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Bulletin 288 June, 1934

The Plum Tree Borer

(Synanthedon pictipes G. & R.)

Its Distribution, Life History, Economic Importance and Control

Department of Entomology Zoology
Agricultural Experiment Station
South Dakota State College of Agriculture
and Mechanic Arts
Brookings, South Dakota

The Plum Tree Borer

(Synanthedon pictipes G. & R.)

Its Distribution, Life History, Economic Importance and Control[1]

by

G. I. Gilbertson

The plum tree borer is one of the most destructive insect pests of plum trees in South Dakota. The early death of most of our plum trees may be attributed largely to this insect. Through various avenues, such as surveys, nursery inspection, correspondence, etc., we have found it to be widely distributed over our state.

Distribution

The plum tree borer, often known as the lesser peach tree borer, is a native American insect. It is quite generally distributed throughout the eastern half of the United States. It ranges from Canada to the Gulf of Mexico, and from the Great Plains to the Atlantic Coast.

In South Dakota, the borer may be found wherever plums are grown under cultivated conditions. It is also found destructive in thickets of wild and native plums. In the drier sections of the State where native plums are found in thickets along water courses, draws, etc., this insect is commonly encountered.

Prior to the introduction of cultivated plums and cherries, the borer directed its attack against our native drupes. However, when cultivated plums and cherries were introduced and established in the State, the insect included these as food plants and proved to be highly destructive to most varieties.

Food Plants

The plum tree borer is known to infest our native plums (Prunus americana March and Prunus nigra Ait.), our native chokecherry (Prunus virginiana L.) and the western form (Prunus virginiana var. demissa Torr.), the native pin cherry (Prunus pennsylvanica L.), and the native black cherry (Prunus serotinia Ehrh.).

Our cultivated drupes, cherry and plum, are seriously attacked by the plum tree borer. Extensive plantings of these trees have been entirely killed by this insect.

1 This Experiment Station project was financed through Adams funds.

The borer was reared in 1893 by F. M. Webster from the black-knot fungous diseased areas on plums and cherries. We have encountered this same situation on our drupes.

Beutenmuller (1896) records this insect breeding in juneberry (Amelanchier canadensis).

This insect has long been known to be a serious pest of peach trees, and so it is known in localities as the lesser peach tree borer. However, in South Dakota we have practically no peach plantings and, therefore, from this angle this name is only of passing interest to us.

Nature and Extent of Injury

The plum tree borer is to be found more often in neglected plantings or thickets of unpruned and uncared for trees (Fig. 1). The adult insect prefers to deposit eggs in broken bark; therefore, borers are very apt to get started in cankers and sunscald, in split crotches, in pruning scars, in abrasions caused by harness appurtenances and by implements in cultivation. It is also found under loose bark of older trees. Injury is caused by the borers or larvae feeding upon and destroying the cambium and inner bark layers. Having become established in an area, the borers feed upon the tender bark at the wound margin. They rapidly increase this area and extend it through their voracious feeding far beneath the surrounding outer bark. It is common to find a dozen or more borers feeding around each wound area.

These borer-inhabited areas become great enough at times to include all living bark on one side of the tree trunk. As a consequence, the branches on the one side of the tree die (Fig .2). Very often the borer

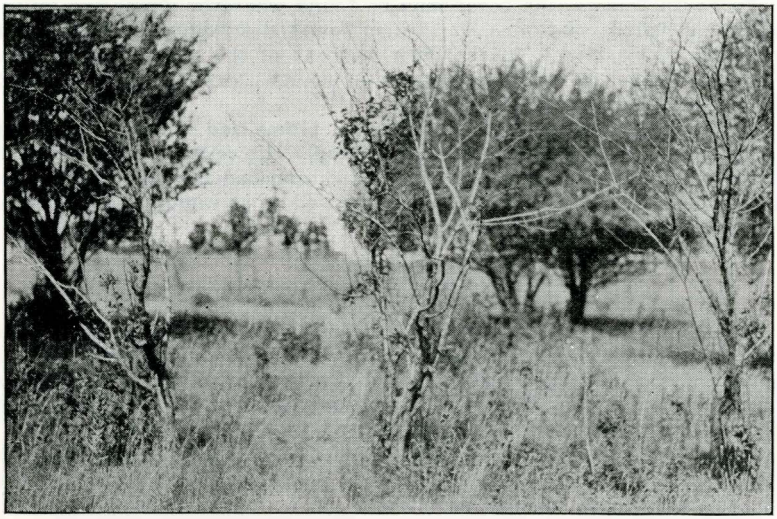


Fig. 1—Neglected plum trees attacked by the plum tree borer. Original.

Fig. 2—Plum trees heavily infested with plum tree borers. Original

infested area completely girdles the trunk or larger limbs, and causes the death of the entire tree or branch. At times the injury may extend inward and the trunk and the larger limbs may become honeycombed. In most cases, borer-inhabited locations may be rendered more or less conspicious by the exudation of sap, gum, frass and excrement. The sap which oozes from cracks and burrow openings may more or less harden to form masses of gum. At times we find association of fly larvae under the bark with borer infestations. These fly larvae are secondary feeders and are living upon fermenting sap and gum.

Synonomy

The adult plum tree borer or lesser peach tree borer is a moth and is a member of the clear wing family (Aegeriidae). The young or larva of this family, are borers which feed on the inner bark or pith of trees and lesser plants.

The insect under consideration was first described in 1868 by Grote and Robinson from adults taken in Pennsylvania (3). It was given the species name of pictipes and placed in the genus Aegeria of Fabricius. In 1881 Henry Edwards redescribed the insect from specimens obtained in New Hampshire and Massachusetts, calling it Aegeria inusitata. In

1893 Beutenmuller fixed the name inusitata as a synonym of pictipes. In 1890 Smith removed the species pictipes from the genus Aegeria to the genus Sesia of Fabricius which transfer was accepted by Beutenmuller (1896) and Dyar (1902). However, in 1903 Holland (4), stating that the genus Sesia had been restricted to a genus of Sphingidae of Fabricius gave Hubner's proposed name Synanthedon to this genus of moths. This scientific name now obtains, and the plum tree borer or lesser peach tree borer is known as Synanthedon pictipes G & R.

Description of Stages

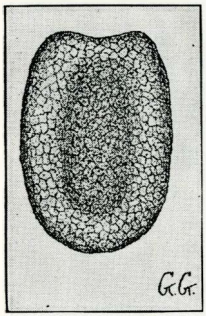


Fig. 3.—Egg of the plum tree borer enlarged Original.

The plum tree borer has a complete metamorphosis and has therefore, four stages in its life cycle: the egg, the larva or borer, the pupa and the adult.

The Egg—Fig. 3.—The eggs (Fig. 3) of the plum tree borer are reddish to rusty brown in color. The egg is more or less oval or elliptical in outline, with a slight concavity at the anterior pole of the egg. The surface of the egg is somewhat rough and finely reticulate or sculptured. The upper surface of the egg is slightly concave, the concavity being oval and following the contour of the egg margin. The egg averages 0.62 millimeter in length and 0.39 millimeter in width.

The Larva or Borer.—The larva, caterpillar or borer when first hatched is very small and difficult to detect. It is dull white in color. In later life, however, it may take on various shades of creamy white color, tinged with pink (Fig. 4). During its period of larval life, the borer grows and molts five times. Each molting of skin marks the end of a separate period of larval development and is called an instar. The following is the tech-

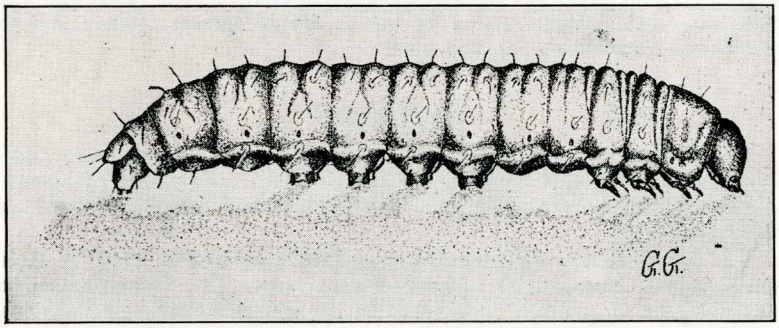


Fig. 4—Larva or Borer. Original

nical description of the sixth instar or full grown larva or borer according to Girault (2):

"Length, 20.5 mm., average. Greatest width, 3.4mm. Width of head, 1.94 mm., average. Normal for the family: Body soiled cream color, immaculate, with the usual more or less generalized characters. Head yellowish brown, darker at base of clypeus and on labrum and mandibles, and blackish at the lower outer angles of the paraclypeal pieces, edges of clypeus, and tips of the mandibles; pale at vertical triangle, outer edges of paraclypeal pieces, gular surfaces, epistoma, palpi, and antennae, the last two somewhat darkened; mandibles broad and short, indistinctly five-toothed, the two inner teeth mere serrations, the third tooth short, truncate, and broad, one-half shorter than the second, which is shorter and broader than the first, which is also obtuse; cutting edge of mandible oblique; two setae present, arising together from middle of inner edge. Clypeus long, acutely triangular, its lateral margins sinuate, not distinctly truncate at basal corners, which are impressed and bear two setae, one caudad of the other; paraclypeal pieces long, narrowed centrally, including the clypeus; on the inner side of each paraclypeal piece near the posterior end is a slight depression from which arises a small seta, near the apex of the clypeus. Ocelli 6, weak, pale, the first four in a quadrangle, each with a distinct lateral pigment spot; the fifth more cephalad, ventro-laterad of antenna, also with pigmentation; the sixth smaller, caudo-laterad of the fifth, and without pigmentation; the group protected by setae.

Cervical shield pale yellow, bearing twelve setae, in two groups of three each on each side of meson, all separated, and the caudal one of the first group separated by a suture; laterad of the shield, cephalad of spiracle, a group of three from a calloused tubercle, of which the cephalic two are much the longer; directly laterad a group of two from a fleshy elongate tubercle, the caudal seta the larger, between these setigerous tubercles, caudad and opposite the spiracle, is a narrow nonsetigerous tubercle, much narrower than the second setigerous one (one next to the fore leg); spiracle oval, brownish; "vii" and "viii" small, on the venter (?) and base of fore leg. On segments II and III, i in the dorsal region consisting of two setae, the laterad larger ii the same, slightly advanced, dorso-lateral aspect; iii single, minute, caudad between ii and iv, nearer the latter; iv single, larger, in a line laterad with iii, advanced slightly beyond i, and in the stigmatal line; v small, its setae larger than iii, single, much advanced, cephalo-laterad of iv; vi some distance caudo-laterad of v, about in a line transversely with i, single, equal to iv, above base of leg; all in the second annulet. A calloused spot behind iii, and a smaller above vi, some distance caudad of v. Segment IV, single, i cephalad, small, in first annulet; ii larger, caudo-laterad of i; i and ii from dorsal aspect, forming a trapezoid; iii some distance from i in a transverse line, equal to ii, apparently in the first annulet, just above spiracle; iv and v combined just below the spiracle, the seta of v larger; vi caudad,

nearer to vii than to iv and v; vii consisting of two setae in the ventro-lateral line, and viii of one seta in the ventral region, minute; a minute calloused spot behind iv and v. Segment V, the same, vii consisting of three setae, one of which may be obsolete. Segments VI, VII, VIII, and IX, the same; vii three setae on cephalo-lateral aspect at the base of proleg; viii, minute and single, inner side base of proleg; the intermediate seta of vii longest. On segment X, ii caudad of i, vii consisting of two setae, the inner the larger, vi nearer to vii. Segment XI, i and ii closer, the latter also closer together transversely, iii cephalo-mesad of the spiracle; iv small, against, and cephalad of the spiracle; XII a single setae. Segment XII, i apparently absent; ii, iii and iv in a transverse line, iii and iv combined; v minute, between iv and vi, slightly cephalo-laterad of iv; vi large, cephalad; vii and viii single. Anal shield sub-obsolete, pale, bearing four large setae on each side, minutely maculate. Segment XIII, four minute tubercles across the venter (vii and viii?), in front of each proleg, and just below the shield, a line of five on each side of the segment, of unequal size.

Spiracle oval, inconspicuous, brown; that of segment XI larger, somewhat obliqued, and farther dorsad. The crotchets of the legs are variable in number, often unsymmetrical, and generally arranged as follows:

Proleg.	Anterior row.	Posterior row.
1.	14-18	12-14
2.	14-17	12-15
3.	14	12
4.	12	11
Anal.	8	0

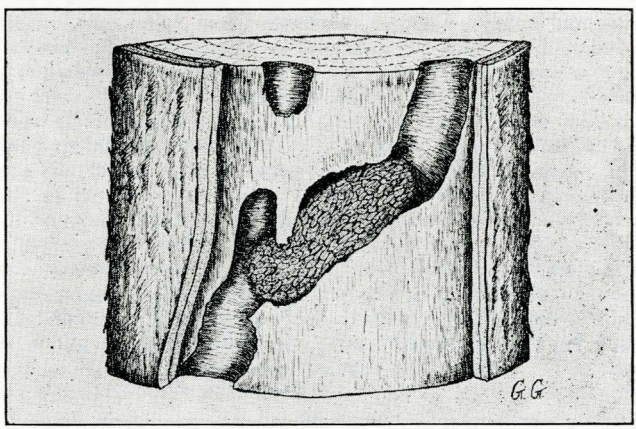


Fig. 5—Cocoon within the borer gallery. Original.

For the first four prolegs, the crotchets vary from 11 to 18 in number; for the anal proleg they vary from 8 to 9."

In South Dakota, the larva or borer passes the winter in various stages of larval growth. Usually the winter is passed in a hibernating cell constructed loosely of frass and silk. When, in the spring, larval growth is complete a cocoon is constructed (Fig. 5). This is made of wood and bark chewed into fine pieces and of silk secreted by the larva. The larva having formed its cocoon and enclosed itself, changes to a pupa within a few days.

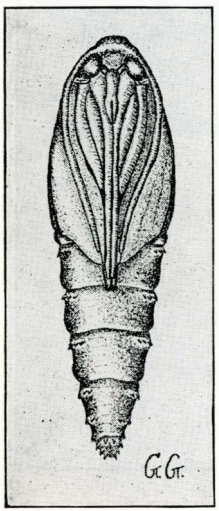


Fig. 6.—Pupa of the plum tree borer. Original.

Pupa—Fig.6.—The pupa (Fig. 6) is yellowish brown in color, with a polished appearing surface. It is cylindrical in form and somewhat spindle-shaped. The wings, legs and mouth parts are folded ventrally, and cover the ventral aspect of the thorax and first four abdominal segments. The head is armed with a cutting plate of heavy chitin used for breaking through the cocoon. The abdominal segments are about equal in length and fitted with rows of short spines. This enables the pupa to wriggle from the cocoon and along the burrows to the outer bark. The pupa of the female moth is larger than the male and has but a single row of spines on the seventh abdominal segment. The pupa of the male is usually somewhat smaller and has on its seventh abdominal segment two rows of spines. The cremaster consists of eight stout spines surrounding the anal end.

When it is first formed, the pupa is white in color, but gradually turns yellowish brown after a few hours. It remains so until time of eclosion, when it turns darker and assumes the steel blue-black color of the enclosed moth.

The Adults.—There are two sexes of this wasp-like moth, the female (Fig. 7) and the male (Fig. 8).

The following description is recorded by King (5):

Adult Female, Fig. 7.—"Expanse 15 to 26 millimeters. Form selnder; general color, metallic blue-black with markings of pale yellow. Head blue-black with the area between the antennae sometimes marked with pale yellow scales. Face in front of eyes narrowly banded with pale yellow. Collar dark above, at sides pale yellow. Palpi pale yellow below; above dark, sprinkled with yellow scales. Antennae filiform, clothed with blue-black scales. Thorax metallic blue-black; above with two pale yellow lateral stripes; posterior border marked with a few yellow scales; below dark indigo-blue, with an irregular patch of pale yellowish-white scales below and slightly anterior to the insertion of the forewings. Abdomen slender and of the same metallic blue-black as the other parts. Posterior margin of a second segment narrowly banded with pale yellow; laterally this band extends forward to the thorax. In some individuals this band is incomplete. The posterior margin of the fourth segment is sometimes

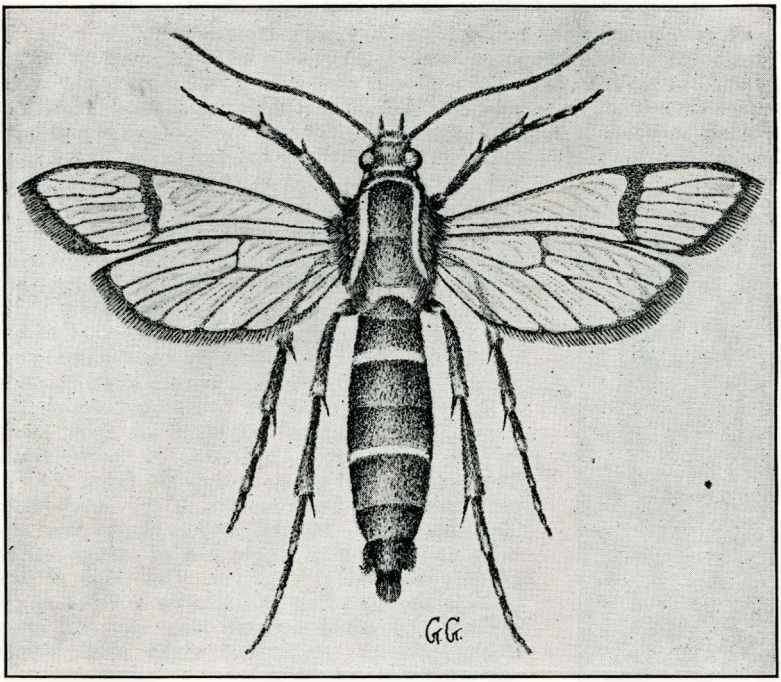


Fig. 7—Female moth enlarged. Original

narrowly banded with pale yellow. In some specimens this band is wanting on the dorsal surface, but in most individuals it is represented in part as a broad band on the under side of the abdomen. Caudal tuft blue-black. Legs dark indigo-blue, tufted with light yellow; tibiae bright indigo-blue; tarsi banded and powdered with pale yellow scales. Middle and hind femora dark; tibiae indigo-blue, interrupted with tufts of yellowish white scales at joints and spurs; tarsi, blue, banded and powdered with pale yellowish-white scales. Tibial spurs prominent. Wings hyaline, membrane very slightly tinged with yellow; reflections cyaneous. Wing-veins outlined with blue or violet-black scales. Fore-wings with the costal margin blue-black or violet tinged, and frequently narrowly lined or powdered with yellow scales; discal spot violet-black or blue-black with pale yellow scales on the inner margin. Outer margin of fore-wings violet-black with a few yellow scales intermingled; fringe dark gray. Membrane of apical portions of the fore-wings sprinkled with delicate, light cobalt-blue scales. Inner margin of fore-wings marked with a narrow band of yellow. Border of hind wings violet-black, fringe dark gray."

Adult Male, Fig. 8.—"Expanse 15 to 23 millimeters. Similar to female in color and markings, body more slender. Easily distinguished from the female by the finely tufted antennae. Caudal tuft hastate in form, narrowly bordered with white on the outer edges.

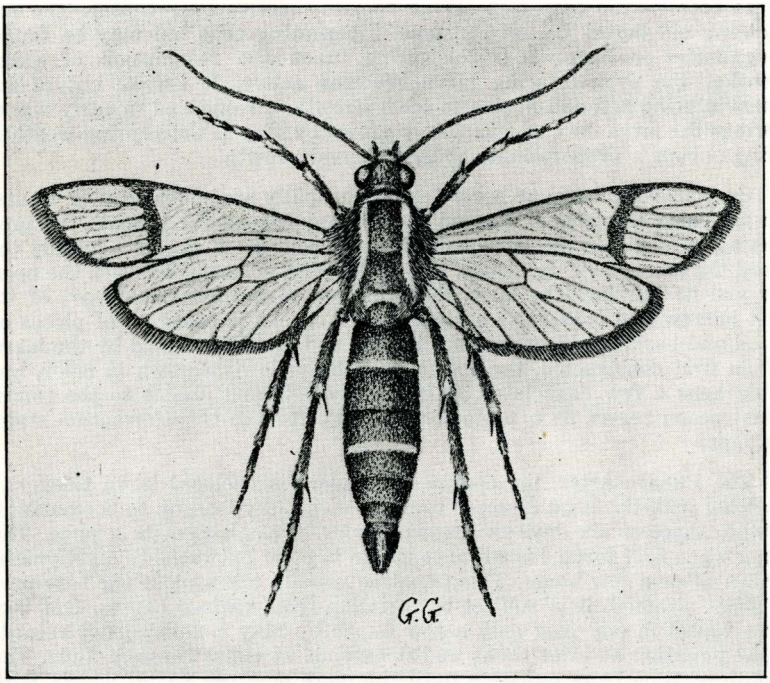


Fig. 8—Male moth enlarged. Original.

Normally the frenulum in both the males and females of Aegeriidae appear as a single bristle. In the females the bristle is formed by the coalescence of several setae; however, individuals occur with the frenulum divided. With the species under discussion, Girault points out that the frenulum is divided in the female. The author has found that not infrequently in the female the frenulum is composed of two setae which are quite closely fused and appear as one; and again in other individuals the frenulum is composed of two setae which are not fused, and which separate upon being removed from the wing. In view of these facts this character cannot always be relied upon in determining the sexes. The antennal characters are reliable and are more easily observed.

Seasonal Cycle

Overwintering Larva.—The plum tree borer passes the winter as a larva or borer (Fig. 10.) From observations made at Brookings we find overwintering larva in various places, such as in deeper galleries, in crotch crevices, under loose bark, etc. While low temperatures curtail activities, warm fall weather may extend their feeding into November. Upon the approach of cold weather, the majority of borers construct loose hibernating cells or cocoons of silk and woody materials. Within

these cocoons the curled-up larvae remain inactive over winter. The remaining old borers do not construct hibernating cells but may be found in galleries or burrows. In the spring, upon the resumption of warm weather the overwintering larva becomes active. It breaks out of its overwintering cell and begins to feed. Growth is rapid and in early warm springs the larva may be completely grown by May 1. Cold spring weather brings about a proportionate delay in larval growth.

Cocoon.—The larva or borer feeds principally at the margins of wound areas. These margins of injured tissues may extend far beneath the protecting bark. When the larva has grown to full size it gnaws a gallery toward the outer bark and leaves only a thin disk covering between the open air and its burrow. The larva then retreats to the innermost part of its exit burrow and constructs a cocoon. This cocoon is made up of pieces of wood and bark, finely ground or chewed, and of silk secreted by the larva When first constructed, the cocoon is light yellowish-brown in color, but it darkens a few days later. It is usually soft and pliable to the touch. This cocoon serves as a protective housing for the transformation stage or pupa.

The Pupa.—After the cocoon is made, the enclosed larva takes its position with the head directed toward the gallery leading to the surface. Within three to six days the caterpillar or larva changes to a pupa. The pupa when first formed is white to cream in color but turns to a yellowish-brown after a few hours. This pupation usually takes place the fore part of May, although it is subject to variation from various causes. Our records reveal in one year only a few pupae by May 1. Subsequent records show pupation at later dates and it extends at times through June. The length of time from pupation until the moth emerges varies widely with the temperatures. Under ordinary circumstances, 20 to 30 days are required for the completion of this transformation. It may take longer. As the time for moth emergence approaches, the pupa turns much darker and assumes the color of the enclosed moth. It becomes steel blue-black a day or two before the moth issues.

Moth Emergence.—Preceding the eclosion of the moth, the pupa becomes somewhat swollen and quite active. Aided in forward progression by means of the spines on its abdominal segments and the anal cremaster, the pupa wriggles to the anterior end of its cocoon. By means of the chitinized cutting structure on the head, the pupa pushes forward through the cocoon wall and into the gallery leading to the disk. The forward motion is continued until the thin disk is pushed out and the pupa projects itself one-half to two-thirds its body length into the open air. Only the last few abdominal segments remain in the burrow while the pupa is thus projected from the bark (Fig. 9). In this position, the pupa rests for a time. Then begins a series of contortions in which the enclosed moth brings pressure to bear upon the front portion of the pupal case. This pressure finally causes the rupture of the pupal case along a middle dorsal line. As the contortions of the moth continue, the antennal and wing sheaths are ruptured and the moth climbs out from the imprisoning case. The moth climbs upward and remains quiet for a period of from 30 to 40 minutes. During this quiescent period, the wings, which at first are small cape-like pads, become expanded and when dry, the moth is able to fly.

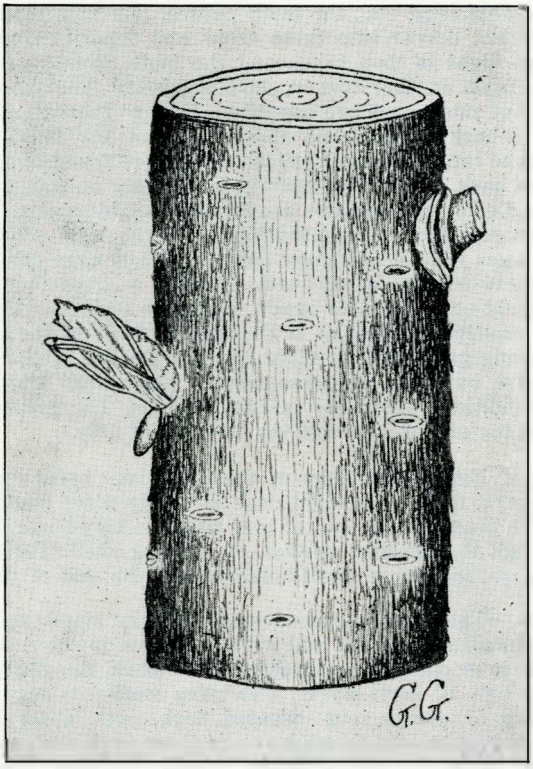


Fig. 9—Empty pupal case projecting from bark. Original.

The first moths have been found by June 1. They are more abundant during mid to late June and disappear in early July.

Mating and Egg Laying.—Under favorable conditions, the males and females may mate in about an hour after they emerge from the pupal case. The sexes assemble through the sense of odor. Scent glands, located on the ovipositor or egg-laying instrument of the female, diffuse a volatile substance into the air. To this odor, the males respond instantly, fly to the female, and mating takes place.

Oviposition or egg-laying occurs shortly after mating. At this time, the females are nervously active, and fly in a rapid and erratic manner. It is difficult to follow her erratic flight from plant to plant. In nearing a tree, the female flies up and down near the trunk, and finally alights. Moving about on the bark surface, the female moth thrusts out its ovipositor repeatedly, frequently touching the bark. When the sensitive tip

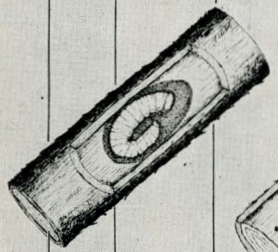
of the ovipositor encounters cracks and crevices in the bark, wounds, rough places, abrasions, etc., the moth pauses. She then thrusts her egg-laying instrument deeper into these areas and deposits from one to six eggs. A short flight is then taken and the moth alights upon the same tree trunk or upon another tree in close proximity. The same maneuvers are repeated and more eggs are deposited. In our observations, eggs were to be found in bark crevices and abrasions from any cause, which were on the trunk and larger limbs. At times, eggs were found under overhanging and curled bark. Egg-laying usually takes place on warm, sunny days. Wind, rain and cold temperatures render the female inactive. We are unable to obtain satisfactory information as to the total number of eggs laid. Indoor cages yielded anywhere from 30 to 100 eggs per female. Dissections of these females after death revealed a great many more developed but unlaid eggs. Outdoor cages yielded no further evidence. Nor do we have any positive evidence as to the length of life of the sexes. Indoor cage experiments gave three to eight days as the life of the adults. Outdoor cages gave us about the same results. Eggs were first encountered under field conditions about the middle of June. The greatest numbers were found at the end of June and the forepart of July.

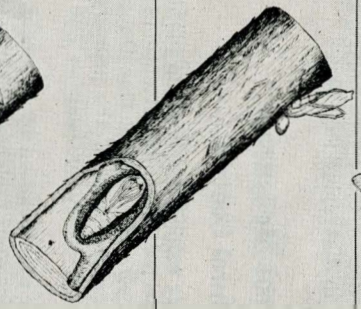
Hatching of Eggs.—The eggs of the plum tree borer hatch in from eight to ten days. Ordinarily eight days is required for embryonic development to take place. At the end of that time the tiny borer or larva cuts its way through the anterior portion of the egg shell. The hatched egg retains its shape, leaving a small hole to mark the exit of the larva.

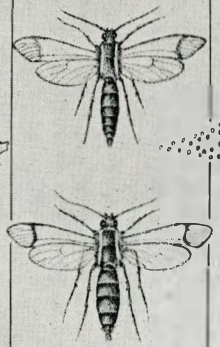
The Larva.—The newly hatched larva is very small and almost invisible to the unaided eye. It is dull white to cream in color. As the egg is usually placed in or close to an abrasion in the bark, the young borer does not gnaw through all bark layers. The larva works its way under loose pieces of outer or margins of diseased bark, cuts, abrasions, wounds, etc. After entering the tree through one of these avenues the young larva begins feeding upon the tender living tissues. It feeds voraciously and forms burrows and galleries between the bark and the wood of the tree. These channels become more or less clogged with semi-liquid gummy secretions from the tree. Mixed with this material will be excrement from the borer and woody frass or sawdust-like material made by the mouth parts of the borer. Very often this gummy material will be forced to the surface of the bark where it will in time solidify into a resin-like mass. The larva hatching in late July or early August grows rapidly and continues to feed throughout the summer. As feeding continues, the wound area increases and the borers may at times gnaw quite deeply into the wood of the tree. Upon the approach of cold weather, the larva ceases to feed and constructs its overwintering cell. Within these winter cells they remain inactive until spring, when warm weather again prompts them to resume their feeding and ultimate growth.

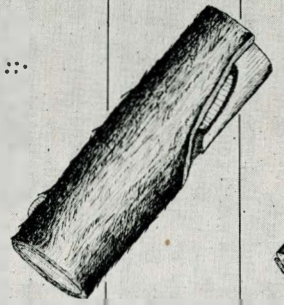
Number of Generations.—From our work on this insect we were unable to find evidence of a second brood. Our test trees showed no indication of fall oviposition. No adults were captured after early July. We have come to the conclusion that in this northern and midwestern area, the plum tree borer is single brooded.

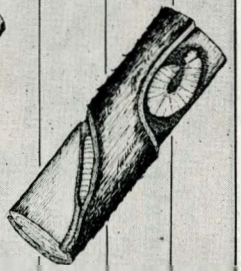
Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.











Overwintering larva curled beneath bark in oval hibernating cell

Early April the larva resumes feeding. Later in April the larva spins a cocoon and within it changes to a pupa

In May the pupa wriggles from its cocoon and thru a gallery pushes its way to the outside, until ⅓ to ⅔ of its body protrudes from the tree trunk.

In late May and during June the pupae give rise to adults. The sexes mate shortly after emergence.

In late June and in early July, small, oval, brownish eggs are laid in bark crevices, wounds etc. The eggs hatch and the larvae or borers burrow into the bark and begin feeding.

Thruout late summer and early fall the larva or borer feeds and increases in size.

Upon the approach of cold weather the borer constructs an oval overwintering cell and hibernates until spring

Seasonal Cycle of the Plum Tree Borer
Fig 10

Gilbertson

Natural Enemies

The plum tree borer is subject to attacks of both parasites and predaceous enemies. This is especially true where the borer is working in exposed or accessible areas. However, owing to the more or less protected situations in which the borers feed, they do not seem to be as subject to natural enemies as are exposed insects.

In South Dakota, we have noted but one Hymenopterous parasite, Microbracon dorsator Say. This is a small four-winged fly-like creature. It parasitizes the borer or larva. That is, the grubs or young of the parasite feed internally upon the tissues of the borer. After the borer has constructed its cocoon for pupation, the young of the parasite kills its host and emerges into the cocoon. Within the cocoon of the borer, the parasitic larvae spin silken cocoons of their own making. There they change to pupae. This parasite has not been encountered in very great numbers. It is the only parasite which we have reared.

At times, the larvae in their overwintering cocoons were covered with a fungous growth. These larvae were dead. This fungus also destroys the pupae. At times, this fungus seems to be quite a factor in curtailing the numbers of plum tree borers. The disease has not been identified.

Ants are a factor in the suppression of the plum tree borer. When the borer is found working in exposed or accessible areas, ants of several species have been observed preying upon these larvae. The younger larvae are destroyed piecemeal and carried away. We have also observed the emerging moth being attacked and dragged away.

Birds are valuable in reducing the numbers of plum tree borers. They feed upon the exposed larva, upon the projecting pupae and upon recently emerged moths. We have observed woodpeckers extracting the larval and pupal stags from loose and curled bark. It is difficult to estimate the value of birds in reducing the population of plum tree borers, but we believe they are of considerable service in destroying this pest.

Control Measures

Cultural Control

Generally the plum tree borer establishes itself in plantings or thickets of plums that have been neglected. We called attention to the fact that the majority of borers make their entry into a tree through a primary abrasion or wound. The following are some of the primary injuries:

1. Dead and dying bark areas caused by fungous and bacterial diseases.
2. Dead and unhealthy bark areas caused by sunscald.
3. Crotches with deep crevices, split crotches and broken branches.
4. Wounds caused by cultivating implements or harness appurtenances.
5. Pruning scars.
6. Wounds made through careless picking of fruit.

1.—Fungous and bacterial diseases.—At times, areas show definite lesions or cankers made through disease organisms. These lesions are very often attractive to the female moth for egg-laying purposes. Several

larvae have been found feeding around these areas. Plum plantings treated with a regular spraying schedule show a minimum of diseased bark areas. A regular spray schedule calls for a dormant lime-sulphur spray in the spring. This should be followed by two summer sprays, using lime-sulphur summer strength to aid in controlling these diseases. Care must be exercised in the removal of this wood, so that infection will not be spread to healthy tissue. Trees cared for in this way prove less attractive for egg-laying and suffer less borer injury.

2. Sunscald.—Repeated changes in temperature, freezing and thawing, and the effects of the direct rays of the sun may bring about the death of the cambium in exposed areas of the larger limbs or trunk. As an abrasion appears in this area, borers or larvae are very apt to become established here. Any measure which may be utilized to protect the tree against sunscald will lessen liklihood of borer infestation.

Crotches, broken branches, etc.—Trees with deep anguar crotches and branches with deep crevices at their point of origin are prone to be infested with plum tree borers. These places are very likely to split open through swaying in heavy winds. No corrective measure can be instituted in older trees, but it is a point well worth remembering when young trees are set out. Young trees with wide angled crotches should be chosen. Prune away the branches with deep angled or creviced crotches. Branches are very often broken through wind whip or weight of mature fruit. The establishment of borers is also favored through sap and gum exudation at the point of break or split. Broken limbs should be removed and wounds covered with pure white lead.

4. 5. and 6. Wounds through cultivation, pruning and picking.—Abrasions, wounds and bruises are often caused by cultivating implements, harness buckles, whipple-trees, careless pruning or during harvesting of fruit. Care should be exercised in any of the above operations so that the bark of the trunk and larger limbs is not cut, broken, scraped or torn.

Preventives.—We have stressed the fact that the insect attacks trees which are diseased, injured, or have checked or wounded bark. It is evident, therefore, that any measure which will prevent the primary abrasions will mitigate insect attack. Plum culture has for its object the maintenance of individual trees in a vigorous and clean condition of health. It includes also the avoidance of mechanical injury through aforementioned causes. It further includes the prompt treatment of wounds, broken branches, etc. Strict adherence to plum orchard management which includes these simple rules results in a minimum of infestation by the plum tree borer.

Chemical Control

Plant borers as a group are exceedingly difficult to control through insecticidal methods. Working in stems or underneath bark, they are constantly protected from the usual chemical treatments. They are not ordinarily reached by stomach poisons, nor can they be touched with contact insecticides. Literature concerning borer control is replete with treatments (6) consisting of various washes, paints, sprays, protective coat-

ings, mechanical wrappers, etc. Some of these treatments have been based upon their repellent action on the adult for prevention of egg deposition. Some of the chemicals have been designated as ovicides and have for their object the killing of the eggs through contact action. Still other methods indicate the killing of the newly hatched borers through caustic or corrosive action. Various protective coatings have been tried, ranging from sticky entangling material to molten wax. One approach toward borer control has been through the use of mechanical protectors or wrappings of fabric, paper or metal, to exclude borers from entering the tree. Literature further records the fact that the majority of these treatments have met with varying degrees of success or failure. None has given expected or desired results. None can be relied upon to protect the trees against the attacks of borers.

During the progress of our work on the plum tree borer, we have tried a great many of these treatments. We have discarded them one by one after giving them a fair trial. We were disappointed in results obtained. The percentage of kill was too low to warrant their use.

In the year 1925 (9) and 1926 (10) we approached the problem of plum borer control through the medium of toxic gases. The borer is located beneath protecting bark layers, so the use of stomach poisons or contact insecticides is out of the question. The vapors, however, of a toxic material are not hindered but may readily penetrate into the burrows and galleries of the borer. Upon the inhalation of these toxic vapors, in sufficient concentration, the insect is killed. There is a wide range of fumigants or toxic gases. Choice was narrowed down when toxicity to plant tissue is considered. After experimenting with a number of chemicals whose vapors are fatal to insects, we finally chose paradichlorobenzine as the material having the most promise. Paradichlorobenzine is also known as dichlorocide, paracide, paradi, paradichlor, crystal gas or simply P. D. B. For convenience, it will often be referred to as P. D. B. in this bulletin.

Paradichlorobenzine, $C_6H_4Cl_2$, is a crystalline substance with a shiny white luster. It is insoluble in water, has a boiling point of 172°C. and a melting point of 53°C. It has a specific gravity of 1.268 and a molecular weight of 146.96. P. D. B. is soluble in a number of organic solvents, including molten paraffine, mineral oils, cottonseed oils, etc. Upon exposure to air, the crystals evaporate completely without disintegration. The gas which arises from the crystals is heavier than air and has a pleasant ether-like odor. The gas is relatively non-toxic to man. It is lethal to most insects if they are subjected to a high concentration of the gas for some length of time.

P. D. B. was first used successfully by Blakeslee against the peach tree borer. The peach tree borer is to be found attacking the trunk at soil level, or slightly below soil level. In the control of this insect, a ring of P. D. B. crystals was placed on the soil around the tree trunk. This band was placed one to four inches from the trunk and covered with soil. The dose varied from ¾ ounce to 1 ounce. The earth serves to confine the gas but allows it to diffuse into the burrows of the peach tree borer. It kills the borer through continued inhalation of the P. D. B. gas into its breathing system. However, the plum tree borer does not confine its attacks to the tree trunk at soil level. It is to be found on the trunks from soil levels

up to and including the major branches of the tree. It was evident, therefore, that some means must be devised to bring the P. D. B. to the higher areas infested with the borer. At the outset of the investigation (1925 and 1926) we began a few experiments to determine which of the various solvents of P. D. B. might serve as a carrier. The years 1925 and 1926 brought to light that of the various organic solvents ,liquefied paraffine and some vegetable oils seemed to be best suited as carriers. Accordingly, we reported in the Report of the South Dakota Agricultural Experiment Station, 1926, on liquefied paraffine. We used the following formula at that time and it has not since been materially changed. See 1, 9, 10, 11, 12, 13, 14, 15.

Four pounds of paraffine were liquefied in a double boiler through the agency of heat. When liquefied, one pound of paradichlorobenzine was added and stirred until dissolved. Keeping the material liquefied through the hot water in the double boiler, the material was painted onto infested trees by means of paint brush. The material hardened immediately, enclosing the trunk or branch with a waxen cylinder. The dissolved P. D. B. slowly vaporized, some of the vapor escaping into the open air and some of the fumes diffusing into the burrows of the borers. Through careful hourly checks over a group of trees, larvae subjected to this treatment recovered up to eight hours exposure. However, the time required to kill was as variable as nine hours for some larva, up to 13 hours for others. Moreover, none of the larvae in our tests recovered after the 13 hour exposure. A great many trees were treated in the year 1925. In some experiments the trunk was scraped of loose bark, etc.; in some trees no attempt was made to remove bark material. No appreciable difference was found in the percentage of kill. Some difference was found, however, in the amount of material used. There was some variation in percentage of kill, varying from 90 per cent in some trees to 98 per cent in still others. The material was applied in late July and the forepart of August. After being reasonably sure that the egg-laying period was at an end and that the majority of eggs had hatched, the treatment was applied.

In the progress of this investigation, Snapp and Swingle in Georgia, 1928, carried out a series of tests with P. D. B. and paraffine. They report in 1930 (7) an 85 per cent kill in one instance and a 90 per cent kill in others with the P. D. B.-paraffine mixture. Again in 1931, Snapp and Thomson (8) report on P. D. B.-paraffine mixtures and on P. D. B.-cottonseed oil mixtures. They find the P. D. B. and cottonseed oil the more efficient of the two. In the year, 1927, our experiment utilizing an oil as a carrier replacing the paraffine, were in progress. Realizing that the process of liquefying paraffine and keeping it liquefied through the application was cumbersome and inconvenient, we turned our attention to oils as a carrier. However, we did not report the progress in any publication. We eliminated all but cottonseed oil and used the following mixture: one pound of paradichlorobenzine dissolved in two quarts of cottonseed oil. Cottonseed oil can be obtained in various forms. There are, moreover, a number of corn oils sold as cooking oils. These are not as efficient as cottonseed oils. This material was applied by means of a paint brush to infested trees. The material was easier to apply, but gave no better kill than did the P. D. B-paraffine mixtures. In some blocks of test trees the

P. D. B.-paraffine mixture gave a higher percentage of kill than did the P. D. B.-cottonseed oil mixture, while in still other blocks the reverse was true.

Crude cottonseed oil is not always available, but in every community paraffine can be obtained. The choice of the carrier, therefore, is governed by its availability with no particular killing advantage in favor of either. However, there is one decided disadvantage in using cottonseed oil- P. D. B. mixtures. The entire trunk or limb or healthy tissue can not be covered without suffering damage or injury. Only infested areas should be treated. It is practically impossible to locate all borer infested areas through a superficial examination. Perhaps this is the explanation for the fact that in some trees thus treated, the percentage of kill dropped below 90 per cent.

We record no injury from the P. D. B.-paraffine treatment on either young or old trees. In fact, to test out this question, we coated a number of two-year-old trees with P. D. B.-paraffine mixture entirely, including the trunk and all branches up to the leaf petiole. These trees suffered no injury.

Recommendations

As a result of our work on the plum tree borer, we recommend the following treatment.

Preceding any insecticidal application, the trees should be carefully gone over to remove dead and broken branches. Where pruning is necessary, this should be done. Any phase of orchard or tree management which makes and maintains vigorous tree growth should be applied. After this is done, one of the following treatments may be applied:

Paraffine	4 pounds
Paradichlorobenzine	1 pound

Liquefy the paraffine in a double boiler through the aid of heat. Add the paradichlorobenzine and stir the mixture until the crystals of P. D. B. have dissolved. The substance will remain liquefied through the hot water in the double boiler for a considerable length of time. It is applied to the trunks and larger limbs by means of a paint brush. The entire trunk and the larger limbs are entirely coated. No injury has been recorded from this treatment.

Or as an alternate treatment:

Cottonseed oil	2 quarts
Paradichlorobenzine	1 pound

Add the crystals of P. D. B. to the oil and stir until dissolved. This may take a little time. By means of a paint brush, apply the mixture liberally to the areas infested. The material is ordinarily too thick to be applied with a sprayer. Treatment should extend a few inches beyond the area of borer infestation. Only infested areas should be treated. This necessi-

tates a careful examination of the tree for borer infested areas. It is not essential that gum, frass, loose bark, etc. be removed before treatment.

The time of year to apply the material is from the end of July through August and the fore part of September. It is done at this time so that the eggs will have hatched, for the treatment is aimed at the larva or borer.

Whichever formula is chosen, do a thorough job. Follow the recommendations for best results.

Summary

The plum tree borer, or as it is often called, the lesser peach tree borer (Synanthedon pictipes G. & R) is quite widely distributed over South Dakota. It is to be found attacking wild plums, wild cherries and our cultivated varieties of plums and cherries.

The borer attacks the trunk and larger branches and may be found beneath the surface bark feeding upon the cambium and living tissues. Neglected plantings are most frequently attacked. At times, the borer may kill the bark tissue on one side of the tree, killing the branches on that side. Very often the borer may girdle the trunk, causing the death of the tree.

There is but one generation of this insect per year at this latitude (Fig. 10.) The winter is passed in the partially grown larval or borer stage. Feeding is resumed in the spring and the borer completes its growth on or about the first of May. It makes a cocoon and within it changes to a pupa. Within 20 to 30 days, transformation is complete and the pupa wriggles to the outer bark through a gallery made by the borer. It pushes its body through the outer bark layer until a half or two-thirds of its body length projects into the open air. The moth then emerges. Within an hour the sexes may assemble and mate. The moths have been found on June 1, more abundant in mid-June, and in a few numbers in early July. Egg laying takes place a short time after mating. The small reddish brown eggs are laid usually in crotches, crevices, beneath loose curled bark and around wound margins. The eggs hatch in from eight to ten days. The larva works its way to the cambium where it feeds and grows until fall. It then constructs an overwintering cell and hibernates until spring.

While the plum tree borer is subjected to the attacks of parasites and predators, it still maintains itself as one of our most serious plum tree insects. It is therefore necessary to resort in all cases to cultural and chemical controls. Cultural controls invoke all phases of orchard management which maintains the vigor and health of the trees. Therefore, if a tree is maintained in a healthy, vigorous condition, it is not so subject to borer infestation.

Chemical control consists of toxic gases which enter the burrow and kill the larva. The gas used is the volatile vapor from paradichlorobenzine, often called P. D. B.

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