of the

leaf or to a different leaf entirely and begin the process of egg-laying anew. Occasionally a sawfly was seen to attempt to cut egg slits in the leaf tissue next to the midrib, but such work was soon abandoned. In a few instances an egg or two were found glued to slits made in one of the principal veins coming off from the midrib.

Description of egg mass: An egg mass varies not only in length but also in breadth, depending upon the number of eggs in the mass, upon the thickness of the midrib of the leaf and its petiol and upon the position of the mass upon these. All other conditions being equal, the smaller the number of eggs, the smaller is the mass and vice versa. However, the thicker the midrib and the closer to the base of the leaf blade the mass is located, the greater is its breadth and the shorter its length.

A compact egg mass consisting of 40 eggs arranged in 8 rows measured 12 by 2½ mm; another mass containing 58 eggs arranged in 6 rows measured 20 by 2mm; another having 61 eggs arranged in 5 rows measured 22 by 2 mm; while a double egg mass laid by two sawflies and consisting of 108 eggs arranged in 7 rows at the base and 4 at the tip measured 31 by an average of 2 mm.

The arrangement of the eggs in a mass is well shown in figures 4 and 10. While the eggs seem to be arranged in longitudinal rows on the midrib, a close examination shows that these rows are quite irregular. This is to be explained through the fact that the sawflies do not deposit one complete row of eggs after another, but they attach as many eggs as possible to a given area on a midrib and then work forward.

Number of eggs laid: The number of eggs laid by each female varies considerably, as few as 24 having been deposited by one specimen and as many as 61 by another. The average number of eggs laid by 40 sawflies was 46, but when some of these females were dissected after they had finished egg-laying and had died, many eggs were found within their reproductive organs. The following table gives a record of the number of eggs deposited and the number still retained within the body of 7 sawflies.

Table 2

Number of eggs deposited and number retained within the body of 7 sawflies

Specimen number	Eggs laid	Eggs retained
1	24	28
2	30	25
3	30	32
4	40	32
5	45	11
6	48	3
7	42	6

From the above table is is seen that it is possible for a female to lay, at least 72 eggs.

Occasionally a female sawfly may add her eggs to a mass previously laid by another female (Fig. 10). This occurred several times in our cages outdoors and in a few instances in the laboratory indoors. Such masses may contain over 100 eggs.

Longevity of adults: The adult sawflies live but a short time even under the most favorable circumstances. Fertilized females could be kept alive only two days, while those that had not mated, lived a day or two longer. Male specimens fared but little better than did the female, an extra day being the longest extension of time that could be credited to them.

Fig. 10. Female sawfly adding her eggs to a mass already laid. Enlarged 1½x.

Effect of oviposition on leaf: Because the under side of the midrib of the leaf upon which eggs were laid, was lacerated, it grows much slower than does the upper, with the consequence that the leaf curls downward.

THE EGGS

Duration of the egg stage: The duration of the egg stage is largely dependent upon the prevailing temperature, cool weather lengthening the incubation period and hot weather shortening the same. While in exceptionally hot weather the eggs may hatch in four days and in exceptionally cool weather they may require as much as seven and eight days, the average incubation period is five to seven days.

Development of the egg: As an egg develops, its shape as well as its size changes. The size increases until just before hatching an egg measures 1.3 to 1.5 mm. in length and .56 to .62 mm. in width. The shape of the egg changes from a broadly elliptical to a cylindrical form with rounded ends; later this becomes oval, the largest end being directed towards the base of the leaf blade. At this time two pink spots, the eyes of the larva, make their appearance in the large end of the egg. Later these spots turn black and then the black antennae and thoracic legs and the brownish mandibles become visible. In

a short time, the entire larva begins to show plainly through the egg shell. A close examination of the eggs reveals the fact that the larva is folded near the middle of its body, that the head and back ends of the larvae are in the large pole of the egg and that the folded portion of the body is in the other pole. The head, thorax and anterior portion of the abdomen occupy the lower half of the egg while the remainder of the abdomen occupies the upper half.

Hatching: Just before the egg hatches, the larva reverses its position inside of the egg and then it cuts the egg shell with its jaws or it ruptures the shell through pressure exerted against it with its head. As soon as an opening is made in the egg shell, the larva enlarges the hole by pressing its head against and through it and then the insect proceeds to make its way out of the egg. However, before the body is worked out more than one-half its length, the "worm" spins supporting threads of silk to hold the body firmly to the egg mass or leaf. A wave-like contraction now passes over the body from the posterior to the anterior end, which contraction forces the larva forward. More threads are now spun and then follows another contraction. This is repeated again and again until the "worm" has not only emerged from the egg but also reached the leaf tissue where it is to feed.

Occasionally a larva does not reverse its position in the egg before it makes its escape. In such instances the egg shell is usually ruptured at that end of the egg that is occupied by the folded abdomen.

The egg shells are not eaten by the larvae but remain clinging to the leaves as whitish or yellowish shrunken skins.

THE LARVAE

Duration of larval stages: The duration of the larval stages of **Neurotoma inconspicua** are dependent to some extent upon weather conditions, cool rainy weather retarding the development and dry hot weather hastening the same. Following is a table giving the average duration in days of the larval stages of 15 male and 15 female "worms". These larvae represent a portion of the progeny of three females and were reared at the same time and under conditions as nearly alike as possible.

Table 3

Average duration in days of the larval stages of 15 male and 15 female larvae

	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Sixth instar	Seventh instar	Total
Males	2.25 days	2.26 days	2.6 days	2.4 days	3.33 days	4.13 days		17 days
Females	2.6 days	2 days	2.13 days	2.46 days	2.86 days	3.2 days	4.8 days	19.53 days

The following conclusion may be drawn from these rearing experiments: there is quite a large variation in the duration of the same instar of male and female larvae; the average duration of the first, second, third or fourth instar of a male larva is less than the average duration of the fifth or sixth instar, while the average duration of the first, second, third, fourth or fifth instar of a female "worm" is less than the average duration of the sixth or seventh; the last instar of male and female larvae is longer than any of the preceding instars; the total length of time spent above ground by the female larvae is longer than it is by the males.

Locomotion: From the time that the larvae have hatched from the eggs until they are ready to leave their food plants and enter the ground, they use one and the same method of locomotion. This consists of a forward or backward movement brought about by forcing the body in one direction or another through arches of threads of silk which they spin. The dorsal side of the body is held against the object over or under which the larva is traveling, movements forward or backward being brought about by a contraction which passes over the body in wave-like fashion. No practical use is made of the legs or cerci during locomotion.

When the larvae have become full-grown and are ready to leave their food plants, their method of locomotion becomes very different from what it was during the feeding part of their life. The insects now drop to the ground, turn upon their venter and crawl hurriedly and awkwardly along. Now again a wave-like motion passing over the body is largely instrumental in forcing the insect forward. However, the pest is also assisted through the head which is used as a lever. Silk threads are spun over the ground as the "worms" travel forward, but in spite of this, the body rolls from side to side and frequently falls one way or the other. But whenever this occurs, the larva hurriedly rights itself and hastens on its journey.

Molting: Molting takes place during any part of the day

and while the larvae are inside of their web. A short time before this phenomenon is to take place, the insect becomes somewhat inactive, the yellowish color of the head becomes duller, while the longitudinal tracheae and the short tracheae connecting these with the spiracles turn silvery-white in appearance. The body is straightened except for the head which is bent sharpely downward. The thorax now swells and suddenly a rent is formed lengthwise in the skin covering the back of this part of the body. Later this cleft passes forward through the integument covering the head. Through the opening thus made, the insect works its way out of the old skin, the integument being gradually worked backward to the end of the body. The inner lining of the tracheae and fore- and hind-intestine are also shed and appear as thin white threads. The whole process of molting may be completed in eight minutes but it may require one and one-half hours to accomplish the task.

Immediately after molting, the pigmented areas of the body are pale and poorly developed; the same is also true of the chitinized parts. But after the lapse of an hour and one-half, the coloration and chitinization have become fully developed.

Male and female larva fully developed: A male larvae after it has passed into the sixth instar and a female after it has gone into the seventh, feeds for two to five days before preparing to enter the ground. By the end of this time the body length of the male has increased to 16 to 17.5 mm. and of the female to 19.5 to 24 mm. while the head has grown proportionately. The body now is firm and distended and the sublateral folds are no longer conspicuous.

Dissections of the larvae discloses the fact that the reproductive organs are imbedded in fat tissue and that they are abundantly supplied with tracheae. The male organs differ from the female in size, shape, texture and structure. The testes are delicate, kidney-shaped or elliptical bodies measuring .22 to .275 mm. in breadth and .35 to .5 in length, while the ovaries are firmer bodies broadly elliptical or oval in shape and measure .25 to .35 mm. in breadth and .45 to .58 mm. in length. The reproductive organs are composed of follicles, those of the ovaries being larger than those of the testes but smaller in number. The follicles of each ovary usually number 9 to 10 while those of a testis number 16 to 18.

Preparation by larvae to enter ground: After a Neurotoma larva has become full-grown, it spins a flimsy, cylindrical, brown case about itself and inside of this passes through

an adjustment period preparatory to entering the ground. The case is open at both ends and since the larvae were gregarious when these cases were formed, the cases are clustered. The larvae now rest for a day or two, but they may partake of food up to within a short time before entering the ground. During this resting period, their body becomes considerably shorter, firmer and less distended. Should the "worms" become disturbed now, they wriggle out of their cases and drop to the ground. Here they may remain for a few seconds, but soon they turn upon their venters and crawl hurriedly but awkwardly away, seeking an opening in the ground which they may enter.

Depth to which larvae burrow: The depth to which the larvae burrow varies from 1 to 11½ inches. In soil of average compactness, the "worms" may work their way 3 to 8 inches beneath the surface of the ground, in a hard soil they may burrow down 1 to 5½ inches, while in the loose soil, the larvae go as deep as 5 to 11½ inches. When the insects have reached the depth to which they will penetrate, they hollow out a chamber by twisting the body around and around and inside of this cell they curl up and remain throughout the rest of the summer, fall, winter and early spring (Fig. 9, 11).

Larval chambers: The larval chambers are broadly elliptical and made so that their long axes are more or less vertical. The chambers are of two sizes, the smaller having been made by the male larvae and the larger by the female. Considerable variation exists in the inside measurements of these cells; the small ones vary from 8 to 10 mm. in length and from 4.5 to 5 mm. in breadth, while the large ones measure 10 to 12 mm. in length and 5 to 6 mm. in breadth.

Larvae in chambers: The larvae maintain a definite position while inside of their underground chambers. This position is well shown in figure 11.

Larvae that were collected from their cells in the soil in late summer, fall or early spring, could be readily divided into two groups, small sized specimens or males and larger ones or females. These "worms" differ from those that are full-grown but are yet in their feeding period by being smaller, firmer of body and cleaner in general appearance. The color of the body is now grass-green or pink although intermediate colors also may occur. Upon dissection it was learned that these colors were due to a greenish or pinkish fat body.

Pupation: When a larva is about to pupate, the abdomen is straightened but the head and thorax are bent sharply downward so as to form more or less of a right angle with

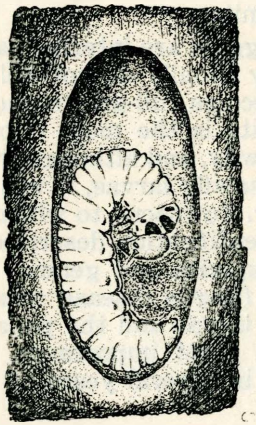

Fig. 11. Larva in chamber in soil. Enlarged 3x.

the remainder of the body. The abdomen then shortens and thickens and is withdrawn from the integument at the posterior end, which integument then shrivels. The thorax in the meantime swells and at the same time the pupal wings become discernable. A rent now forms in the integument covering the thorax on its dorsal side. From now on the shedding of the skin is very similar to the molting process of the larva already described.

THE PUPAE

Duration of the pupal period: The length of the pupal life varies with the prevailing temperature, but usually it ranges between 7 and 10 days.

Development of pupa: When a pupa first emerges from the larval integument, its chitinization is very poorly developed and the colors of the various body parts are very delicate and much lighter than they will be in a few days hence. Gradually a change occurs, the chitinized body of the adult and the darker coloration that goes with it making their appearance.

ENEMIES

The enemies of the plum webspinning sawfly may be divided into two groups: parasites and predaceous enemies.

PARASITIC ENEMIES

The parasitic enemies which were discovered obtaining their livelihood at the expense of **Neurotoma inconspicua** were

three, a tachinid fly larva or maggot, an unidentified fungus and an unidentified mite.

The tachinid maggots are internal parasites of the Neurotoma larvae but they usually do not kill off their hosts until their victims have become full-grown and entered the ground. Although this parasite is the most important enemy of the plum webspinning sawfly, and although it may destroy as high as 50 percent of the sawfly larvae, it was new to science when we discovered it. Mr. Townsend to whom specimens of the insect were sent for identification described them as **Eubrachymera debilis,** a new species and genus.

An unidentified fungus disease occasionally attacks and kills the hibernating larvae and the pupae of Neurotoma, but this disease is of no great importance, for it was met only about a dozen times in several years of work with this pest. Fig. 12).

Fig. 12. Neurotoma larva killed by fungus disease. The larva had burrowed into the soil and was there destroyed. Natural size.

A small reddish unidentified mite was found attached to the body of the larvae and adults of Neurotoma but this parasite was even less important than the fungus just discussed.

PREDACEOUS ENEMIES

The predaceous invertebrate enemies of the plum webspinning sawfly feed chiefly upon the larval stages of Neurotoma. These enemies, arranged in the order of their importance, are the following:

Larvae of Chrysopa or aphis lions

Nymphs and adults of **Podisus maculiventris** Say

Ants of the following species:

Formica rufa Linn subsp.**obscuripes** Forel var. **melanotica.** Emery and **rubiginosa** Emery

Lasius niger Emery var. **neoniger** Emery

Lasius niger Linn. var. **americanus** Emery
Spiders of several undetermined species
Damsel fly of undetermined species
Adults of **Adalia bipunctata** Linn. or lady beetle

The larvae of Chrysopa and the nymphs and adults of **Podisus maculiventris** make their way through the web of their prey very readily and when they come upon a Neurotoma larva, they suck out its blood. These enemies must be rated as the most important of all the predaceous enemies of Neurotoma.

The ants listed above were those found destroying the larvae of the plum webspinning sawfly. Not only do the ants attack, kill and carry away the "worms" that are not well protected by webs on trees or bushes but they also destroy those that are full-grown and that have dropped to the ground preparatory to entering it. The ants will also attack and kill adult Neurotoma, but usually only such adults are found and destroyed as have already reproduced.

Occasionally a male or female sawfly was taken from the web of a spider but since this occured but seldom, spiders cannot be looked upon as of any considerable importance in the natural control of this pest.

Mr. George Gilbertson reported seeing a damsel fly feeding upon a Neurotoma larva, but since this is not the natural food of the damsel flies, these insects are of no greater importance as checks to this pest than are spiders.

A ladybird beetle (**Adalia bipunctata** Linn.) was seen to feed upon a small but weakened Neurotoma larva, but these insects cannot be looked upon as serious obstacles to the natural increase of the plum and sandcherry pest.

CONTROL

Very little if any actual control work of this pest was carried on in the past by entomologists. In order that knowledge might be had of the action of various insecticides upon the larvae with which this bulletin deals, a series of spraying experiments were conducted in the nursery of the Gurney Seed and Nursery Co. of Mitchell, S. Dak., and in the horticultural plots of the South Dakota State College, Brookings, S.

Dak. These experiments were carried on during the years 1915, 1916 1917, 1918 and 1919 and were made upon "worms" infesting plum trees and sandcherry bushes. In each experiment, we were careful to work with larvae ranging in age from the first instar to the last.

SPRAYING

Attempts to destroy the larvae through spraying were made with two class of insecticides, stomach poisons and contact insecticides. The spray materials were applied through a barrel sprayer and also through a Deming Planter's Gem sprayer. Disc type of nozzles were employed in all of our spraying experiments.

The following formulas were used in making up the sprays containing stomach poisons:

Calcium arsenate in powder form	1 pound
Freshly slaked lime	2 pounds
Water	150 gallons
Lead arsenate in paste form	1 pound
Water	50 gallons
Lead arsenate in paste form	2 pounds
Water	50 gallons
Magnesium arsenate in powder form	1 pound
Water	50 gallons
Paris Green	1 pound
Freshly slaked lime	2 pounds
Water	200 gallons
Zinc arsenite in powder form	1 pound
Freshly slaked lime	2 pounds
Water	150 gallons

Table 4 indicates the result obtained by using the sprays made up according to the aforementioned formulas.

Table 4

Summarized statement of results obtained by spraying with stomach poisons.

Experiment	Poison used in spray	Strength of spray	Number of trees sprayed	Effect on foliage	Percent of larvae killed
1	calcium arsenate in powder form	1 pound to 50 gall. of water	20 sandcherries 20 plum trees	Severely burned	100
2	lead arsenate in paste form	1 pound to 50 gall. of water	25 sandcherries 25 plum trees	none	100
3	lead arsenate in paste form	2 pounds to 50 gall. of water	25 sandcherries 25 plum trees	none	100
4	magnesium arsenate in powder form	1 pound to 50 gall. of water	20 sandcherries 20 plum trees	Severely burned	100
5	paris green	1 pound to 200 gall. of water	20 sandcherries 20 plum trees	Severely burned	100
6	zinc arsenite in powder form	1 pound to 150 gall. of water	20 sandcherries 20 plum trees	Severely burned	100

In the experiments summarized in table 4, it was found that the poisoned larvae began to die five hours after spraying took place. However, a 100 percent kill was not obtained until 3 days had elapsed in experiments 1, 3, 4, 5, and 6 and until 4 days had passed by in experiment 2. It was also discovered that larvae in the first and second instars were more readily killed than were older "worms". Further, it was learned that the smaller the web and the less food material it enclosed at the time of spraying, the sooner would the larvae be killed by being forced to feed upon the poisoned foilage.

The lead arsenate sprays were the only ones which did not burn the leaves of the sprayed plants. The calcium arsenate, magnesium arsenate, paris green and zinc arsenite sprays all burned the foilage severely and caused a partial or total defoilation of the treated plants.

A number of contact sprays were also used in an attempt to destroy the Neurotoma larvae. These sprays were made up according to the following formulas:

Black Leaf 40 ---------- 1 part
* Water ---------- 800 parts

* Black Leaf 40 ---------- 1 part
Water ---------- 500 parts

* Black Leaf 40 ---------- 1 part
Water ---------- 250 parts

* Black Leaf 40 ---------- 1 part
Water ---------- 125 parts

Kerosene emulsion 5, 10 and 15 percent

Soap (Kirkes White) ---------- 1 pound
Water ---------- 8 gallons

Soap (Kirkes White) ---------- 1 pound
Water ---------- 4 gallons

Soap (Kirkes White) ---------- 1 pound
Water ---------- 2 gallons

Table 5 shows the results obtained through the use of the contact sprays.

Table 5

Summarized statement of results obtained by spraying with contact sprays.

Experiment	Spray used	Strength of spray	Number of trees treated	Effect on foliage	Percent of larvae killed
1	Black Leaf 40	1 - 800	20 sandcherries 20 plum trees	none	60
2	Black Leaf 40	1 - 500	20 sandcherries 20 plum trees	none	55
3	Black Leaf 40	1 - 250	20 sandcherries 20 plum trees	none	60
4	Black Leaf 40	1 - 125	20 sandcherries 20 plum trees	none	73
5	Kerosene emulsion	5 per cent	25 sandcherries 25 plum trees	none	78
6	Kerosene emulsion	10 per cent	20 sandcherries 20 plum trees	none	73
7	Kerosene emulsion	15 per cent	20 sandcherries 20 plum trees	none	84
8	Soap, Kirkes White	1 lb. to 8 gall.	20 sandcherries 20 plum trees	none	57
9	Soap, Kirkes White	1 lb. to 4 gall.	20 sandcherries 20 plum trees	none	80
10	Soap, Kirkes White	1 lb. to 2 gall.	20 sandcherries 20 plum trees	none	40

* Kirkes White Soap was added to this spray at the rate of 4 pounds to 100 gallons of the spray.

In connection with the experiments summarized in table 5, a number of facts are to be noted. None of the contact sprays gave a 100 per cent kill even when used in such quantity as to drench the webs and bathe the bodies of the "worms". The younger larvae succumbed much more readily to the effects of the spray than did the older. As the strength of a spray was increased the mortality effect which it caused amongst the Neurotoma larvae did not always increase proportionately. Frequently some of the worms would leave their spray-soaked web and migrate to another part of the tree, only to continue their destruction there. The various contact sprays did not penetrate and wet down the webs with equal effectiveness. Kerosene emulsion ranked first in this respect and then followed the soap sprays and finally the Black Leaf 40.

DUSTING

Attempts were also made to poison the Neurotoma larvae by dusting the infested bushes and trees with the following materials:

Calcium arsenate	1 part
Powdered sulphur	15 parts
Lead arsenate	1 part
Powdered air-slacked lime	15 parts
Magnesium arsenate	1 part
Powdered sulphur	15 parts
Paris green	1 part
Powdered sulphur	15 parts
Zinc arsenite	1 part
Powdered sulphur	15 parts

Before any of the dusts were applied to the foliage, they were thoroughly mixed and then passed through a screen with twenty meshes to the inch. The applications were made to the trees and bushes with a "Leggett's Champion Duster". No attention was paid as to whether or not dew was present on the foliage at the time of dusting, for preliminary experiments had proven to us that this was a negligible factor.

The killing and burning effects of the dusts were very similar to those which were obtained where the poisons were applied to the foliage in the liquid form. A 100 percent kill was obtained in both cases, but with the dry application of the poisons, usually a day or two longer was required to kill all of the larvae. This was to be explained through the fact that the dusts did not penetrate the webs as readily as did the liquid sprays.

Notes on the effects of spray and dusts on larvae: In our spraying and dusting experiments, it was found that some of the larvae would leave the treated webs and migrate to another portion of the tree or they would disappear entirely. Larvae that were dying from the effects of a stomach poison or contact spray would very often emit a blackish or brownish fluid from their mouths or anal openings. Sometimes some of the larvae would be partially paralyzed from the effects of a nicotine or soap spray, remain so for several hours and then recover entirely.

RECOMMENDATIONS

To avoid the injury caused by the larvae of the plum web-spinning sawfly, plum trees and sandcherry bushes should be sprayed or dusted with lead arsenate as soon as the larvae make their appearance or about the middle of June. If spraying or dusting is delayed, there is an ever increasing destruction of foliage until the larvae are either killed or until they become full-grown. If lead arsenate is to be used in a spray, it should be employed at the rate of ½ pound of the powder or 1 pound of the paste form to 50 gallons of water. The poison should be made up in the form of a thin paste before it is added to the spray tank. If the poison is to be dusted upon the plants it should be diluted at the rate of 1 pound of the arsenate to 15 parts by weight of air-slacked lime or powdered sulphur.

Should the grower discover the eggs of this pest on the leaves of his trees or bushes, he should destroy them. This is best done by plucking off the leaves upon which they are found and then crushing the eggs by stepping upon them.

Because of their burning tendencies, paris green, calcium arsenate, magnesium arsenate and zinc arsenite should not be applied to plum trees or sandcherry bushes.

ACKNOWLEDGEMENTS

The writer is indebted to Mr. George Gilbertson for the preparation of figures 3, 5, 6, 7, 9 and 11 and for much other aid which he kindly rendered. I am also indebted to Mr. S. A. Rohwer for the description of the male and female sawflies included in this bulletin.

LITERATURE CITED

(1) Dalla Torre, K. W.
1894. Catalogus Hymenopterorum hucusque descriptorum systematicus et synonymicus, vol. 1, p. 419 and 432.

(2) Fernald, H. T.
1903. The plum webbing sawfly. In Ent. News, vol. 14, p. 298.

(3) Fletcher, J.
1896. The plum web-worm. In Rept. of Ent. and Bot. Dom. Exp. Farm, p. 253.

(4) Rohwer, S. A.
1911. The genotypes of the sawflies and woodwasps, or the superfamily Tenthredinoidea. In U. S. Dept. Agr. Div. Ent. Tech. Ser. Bul. 20 pt. 2, p. 82, 85.

(5) Severin, H. C.
1918. The plum webspinning sawfly. In cir. 5, Office of the State Entomologist of S. Dak.

(6) Severin, H. C.
1919. Invertebrate enemies of the plum webspinning sawfly. In Proc. S. Dak. Acad. Sci. p. 23.

(7) Slingerland & Crosby
1914. The plum webspinning sawfly. In Manual of Fruit Insects. p. 254 - 255.

(8) Williams, T. A.
1896. The webspinning sawfly of plum and cherries. In S. Dak. Agr. Exp. Sta. Bul. 48, p. 14 - 17.