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ENTOMOLOGY 20

MONOGRAPH OF THE GENUS SAPERDA

BY

EPHRAIM PORTER FELT D.Sc.
State Entomologist
and
LOUIS H. JOUTEL

cancelled

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ENTOMOLOGY 20

MONOGRAPH OF THE GENUS SAPERDA

PREFACE

In the preparation of this paper all the original descriptions of the various species have been carefully examined, and as many of the types as were in this country have been studied. Most of our species are so well marked that there was little trouble in identifying them, and only t r i d e n t a t a and forms of p o p u l n e a presented difficulties. The first mentioned has a species which resembles it very closely, and the question was, which had been described by Olivier. The original description was so vague that it applied equally well to either; but fortunately Olivier had figured the form described, and this proves beyond doubt that our common eastern borer of the elm is his species. Several forms, which could not be referred to any of our species, were found, one of which presented all the characters of the European p o p u l n e a , and there is no doubt that it has long been established in California, Oregon, Washington and British Columbia, having evidently made its way into this country through Alaska.

The writers take great pleasure in acknowledging assistance from the following gentlemen: Dr Henry Skinner and Mr H. W. Wenzel, who employed their kind offices in procuring the loan of specimens from the collections of the American Entomological Society and afforded facilities for the study of material in the Horn collection, Mr Samuel Henshaw of the Museum of Comparative Zoology, who

granted the privilege of studying the LeConte and other collections at Cambridge, Dr H. G. Dyar, who procured the loan of material from the National Museum, Mr E. A. Schwarz, who furnished facilities and aid in studying the collections at Washington, and also the following gentlemen, who rendered various services, Messrs Charles Schaeffer, Frederick Blanchard, F. C. Bowditch, Germain Beaulieu, H. G. Klages, Charles W. Leng, C. V. Piper, W. S. Marshall, J. J. Rivers, Charles Fuchs, Dr D. M. Castle, E. D. Harris, Philip Laurent, F. E. Watson, C. W. Woodward, H. C. Fall, William T. Davis, C. J. S. Bethune, F. M. Webster, Charles Palm, W. Knaus, A. F. Winne, Dr R. E. Kunze, Charles Stevenson and C. J. Oeillet. Dr Henry C. Van Dyke kindly contributed notes on localities of h o r n i i , and a number of New York collectors kindly allowed us the privilege of examining the material in their collections.

The junior author has collected members of this genus for a number of years and has made many trips about New York city to secure their workings, often in the company of his friend, William T. Davis, who took much interest in securing desirable specimens. All of the species have been bred but the typical p o p u l n e a , m u t i c a , h o r n i i and c r e t a t a , though we have had workings of the latter.

The junior author has undertaken the illustration and systematic study of the species; while his associate has studied the insects more particularly from an economic standpoint and has summarized the literature and compiled the bibliographies.

GENUS SAPERDA OF FABRICIUS

This genus is one of great economic importance, since it contains two species which are very injurious to appletrees and another which may possibly acquire this habit. One species is known as being very destructive to the American elm, one often seriously injures hickory, another sometimes destroys large numbers of our lindens, and a fourth is exceedingly injurious to poplars; the latter are also attacked by several other species of the genus.

This group is also of interest to the systematic student, since it shows in a limited number of species great divergence and specialization from a common type. Much confusion has hitherto existed concerning the identity of our western species, and this was only partly

cleared up by the characterization of hornii. Our study has brought out the interesting fact that, among the so called western forms of moesta, one is identical with the European populnea, and can not be differentiated in any particular from that species. We find that two species have been included under the name tridentata, as well as a distinct variety of lateralis. All but three American species occur in New York State, and our study has on that account been monographic.

Series of all American species have been examined, and several characters not noted or seen by former students have been found. The European and Asiatic species have all been studied, except a few Siberian forms which are probably only varieties. Since both sexes were not obtainable of all the exotic forms, it has not been possible to include a discussion of them in this paper. They are mentioned wherever it is necessary to show the close relationship existing between the two faunas.[1] The 13 species and one variety listed by Samuel Henshaw in 1885 have been increased by us to 15 species and five subspecies or varieties.

The species are so closely related, though differing greatly from each other in several characters, that subdivision of the genus is not considered advisable and would not be practicable, as whatever characters might be used, disappear so gradually that the species could not be as well arranged as in the present grouping, and it would tend to bring widely separated forms close together.

The exotic species have been divided into a number of genera and subgenera on characters which we consider, from our studies of the entire group, degrees of specialization.

Mr Mulsant divided the European species on the relative size of the metathoracic episterna, the form of elytra and on the antennae

[1]In studying the two faunas together, the indications are very strong that they were derived from common ancestors; and, while the two are quite distinct in many ways, they have evidently specialized along different but parallel lines, and their characters are intermediate.

The fact that the American species are all of eastern origin (except those few that show their immigration into the Pacific fauna through Alaska) and the Old World ones of western origin would tend to show that at some remote epoch there was a connection between the two continents.

being annulated or not. Species not closely related to each other occur in his subgenera, as they do in any other attempt to divide them. His genera are not now generally recognized. The Asiatic species have been placed in several genera. The genus Thyestes erected by Mr J. Thomson for a Japanese species has no character not found in one or the other of our Saperdas; and we consider his species pubescens allied to puncticollis with some characters also of lateralis; and its annulated antennae connects it with the more highly specialized ones. Another point that shows its close relation to puncticollis is the possession of a process on the anterior claw of the middle pair of legs only; and the form of this process also resembles that of puncticollis. Another genus, Eutatrapha, has been erected by Bates for those Asiatic species with the sides of the elytra carinated. We consider this character a sign of specialization and not of generic value, as we find it in an advanced rudimentary state in our tridentata, where it is not equally marked in all specimens. It is formed by the arrangement of the punctures and is quite different in appearance from the extreme form found in Eutatrapha (Saperda) metallescens. Eutatrapha (Saperda) 16-punctata and varicornis (S. carinata) have this character also, but not so strongly marked. It can be traced in some other of our species, as S. discoidea ♂ and S. hornii, where a straight line of punctures, more or less pronounced in different examples, shows the most primitive form of this character; and its entire absence in some individuals of discoidea robs it of any generic value it seems to possess in its more highly specialized form. To show the slight value of this and other characters taken separately, we would call attention to Paraglenea fortunei from China, which has the elytra carinated and has both claws of all the legs armed with a spine as in lateralis. It is closer to Saperda than any other genus. Glenida suffusa has the elytra carinated but lacks the process on the claws, and is only distantly related to Saperda. Several other genera were desired for study but material was not obtained in time for this bulletin. The males of metallescens have

the claws armed as in tridentata. Males of the other carinated species were not obtained. Should this genus be accepted our S. tridentata would be included in it.

Subgeneric grouping. One character that could be used for a subgeneric division is the presence or absence of the process[1] on the claws of the males. Though we consider this character of little value except to show the relation of the species and really a sign of specialization and not of much generic importance, as its occurrence in genera[2] not very closely related to Saperda shows, its use as a basis of division would group the species as follows.

Group 1	Group 2	Group 3	Group 4
Process on anterior claw of front and middle tarsi	Process on both claws of all tarsi	Process on anterior claw of middle tarsi	Process wanting
obliqua mutica hornii candida calcarata tridentata cretata discoidea vestita imitans fayi	lateralis	puncticollis	populnea and its forms concolor

[1]LeConte and Horn, in their classification of the Coleoptera of North America, make the erroneous statement that this process is wanting in the European species. It is however very prominent in carcharias, punctata, 8-punctata and probably in others of which we did not see males. Lacordairé, in *Genera of Coleoptera*, also seems to imply that it is wanting in the European species. LeConte, in *New Species of North American Coleoptera*, part 2 [Smithsonian Miscel. Coll. 264. 1873. p.239] overlooks the process on the claw of the middle tarsi of puncticollis and the armature of all the claws of lateralis. Subsequent authors have committed the same errors.

[2]In the species of Thyestes which we have seen, the males are armed as in puncticollis. The males in the genus Eutatrapha are armed as in the first group. Those of Paraglenea fortunei are like those of lateralis. The males we have seen of the European species group as follows. To the first group belong carcharias, punctata, 8-punctata, and to group 4 populnea and scalaris. The males of the other species we were not able to obtain.

This grouping separates populnea and concolor from the closely allied mutica and hornii, and brings together some that are not so closely allied, but it shows fairly well the degree of specialization of the species, as will be shown later.

If our species only are considered, a more natural grouping can be made on antennal characters, the species having annulated antennae being more closely related to each other than to those with unicolorous ones; but, when the foreign species are taken into account, this character loses its value, as we find S. perforata and some of the species that have been referred to Eutatrapha and Thyestes with the antennae annulated, though the other characters would lead us to look for unicolorous ones, they being very close to our tridentata and but distantly related to the species this character would place them with. Using the antennae, the species would divide as follows.

Antennae annulated	Antennae unicolorous
obliqua	candida
mutica	calcarata
hornii	tridentata
populnea	cretata
moesta	discoidea
tulari	vestita
concolor	imitans
	fayi
	lateralis
	puncticollis

The foreign species, carcharias, scalaris, perforata, similis, quercus, Eut. varicornis, 10-punctata and T. pubescens would come in the first group; the others in the second group.

The development of the head usually follows that of the process on the claws; but there are exceptions to this rule, as is seen in the case of scalaris of Europe, where the flat front of the head would place it near calcarata instead of with populnea, where it more naturally belongs. In fact, whatever character is taken, it

will be found to be unevenly developed in its relation to the others possessed by the species.

Other characters such as elytral form, shape of thorax and abdomen, etc., seem from our studies to have little if any constant value in grouping the species, as, when they are used, species are brought together that have very little direct affinity with each other.

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Distribution. The genus is confined to the temperate parts of the northern hemisphere. The distribution of some of the species is somewhat erratic, and all but three American forms appear to have originated in the East and occur in the State of New York. Our common c a l c a r a t a, found through the East and Middle West, also occurs in Texas as well as the state of Washington, and has been recorded from intervening territory. On the east coast t r i d e n t a t a has much the same range and is likewise found in Texas, but not in the northwest. O b l i q u a, c a n d i d a, c r e t a t a, f a y i, v e s t i t a, d i s c o i d e a, l a t e r a l i s,

puncticollis and moesta have about the same range, being found in Canada, in the eastern states and also in the Middle West. The typical populnea is found only on the Pacific coast, tulari occurs in the same localities and also in Colorado and Arizona. Concolor is found in Arizona and Colorado. The variety unicolor has the same general range as moesta. Hornii is confined to the western coast from Los Angeles Cal. to British Columbia.

Specific relationships. Before attempting to group the species according to their natural affinities, a few remarks on their specific characters may be of interest. The antennae of most species are unicolorous. In some, obliqua, mutica, hornii, populnea, moesta, tulari and concolor and its variety, they are more or less annulated with gray, (brown and black in obliqua), and two of these species have the first joint enlarged. The length of the antennae also varies in the different species, being very short in mutica.

The shape of the last segment of the female abdomen presents an excellent character for the separation of some species. The pygidium of some is broad with the apex blunt and in others it is long. The tip may be more or less divided into two lobes, the upper surface may be either marked by a median depression or may be convex as in mutica.

The angle formed by the sides varies in different species. The front claws of the anterior and middle tarsi of the males are armed with either a blunt process or tooth, which is lacking on the front pair in puncticollis, wanting on all claws in populnea, moesta, tulari and concolor and present on both claws of each pair of legs in lateralis. This process is subject to variation as to size and form in individuals of the same species, and it has been used as a specific character as little as possible. The shape of the thorax, whether cylindric or narrowed in front, affords a good character. The form of the apex of the elytra is of value in determining species, as they may be rounded, obliquely narrowed, armed with a spine or truncate. The shape of the head

and eyes varies greatly in different species. The punctures of some species are quite constant; but in others, populnea, moesta, tulari, they vary so much that little dependence can be placed on them. The species range in size from calcarata, which is from 7/8 to 1 1/8 inch long, to populnea 3/8 inch in length, but occasional specimens may be much smaller than the normal. The color and markings are quite constant, and only lateralis shows marked variations. Calcarata has a variety, adspersa, which is entirely brown. The legs of most species are black, covered with a gray pubescence, yellow in vestita; those of obliqua, cretata and discoidea are reddish brown with gray pubescence.

Arrangement indicates the degree of specialization. The salient characters of the various species having been given, it now remains to use them in a natural grouping of the forms. It is very apparent that the usual arrangement is arbitrary and based almost entirely on color and markings. It is not to be supposed that the following grouping means that the species are derived or descended from each other. It represents simply our idea of the degree of removal or specialization from an ancestral type and is based on a study of characters of unequal value. It is very evident that our own species have specialized along different lines and have probably originated from several type forms.

The least specialized of our native species is evidently concolor, since it is unicolorous, has no striking characters and presents fewer differences from its nearest allies in other genera, than any of the other species. It has no process on the claws of the male and the rather few elytral punctures are merely shallow depressions without definite edge and are punctate like the remainder of the elytra. The species diverging most widely from it, and therefore the most specialized, is obliqua, since it has characters not possessed by any of the others. It has the elytra separately narrowed and armed with a spine. The thorax is narrowed in front, and the head is small, and deeply impressed between the eyes. The annulated antennae have the first joint swollen and dark, and the elytra are embossed to match the color pattern. The process is very highly

specialized as can be seen by reference to figure 3. The species which possesses the greatest number of these characters is mutica. It is true that it lacks the spine at the apex of the elytra, but it has the narrowed thorax, small head and the antennae with an enlarged, dark basal joint. These two species form a group by themselves closely approached by hornii (which is nearly related to the European similis); it has the annulated antennae, but the first joint is normal and the thorax is nearly cylindric, in some specimens entirely so. The color and maculation are much like those of mutica. We then come to the European carcharias, with its narrowed thorax and annulated antennae. The humeral angles are quite prominent and the elytra tapering. The nearest American representative is candida, an insect which at first would not seem to belong here, but that is due more to the color and markings, characters of the smallest value, since, if we omit the color from consideration, we shall find that the shape and structure are very similar to carcharias, as represented by the narrowed thorax, small head, prominent humeral angles and tapering elytra. The unicolorous antennae show candida to be less specialized than this European species. Calcarata, our next species, is also somewhat related to carcharias and leads naturally to tridentata, which is of the same general shape and has in addition the elytra truncate and weakly sinuate at tip, evidently an early stage of the sutural spine found in calcarata. Tridentata has a character (a submarginal carina beginning at the humeral angle and continuing to the apex) not present in any other of our forms, but which, strange to say, has its counterpart in some old world species.[1]

The remaining species appear to follow in regular order as given in Henshaw's list, except that fayi would more naturally follow lateralis, since it has the rounded head possessed by the species that follow and the same gall-making habit. The spine on its front claws is very small and rudimentary, approaching the condition of

[1]This character is made use of by Bates to form the genus Eutatrapha, to which he refers 16-punctata, varicornis and metallescens. It would also include tridentata. [*See* p. 6]

puncticollis, where it is entirely absent. Imitans is close to lateralis and fayi and presents more characters in common with the last than with tridentata, though its markings are much like the latter.

Fig. 1 Front claw of first and middle tarsi of the following species: 1 and 2, Saperda imitans; 3 and 4, Saperda tridentata; 5 and 6, Saperda discoidea; 7 and 8, Saperda vestita. C= claw, P= process.

Systematic list of American species of Saperda

obliqua *Say*
mutica *Say*
hornii *Joutel*
candida *Fabr.*
calcarata *Say*
var. adspersa *Lec.*
tridentata *Oliv.*
cretata *Newm.*
discoidea *Fabr.*
vestita *Say*
imitans *n. sp.*
lateralis *Fabr.*
var. connecta *n. var.*
fayi *Bland.*
puncticollis *Say*
populnea *Linn.*
subsp. moesta *Lec.*
subsp. tulari *n. subsp.*
concolor *Lec.*
var. unicolor *n. var.*

The development of the process on the claws follows the foregoing arrangement better than any other, and we find that the degree of development is somewhat different from published accounts of earlier workers, who probably lacked sufficient material.

Process moderate on anterior claw of front and middle tarsi: obliqua, mutica, hornii, candida.

Process long on anterior claw of front and middle tarsi: calcarata, tridentata, cretata.

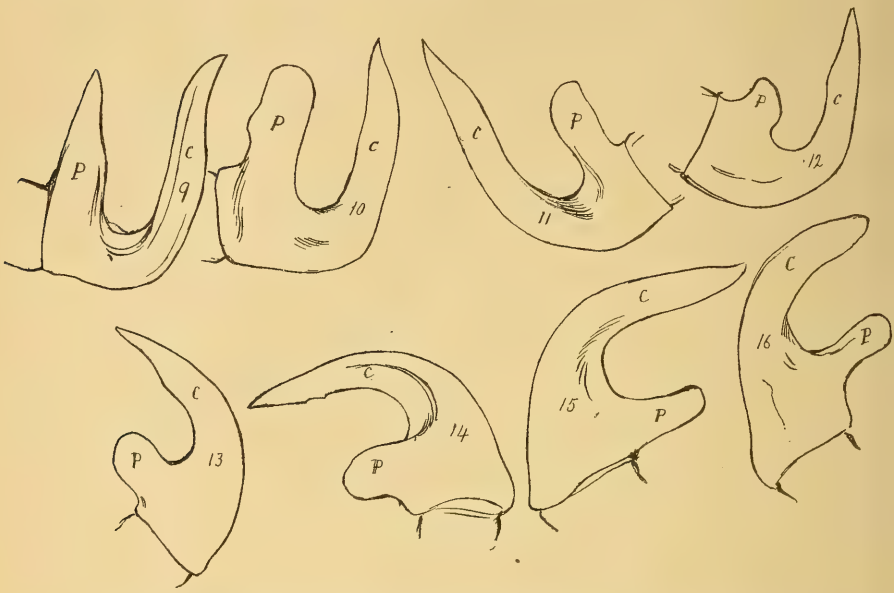

Fig. 2 Front claw of first and middle tarsi of the following species: 9 and 10 Saperda cretata; 11 and 12 S. candida; 13 and 14 S. hornii; 15 and 16 S. calcarata. C= claw, P=process.

Process shorter on anterior claw of front than middle tarsi: discoidea, vestita, imitans.

Process small on both claws of all tarsi: lateralis.

[1] Process very small on anterior claw of front and small on middle tarsi: fayi.

Process wanting on front and large on middle tarsi: punctigollis.

Process wanting: populnea, moesta, tulari and concolor.

[1]As this process shows considerable variation in shape and size in different specimens of the same species, we have taken the most common shape and size as the normal for each species.

Key to species

a Antennae plainly annulate

b Head deeply impressed between the eyes

c Antennae with first joint normal and gray.....hornii

cc Antennae with first joint enlarged and dark

d Elytra obliquely narrowed, ending in a spine at the tip .....obliqua

dd Elytra slightly narrowed and without a spine.....mutica

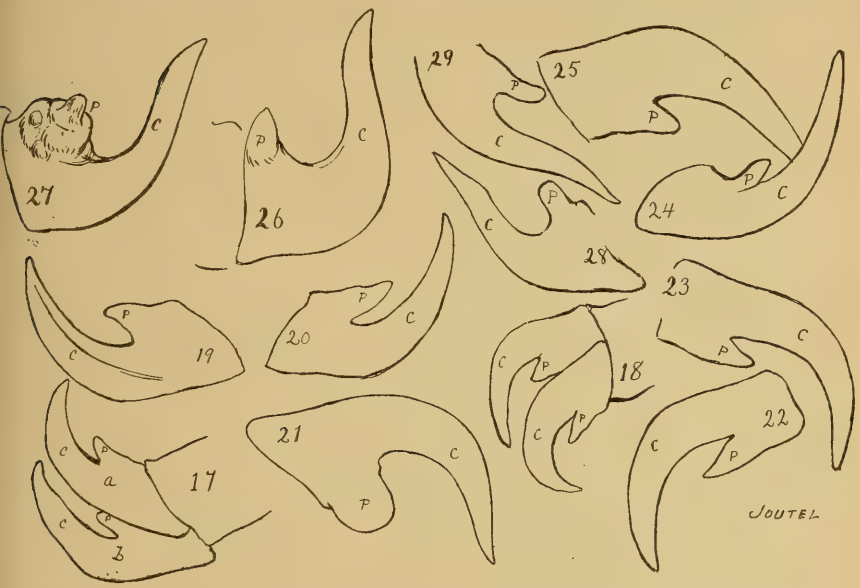

Fig. 3 Claws of following species: 17 Both claws of front tarsi of S. lateralis; 18 Both claws of middle tarsi of S. lateralis; 19 Front claw; 20 Posterior claw of middle tarsi of S. lateralis; 21 claw of middle tarsi of S. puncticollis; 22 and 23 Claws of hind tarsi of S. lateralis; 24 and 25 Claws of front and middle tarsi of S. fayi; 26 and 27 Claw of front and middle tarsi of S. obliqua; 28 and 29 Claw of front and middle tarsi of S. mutica.

bb Head rounded in front

c Antennae with first joint black and normal in size

d Upper side strongly punctate and confluent with few punctulations between, sparsely covered with gray or light fulvous hairs, several spots of dense yellow or fulvous hair on elytra; fulvous stripe on side of thorax.....populnea

dd Upper side with punctures not so numerous, and sparsely covered with gray hairs, unicolorous, punctulations on intervals more numerous; light stripe on thorax nearly obsolete .....subsp. moesta

ddd Upper side with fewer but larger and deeper punctures, more densely punctulate on the intervals and densely covered with red or fulvous hairs; thorax with stripe on sides and top .....subsp. tulari

dddd Upper side finely punctulate and with small shallow punctures and uniformly covered with a dense layer of light gray or yellowish gray hairs; thorax with lateral stripe
concolor

e Punctures much more numerous, hair dirty gray; lateral stripe wanting or nearly so.....var. unicolor

aa Antennae unicolorous

b Elytra rounded with spine at suture

c Gray with yellow patches.....calcarata

cc Color uniform fulvous.....var. adspersa

bb Elytra with marginal or submarginal stripe

c Thorax and elytra brown or yellowish brown with two white stripes; under side white.....candida

cc Thorax yellow with four black spots on dorsum and one on each side; elytra bordered with bright yellow with a black spot in front; under side gray.....puncticollis

ccc Thorax and elytra gray and with an orange red lateral stripe

d Second and third cross bands on elytra oblique, a dark spot usually on each side of the first and one behind the third; front of head very flat; elytra more or less truncate
tridentata

dd First and second cross bands on elytra oblique; front of head flat; elytra rounded at apex.....imitans

cccc Thorax and elytra black

d Sutural and lateral stripe on elytra orange red; head somewhat rounded; under side gray.....lateralis

dd Sutural stripe usually wanting and with one to three cross bands; lateral band reaching to margin; under side gray
var. connecta

bbb Elytra with spots, rarely concolorous

c Cinnamon brown with a white stripe on each side of the thorax

d A large white spot in center of each elytron and a smaller one near its apex, neither reaching to margins; sides and under surface white.....cretata

dd White stripe on thorax continuing on elytra at humeral angles; the elytra with two white spots, one at the middle, the other near the apex and almost sutural; sides and under surface white; the spots are more or less obsolete in the male..fayi

cc Cinnamon brown, sometimes nearly black, with a transverse, undulate, yellowish olive fascia across the middle of the elytra; sometimes with an additional spot both before and behind this fascia; thorax and apex of elytra and scutellum olive; legs light reddish, under side lighter.....discoidea ♀

ccc Uniformly reddish brown, sometimes black; legs reddish; under side lighter.....discoidea ♂

cccc Olive yellow with three denuded black spots on each elytron, some or all occasionally wanting.....vestita

Grouping and summary of the food habits of the larvae

The larvae of this genus may be divided by their food habits into three classes: (1) those that bore in the large branches and trunks of living trees and feed on the sap, calcarata, candida, cretata, vestita and possibly hornii and mutica; (2) those that live in small branches and usually produce galls, subsisting on sap, and not making the extended galleries of the first group, fayi, populnea, obliqua, concolor; (3) those that feed on living and dead tissues of dying or recently killed trees, tridentata, discoidea, lateralis, imitans and puncticollis. The manner of feeding and the portion of the tree attacked vary with different species, and most of the forms have special food plants.

S. obliqua feeds close to the ground at the collar of the black alder, where it often entirely girdles the stem, forming a knot or gall and ultimately killing it; and, when not entirely girdled, the tree is so weakened that the stem soon breaks. A walk through an alder swamp where this insect is common will show a great number of prostrate stems in all stages of decay.

S. mutica. This species is said to live on the willow and is the only eastern form that we have not bred and of which we have been unable to secure workings.

S. hornii feeds on the willow according to Dr H. C. Van Dyke, who has taken the insect on that plant.

S. candida is usually very common in apple and attacks several allied trees. It is quite destructive to seedlings and young trees, where it works at the base of the trunk and roots, and, as several generations follow in the same wound, the tree is soon killed.

S. calcarata works in the trunk and larger branches of the silver poplar in particular and soon kills the trees. It is surprising to see the quantity of sawdust around a badly infested tree, thrown out by the larvae when making their pupal chambers.

S. tridentata works in and under the bark of the trunk and branches of the elm, and has also been recorded in other trees.

S. cretata lives in the thorn and apple, usually in the trunk and larger branches, and works somewhat like S. calcarata, but the burrow is longer and more tortuous.

S. vestita attacks the linden and in our experience works mostly at the base and roots. We have never found it more than 12 inches from the ground, and that seldom. It can always be found in exposed roots and at the base of the tree close to the ground. In either case the larvae usually work in the subterranean parts. Prof. F. M. Webster has also noted this habit.

S. discoidea lives under and in the bark of hickory, specially dying trees or those recently killed by Scolytus quadrispinosus Say. It can be easily bred from a piece of dead bark.

S. imitans is not known in its early stages but probably bores in hickory and not in elm.

S. lateralis works in hickory at some injured place near the root and is partial to the base of sprouts that grow around stumps on recently cleared land.

S. fayi makes a gall very simlar to that of concolor, but breeds in the thorn.

S. puncticollis works in the dead branches of Virginia creeper, eating the inner bark and pupating in a chamber excavated in the wood.

S. populnea feeds on the willow and poplar. S. moesta makes a gall on the balm of gilead, and this, we believe, is its only food plant, and the form tulari lives in willow.

S. concolor makes a gall on poplar and willow shoots.

Saperda obliqua Say

Alder borer

This species, while rarely met with in the adult form, appears to be very common in New York State, judging from the condition of some of the alder swamps we have visited.

Life history and habits. This insect's method of working is quite characteristic [pl. 5, fig. 3], and the badly girdled stems with gall-like enlargements, are not difficult to find. The insect works close to the ground in black alder, frequently girdling the trunks, and in infested swamps large numbers of prostrate stems in all stages of decay may be found. There are usually two or three

borers in each trunk, one of which is very apt to work downward to the depth of 3 or 4 inches and often below the ground level and the others in an opposite direction. The young grubs bore just beneath the bark, much like those of S. c a n d i d a Fabr., and the nearly full grown individuals work near the center of the stems and not infrequently fairly riddle the base, causing it to break in the wind. In fact, the general method of work is very similar to that of the round-headed appletree borer, and the perfect insect emerges from a hole very similar to that made by the species infesting the apple.

The beetle [pl. 5, fig. 6] is generally found near the top of alder branches. Mr Fred Knab, of Chicopee Mass. states that it easily escapes notice on account of its great resemblance to a withered leaflet. He adds that it differs from others of its genus, which are also shy insects, in that it remains perfectly motionless, clinging tightly to the branch and with the antennae extended forward. He has also found this insect on birch. Dr Packard records the beetle as occurring on alder; Dr Smith states that it is rare throughout New Jersey, where it breeds in black alder; and the late Dr Lugger records it as breeding in hazel shoots.

Distribution. This species was described by Say from Missouri; it has been collected about Buffalo by Zesch-Reinecke; Dr Smith records it from New Jersey; and Dr LeConte from Pennsylvania. The following localities for this species have been given by Messrs Leng and Hamilton: Wisconsin, Mississippi, Canada, Massachusetts, New York, New Jersey, Pennsylvania and Missouri. It has been found in various localities about New York city, such as Bronx park, Fort Lee and Staten Island and has also been recorded from Alabama and Montreal. We have seen specimens taken in Illinois in the Bolter collection.

Description. Light reddish brown with darker bands; antennae annulate, with the first joint dark and swollen; thorax narrowed in front; a dorsal stripe of darker brown continuing on the head; a subdorsal stripe that converges and continues on

the elytra around the scutellum; a lateral stripe that connects at the humeral angle with the first of four oblique bands on the elytra. The spaces occupied by the darker portions are depressed and less pilose. The elytra are separately narrowed at the apex and armed with a spine. The head is strongly impressed between the eyes. The work of the larvae is well represented on the plate.

Natural enemies. No literature on this subject exists; but we have found a number of affected alders which showed the work of woodpeckers, and evidently these valuable birds are very efficient factors in reducing the numbers of the borers. In one short limb we found four good sized holes made by the birds in their search for grubs [pl. 14]. We have also found many of the larvae destroyed by a dipterous parasite which pupated in the burrows after destroying the maker; several larvae or pupae of this Tachinid are usually found in each working.

Another small dipterous larva is sometimes found in considerable numbers feeding on the larva or pupa but we have not been able to rear it.

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Saperda mutica Say

Life history. Very little is recorded concerning the life history of this species. Beetles were taken by Mr W. H. Harrington on May 15 and captured by him in the open on June 29. He records this species as living on decaying willow.

Distribution. This beetle has been recorded from the following localities: Missouri [Say], Buffalo [Zesch-Reinecke], New Jersey [Smith], Ottawa Can. [Harrington], Canada, New York, New Jersey, Missouri, Kansas and Nebraska [Leng-Hamilton], Philadelphia Pa. [Wenzel]. Dr LeConte thought that this species was probably the S. populnea of Fabricius and Olivier. Its work is unknown to us.

Description. Black, sparsely covered with a gray or fulvous vestiture which is denser in places, forming numerous spots on the elytra [pl. 7, fig. 2]. These denser places are usually yellower in color. Antennae short, annulate, with first joint enlarged. Thorax narrowed in front with a fulvous line on dorsum, continuing on the head, also lateral line on sides. Head impressed in front between the eyes.

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1902 **Joutel, L. H.** Ent. News, 13:33-34 (Saperda hornii, compared with)

Saperda hornii Joutel

This species [pl. 7, fig. 3] has been mistaken for S. mutica, but can be easily separated from it by the first joint of the antennae being normal in size and also by the fact that the last abdominal segment of the female has a deep longitudinal impression along the middle of the upper side, while mutica has that part convex. The punctures of this insect are also much larger and deeper, and fewer in number.

Some specimens have lost the yellow marks and are entirely gray.

Distribution. Oregon, Los Angeles Cal.,[1] Humboldt county, Cal., Nevada county, Cal., Yosemite Cal., Goldendale Wash.

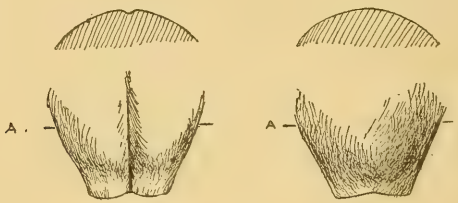

Fig. 4 Last dorsal segment with transverse section at A: 1 S. hornii; 2 S. mutica

Description. Black; shining, entirely covered with a dense layer of light yellowish gray hair, lighter beneath, and diversified above with irregular blotches and streaks of dark yellow arranged on the elytra in broken and irregular longitudinal lines, the line nearest the outer margin and just below the humeral angle unbroken except by the punctures, and continuing nearly to the tip. Elytra obliquely narrowed at apex. Thorax cylindric, sometimes slightly narrowed in front, with a longitudinal stripe of dark yellow hair on each side and on top, under side yellow. Scutellum yellow. Entire insect covered by rather large and deep punctures, slightly smaller beneath. Head: hairs yellow, changing to gray at labrum. Legs and under side of body light yellowish gray with glabrous punctures. Antennae annulate except first joint, which is entirely gray and

[1] In the original description, the locality of the type male in the national museum was wrongly given as Yosemite Cal. It should be Los Angeles Cal.

moderate in thickness. The pygidium of the female has a deep longitudinal depression along the median line, dividing it into two lobes.

Its work is unknown. Mr J. J. Rivers and Dr H. C. Van Dyke have both taken it from willow.

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1902 **Joutel, L. H.** Ent. News, 13:33-34 (Original description)

Saperda candida Fabr.

Round-headed appletree borer

There is perhaps no better known enemy of appletrees than the above named insect. The common designation, apple borer, usually refers to this insect, though by common consent it is gradually becoming known as the round-headed appletree borer in contradistinction to the destructive flat-headed species, Chrysobothris femorata Fabr., which is frequently very abundant in appletrees. The round-headed appletree borer is particularly injurious to young trees, and it is probably responsible for the death of more of these than all other natural agents combined.

Early history. This species was very early known as a notorious pest throughout New England and the Middle states according to Dr Harris. Mr Philip Heartt of Troy lost in 1825 several hundred young appletrees which he valued at $2000, many of them being so seriously affected that the base of their trunks was literally honeycombed by the galleries. The late Dr Asa Fitch stated that, of $10,000 worth of trees sold in Washington county in 1851, fully one half were destroyed within eight years. Not infrequently the borers were so abundant as entirely to girdle the tree. Mr William Couper, in 1862, attributed the great destruction of appletrees about Quebec to the ravages of this insect. Mr D. B. Wier, of Wisconsin, writing of this species in 1872, characterizes it as one of the worst enemies of fruit trees and states as his opinion, that it would destroy 5000 out of 10,000 young trees within three years. Dr

J. B. Smith considers this borer very destructive to young apple-trees in many parts of New Jersey and states that it is a more serious enemy of the quince. Miss Mary Treat, of Vineland N. J., writing of this insect in 1893, stated that it was unusually abundant in that section and threatened to kill the trees in spite of all efforts, 10 to 12 borers being found in one. Mr G. T. Powell, of Ghent N. Y., reports taking 30 grubs from a tree in 1889, a year when they were unusually abundant.

The work of this insect is so insidious that it is difficult to gain an adequate idea of its great destructiveness, specially as the sickly condition of the trees is frequently attributed to some other than the true cause.

The above brief records will give some idea of how dangerous an enemy this beetle is; and it is very likely that in future years appletrees will have to be guarded more closely than in the past, if they are to be protected from serious injuries by this pest.

Life history. The adult beetles have been observed abroad during June, July and August. Dr Fitch states that the beetles begin to appear in Washington county, N. Y., about June 20. They are secretive in habit and deposit eggs in the bark near the ground. Mr Zimmerman records the appearance of the beetle June 2 and 3, 1878, and adds that this date is 20 days earlier than usual. Prof. Cyrus Thomas, writing of this pest in 1877, states that it appeared in May in Illinois, and Mr D. B. Wier, of Wisconsin, gives the date of the appearance of the beetles from the middle of May to the middle of June. Mr Tallman has recorded finding this species in copulation on elm June 7. Dr J. B. Smith, state entomologist of New Jersey, gives the date of the occurrence of the beetles from May 20 to July 15.

The egg of this borer is a pale, rust-brown color, about ⅓ inch long, one third as broad in the middle and somewhat flattened, so that its depth is about one third its width. It is rather easy to find eggshells in the oviposition scars [pl. 1, fig. 2], and it will be seen that they are fairly tough, without any sculpture and sufficiently plastic to receive impressions of wood fibers between which they may be placed.

The oviposition scars [pl. 1, fig. 2; pl. 8, fig. 1] may be readily detected as longitudinal slits in the bark, ranging from ¼ to as much as ¾ inch in length. These scars have somewhat irregular, dried edges, and in early spring usually have small, rust-red borings hanging therefrom [pl. 8, fig. 2]. Their location is made more apparent by the adjacent discoloration and shrinking of the areas where the young grubs are at work in the underlying green tissues [pl. 8, fig. 3]. These scars are sometimes very abundant on young trees. The writer observed 11 of them on a portion of a smooth trunk less than 6 inches long and 1½ inches in diameter [pl. 8], and all were within 6 inches of the ground, two being close to its surface. The importance of these marks lies in the fact that they indicate the location of the young grubs, which may be reached and destroyed in the fall or early spring without material injury to the tree. The splitting of the bark is primarily caused by the female in preparing for deposition of her eggs, and the orifice is further enlarged by the consequent shrinkage and drying following the operations of the grub. On cutting into one of these scars [pl. 8, fig. 3] in early spring, young grubs, ranging in size from ⅛ to ¼ inch in length, may be found in the shallow cavity in the inner bark and outer sapwood, and in some cases remains of the eggshell may be observed. The method of oviposition has been described by Dr C. V. Riley as follows:

> The female beetle makes an incision in the bark, causing it to be split from ⅛ to sometimes ½ an inch. The incision is often made entirely through the bark, and the egg is thrust between the bark and the liber at right angles to one side of the slip, from ⅛ to ¼ of an inch from the aperture. Sometimes the bark is but partially penetrated, in which case it is pried open on one side of the aperture for the reception of the egg. In either case the egg is accompanied by a gummy fluid which covers and secures it in place and usually fills up the aperture. In young trees, with tender bark, the egg is usually thoroughly hidden; while in older trees it is sometimes so shallowly embedded as to be readily seen.

Mr W. Junkins, in the *New England Homestead* of Jan. 3, 1885, has also described this interesting process, as it occurs on twigs set in moist sand in a jar: June 15 he observed one of four females

deposit an egg. "She first made an incision in the bark close to the sand; then, turning her head upward, with her ovipositor she placed the egg in the bark nearly ¼ of an inch from the incision, the bark having been started from the wood."

Mr D. B. Wier states that the beetles copulate from 10 days to two weeks after reaching maturity, and soon after the females commence to lay eggs. They are mostly deposited by night, usually from 1 to 10 inches from the ground. He observed that, where the beetles are numerous, several females will often lay their eggs on the same tree at different times, sometimes as long as two or more months apart. He has found as many as 27 young borers of eight different sizes in one tree in September. The eggs are said by Professor Chambers to hatch in about 14 days, and Professor McMillan gives the time as 18 days. The period observed by Mr Junkins, June 15 to July 7, was 22 days. Mr Buckminster believed that the females lay about 10 eggs, which hatch in about eight days, as stated by Gay. Dr Saunders, in his *Insects Injurious to Fruit,* states that the beetle bores into the bark and deposits an egg in the cavity thus made; and Dr Dimmock, writing of this species in the *Standard Natural History,* observes that the cavity is filled with a cementlike secretion.

The young borer, or larva, almost invariably works downward just under the bark, making a somewhat sinuous channel with an oval enlargement at a variable distance from the point where the egg was laid. This oval chamber is evidently where the winter is passed. The presence of the insect is readily detected later, or in spring, by the rust-red borings which are ejected or forced out of the galleries [pl. 1, fig. 3]. There has been some discussion as to whether the larva actually ejects the borings. Dr Fitch was of the opinion that they commonly had the aspect of not having been forced out by the worm but of being thus crowded out because the mass under the bark swelled when dampened by rain soaking through the dead tissues and saturating the contents of the galleries. This explanation did not satisfy us. Our observations have been that the older larvae of this species always have more or less clear gallery space to travel about in and this they keep clear for the time being. They connect the interior workings with the chambers under the bark where they

fed on the sap. When gnawing in the interior galleries they throw the debris behind and void their excrement from time to time while working; when tired or with hunger satisfied they take this frass in their mandibles and pack it in the galleries and corners of the "bark" chamber out of the way occasionally removing and repacking in some other place. They will also carry it to openings in the bark of their feeding chambers, and push it out, using the mandibles only. When at work in the "bark" chamber they void their excrement through one of the openings, ejecting it so that it will fall outside. This is usually done when the voided matter is soft and watery.

The life history of this insect may be summarized as follows: The young borer, on the approach of winter, descends as near the ground as its burrow will allow and remains inactive till the following spring, when it begins operations anew, and on the approach of the second winter it is about half grown and still living in the sapwood. It is at this period that the most damage is done, for, where four or five occur in a single tree, they almost girdle it. The next summer, when it has become about three fourths grown, it cuts a cylindric passage upward into the solid wood and, having finished its larval growth, continues this passage to the bark, sometimes cutting entirely through a tree to the opposite side and sometimes turning back at a different angle. Several borers in one tree will fairly riddle its base [pl. 9]. The upper end of the passage is stuffed with fine borings and the lower part with long wood fibers [pl. 1, fig. 5, 6]. After this the larva remains unchanged through the winter, transforming to a pupa the following spring, and the beetle appears some time during the summer, leaving through a circular exit hole [pl. 1, fig. 7; pl. 9]. The latter frequently becomes overgrown, as represented in plate 8, figure 4.

Habitat. This species is said by Dr LeConte to occur in the Middle, Western and Eastern states. Professor Cook states that it is widely distributed in Michigan, and Rev. C. J. S. Bethune, writing of the insect in 1877, records it as very abundant in the Niagara district and in the vicinity of Montreal and Quebec. Professor McMillan stated in 1888 that every orchard in Nebraska was infested.

It has been recorded specifically by various writers, from Canada, all of New England, Delaware, Maryland, Michigan, New York, New Jersey, Pennsylvania, Ohio, Missouri, Iowa, Kansas, Texas, Alabama, Mississippi, Oklahoma, Virginia, Arkansas, West Virginia, District of Columbia, and Mount Desert Me. [Harris].

Food plants. This pernicious borer is apparently limited to relatively few food plants. It is specially injurious to the quince and nearly as much so to the apple. Its native food plants are the thorn, mountain ash, chokeberry (Pyrus arbutifolia) and shad bush. It has been recorded by Walsh as rare on pear and by Beutenmuller as attacking plum and cherry.

Description. Brown above with two white bands joined at the front and extending to the apex of elytra, under side and front of head white. Antennae light gray, legs lighter gray [pl. 1, fig. 1].

Natural enemies. Not very many enemies of this insect have been discovered. An undetermined carabid larva was found preying on the borers by Walsh and Riley in 1866. Promachus saperdae Riley M. S., now known as Cenocoelius populator Say, was bred from borers received from Indiana by Messrs Riley and Howard in 1890. The downy woodpecker and the great golden woodpecker have been seen in infested orchards by Miss Mary Treat of Vineland N. J. but none of them were observed at work around the base of the trees. Dr Fitch in his first report states that the downy woodpecker, which is frequently seen in the orchards, is one of the means provided by nature for keeping this insect in check, and adds that a neighbor, who had devoted much attention to birds and their habits, informed him that he had repeatedly noticed this woodpecker remaining for a considerable time down at the very root of appletrees, busily occupied in some operation. This would seem to be very good evidence that this bird does prey on this borer. That woodpeckers do this is conclusively proved by specimens recently collected in the vicinity of Albany, which show the characteristic work of these birds, but unfortunately give no clue to the identity of the operator.

Preventive and remedial measures. The control of an insect pest of this character may be brought about in two ways: (1) the

insect may be prevented from infesting the tree in some manner, or (2) destroyed after it has obtained entrance.

Dr Fitch had his attention called to the beneficial effect of soap applications, and he states that, if the bark of the trees be rubbed with soap the latter part of May, no borers will attack them. This was tested by him with the result that treated trees were free from the pest, while almost all of the untreated ones were infested with borers. One of the latter, only $3\frac{1}{2}$ inches in diameter, contained 15 of the grubs. Mr Fowler has proposed the use of 2 quarts of whale oil soap and $\frac{1}{4}$ pound of sulfur and enough clay to give the mixture the consistency of paint, and advises applying the compound early enough to prevent the deposition of eggs. Professor Cook in 1881 thought washing the trunks and larger branches of the trees in May and the last week in June with soap would protect them from the borers, and Prof. C. M. Weed has advised the use of what we know as the carbolic soap wash and observes that it is very effective when thoroughly applied. Some observers, however, state that soap applications, and similar preventive measures, are of comparatively little value, and a few consider the alkaline washes more effective than soap. A band of tarred paper, or bands of newspaper, wrapped tightly around the base of young trees during the period the beetles are abroad, affords considerable protection and is used rather extensively in some fruit-growing sections. The bands should extend from the soil about 2 feet high, should be tied at the top so that the beetles can not get behind the band and should make a fairly tight connection with the ground. Professor Slingerland has recently advised trying a coating of coal tar, first testing to see if the trees were injured by this substance. Whitewashing the trunk has also been advised by certain writers and appears to have a somewhat deterrent effect. The application is comparatively inexpensive and, in absence of anything else, may well be employed. Dr J. B. Smith has advised the use of a poisoned whitewash. The use of ashes about the roots is also good, since, if they are heaped somewhat, they will protect the lower portions

of the tree from injury. The idea of these applications is to coat the bark or protect the base of the tree with some substance which will deter the beetles from depositing their eggs and therefore prevent infestation. These applications should be made in this latitude by the latter part of May and again early in June, or, in the case of permanent bands, the application of them at the earlier date is sufficient. Dr Fitch states that, in his observation, the worst infested trees are shaded and choked by suckers, and he therefore urges keeping the base of the trees clean. It is undoubtedly a good practice to observe this advice, since it at least permits the ready detection of the borers. We believe that suckers at the base of the tree are frequently caused by serious injuries by the larvae, and our experience indicates that a tree with an unprotected trunk is almost as likely to be attacked by the insect as one with its base shaded.

Thomas Say in 1825 recommended covering infested trees the latter part of April or early in May with mortar in order to prevent the emergence of the borers. This, so far as we can learn, has never been extensively tried and is of doubtful value. After the insect has once made its way into the tree, there is nothing better than cutting out the borers and destroying them, or killing them with a wire while in the tree. Either operation is best carried out in September or October or in early spring, because the work of the young borers is apparent at this time, and the recent borings facilitate their detection. A young tree will recover if the bark be extensively cut with a knife, and the overcautious operator should remember that the borer is very likely to cause more injury if allowed to remain. The use of the wire will undoubtedly avoid considerable cutting in some instances, and it should be employed wherever practicable. Dr Fitch has advised cutting into the upper part of the boring, removing the sawdust and then killing the pest by pouring in a considerable quantity of hot water. This is undoubtedly efficient; but it appears to have a limited application, and in most cases it is probable that cutting out or destroying with a wire is to be preferred.

The quince suffers most from this borer, and perhaps the best method of controlling the pest in quincetrees is that described

by Mr Woodbridge Strong in the issue of the *Country Gentleman* for Mar. 20, 1890. His plan consists in providing the quince with a trunk which is practically borer-proof, and he accomplishes this by first taking stocks of English hawthorn and grafting on them varieties of Crataegus crus-galli or coccinia, which are worked on the hawthorn at the surface of the ground, and a year later hawthorn is worked back onto the native stock about a foot above and then quince on that a few inches higher. This compound tree is then set so that the hawthorn stock is below the surface of the ground and the Crataegus occupies the first foot. Mr Strong states that such trees make very satisfactory growth and fruit readily, and that, while the work of preparing them is difficult and involves considerable labor, the results amply justify the expense.

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1852 **LeConte, J. L.** Acad. Nat. Sci. Phila. Jour. 2:163 (Description, habitat, very injurious to appletrees)

1852 ——— Acad. Nat. Sci. Phila. Jour. ser. 2, 2:163 (Description, distribution)

1853 **Haldeman, S. S.** Am. Phil. Soc. Trans. n. s. 10:55 (Synonymy, distribution)

1854 **Emmons, E.** Nat. Hist. N. Y. Agric. 5:119-20, pl.16, fig.3 (Injuries at Troy, habits and remedies)

1855 **Fitch, Asa.** N. Y. State Agric. Soc. Trans. 1854, 14:715-29 (Detailed account as S. bivittata); same in Noxious and Other Ins. N. Y. 1st and 2d Rep'ts. 1856. p.11-25.

1856 ——— Noxious and Other Ins. N. Y. 3d Rep't, p.3-7 (Notes on life history, injuries, remedies); same in N. Y. Agric. Soc. Trans. 16:321-25

1857 **Fowler, Sam P.,** *sec.* Mass. Bd Agric. 4th Rep't, p.448 (Brief general account)

1858 **Briggs, Nathan.** Country Gentleman, July 8, 12:14 (Value of oil and soap for borers)

1858 **Fitch, Asa.** Country Gentleman, July 8, 12:15 (Experiments with soap against S. bivittata)

1858 ——— Cultivator, ser. 3, August, 6:238 (Efficacy of soap against S. bivittata)

1859 ——— N. Y. State Agric. Soc. Trans. 19:594-95 (Injuries in Washington county, soap as a remedy)

1859-60 **Walsh, B. D.** Ill. State Agric. Soc. Trans. 4:345 (Rare in Illinois. Fitch experiments with soap)

1860 **Rathvon, S. S.** Entomological essay read before the Fruit Growers Ass'n Eastern Pa. Gardeners Mo. October, 2:300 (Mention); December, p. 356, pl. 1. (Brief general notice as S. bivittata)

1861 **Uhler, P. R.** Com. Patents Rep't 1860. Agric. p.317-18 (Brief general account)

1861 **Walsh, B. D.** Ill. State Agric. Soc. Trans. 1859-60, 4:345 (Brief comparison with Chrysobothris femorata); reprint in part in Ill. Nat. Hist. Soc. Bul. Trans. 1861, p.159; Prairie Farmer, Dec. 6 [v. ?] n.s.v. ?, p.370-71 (Notes on S. bivittata)

1862 **Couper, William.** Can. Nat. and Geol. 7:278-81, 3 figures (Habits and ravages around Quebec)

1862 **Harris, T. W.** Insects Injurious to Vegetation, p.107-9 (Injurious, habits, remedies, as S. bivittata)

1862 **Packard, A. S.** Nat. Hist. Soc. Me. 2d Rep't, in Agric. Me. 7th Rep't, p.192 (Figure and mention)

1862 **Rathvon, S. S.** Com. Patents Rep't 1861. Agric. p.617-18, fig.77, 78, 83 (Brief general account)

1865 **Riley, C. V.** Prairie Farmer, Jan. 14, [v.31] n.s. 15:21, 5 figures (Figure of imago of S. bivittata)

1865 **Walsh, B. D.** Ill. State Agric. Soc. Trans. 1861-64, 5:499-501 (Habits and remedies)

1866[1] **Brackett, G. E.** Prac. Ent. no.2. Me. Farmer, May 10, S. b. no. 1, p.102 (Describes larva, habits, and means against S. bivittata)
1866[1] ——— Prac. Ent. no. 5. Me. Farmer, June 7, S. b. no. 1, p.103, (Notes on S. bivittata)
1866[1] ——— Prac. Ent. no 9. Me. Farmer, July 12, S. b. no. 2, p.18, 19; Bib. Eco. Ent. pt3, no. 914 (Means against S. bivittata)
1866[1] ——— Prac. Ent. no. 16. Me. Farmer, Aug. 30, S. b. no. 2, p.22, 23 (Seasons of S. bivittata)
1866[1] ——— Prac. Ent. no. 17. Me. Farmer, Sep. 6, S. b. no. 2, p.23, 24 (Picus pubescens destroys larva of S. bivittata)
1866[1] ——— Prac. Ent. no. 18. Me. Farmer, Sep. 13, S. b. no. 2, p.24 (Plugging as a means against S. bivittata)
1866 **Walsh, B. D.** Borers. Prac. Ent. 1:26, fig. 1 (Natural history and means against, as S. bivittata)
1866 ——— Prac. Ent. Mar. 26, 1:47 (Larval habits after Fitch, as S. bivittata)
1867[1] **Riley, C. V.** Prairie Farmer, Jan. 12, n. s. 19:23 (Remedies etc.)
1867 ——— Prairie Farmer, Feb. 2, 19:69 (Mention)
1867 ——— Prairie Farmer, June 8, 19:381 (Brief notice)
1867 **Walsh, B. D.** Prac. Ent. 2:92-93 (Food plants as S. bivittata)
1867[1] ——— Northern Ill. Hort. Soc. Trans. 1867-68, p.91-96 (Six worst enemies of fruit growers, S. bivittata)
1868[1] **Beadle.** Fruit Growers Rep't, p.172 (Prize essay on S. bivittata)
1868[1] **Riley, C. V.** Prairie Farmer. July 11 [v.38] n.s. 22:10, S. b. no. 3, p.32, 56 (Answer to W. Colwell: ravages of S. bivittata)
1868[1] ——— Coleman's Rural World, S. b. no. 3, p.16 (Means against S. bivittata)
1868 ——— Ill. State Hort. Soc. Trans. 1867, 1:108-9 (Saperda less numerous than Chrysobothris)
1868 ——— Noxious and Beneficial Ins. Mo. 1st Rep't, p.42-46, fig. 14 (Detailed account as S. bivittata)
1868 **Walsh, B. D. & Riley, C. V.** Am. Ent. October, 1:39 (Undetermined carabid larva probably preying on larva)
1869 **Packard, A. S.** Guide to the Study of Insects, p.500-1 (Brief general notice)
1869 **Walsh, B. D. & Riley, C. V.** Am. Ent. 1:168 (Advises digging out, as S. bivittata), p.245 (Identified)
1870[1] **Bethune, C. J. S.** Agric. and Arts Ass'n Ont. Trans. 25th Year, p.375-77 (Brief general account)
1870 **Riley, C. V.** Am. Ent. and Bot. 2:276 (Variations in color), p.306 (Larvae can not live in dead trees, as S. bivittata)
1870 ——— Noxious, Beneficial and Other Ins. Mo. 2d Rep't, p.19 (Life cycle 3 years, as S. bivittata)
1870 **Wielandy, J. F.** Am. Ent. 2:148 (Habits, ravages, and remedies, as S. bivittata)
1871 **Bethune, C. J. S.** Ent. Soc. Ont. 1st Rep't, p.69-71, fig. 2 (General account, quotes Beadle as S. bivittata)

[1]Reference unverified.

1871 ——— Fruit Growers Ass'n Ont. Rep't, 1870, p.69-71 (Characters, habits and means against S. candida)

1872 **Dimmock, G.** N. Eng. Homestead, June 22, v.5, no.7, p.49 (Treats of S. candida)

1872 **Wier, D. B.** Wis. State Hort. Soc. Trans. p.156-63, fig. 14 (Detailed account; deals with S. candida as a most noxious insect to fruit growers)

1872-73 **Smith, S. I.,** *sec.* Ct. Bd Agric. 6th Rep't, p.348-49, fig. 3 (Brief notice)

1873 **Bessey, C. E.** Ia. State Agric. Soc. Rep't, p.238-39, fig. 5 (Brief notice)

1873 **LeConte, J. L.** New Sp. N. Am. Coleopt. pt2, Smithsonian Miscel. Coll. 264, p.238-39 (Specific characters)

1873[1] **Riley, C. V.** N. Y. Tribune, May 23, S. b. no. 8, p.64 (Answer to J. Durbin; means against S. bivittata)

1874 **Cook, A. J.** Mich. State Bd Agric. 13th Rep't, p.124-25, fig. 2 (Widely distributed in the state, habits, remedies)

1874 **LeBaron, William.** Noxious and Beneficial Ins. Ill. 4th Rep't, p.157, 159, fig.77 (Mention, as S. bivittata)

1874[1] **Riley, C. V.** N. Y. Tribune, Ap. 8, S. b. no.10, p.34 (Answer to T. H. Wakeley: means against S. bivittata and Chrysobothris femorata, apply soap)

1874[1] **Tracy, William W. & Parmelee, George.** Injurious Insects. Rep't read before the Peninsula Farmers Club at Old Mission Mich. Traverse City. p.12 (S. candida, means against)

1875[1] **Bartlett, J. N.** N. Eng. Farmer, rec. nos. 16-18, v.53 (n. s. v.29), nos. 24-39; Psyche, Sep. 1875, p.103 (S. candida, means against)

1875[1] ——— N. Eng. Farmer, v.54 (n. s. v.30) no. 28; Psyche, Sep. 1875, p.104 (S. candida)

1875[1] **Bell, J. T.** Fruit Growers Rep't. (Notes S. candida captured near Belleville, no doubt imported)

1875 **Cook, A. J.** Cultivator and Country Gentleman, 40:455 (Brief general notice)

1875 ——— Mich. State Bd Agric. 13th Rep't, 1874, p.124-25, fig. 20 (Brief general notice)

1875 **Fernald, C. H.** Me. State Pomo. Soc. Trans. 1874, p.97-98 (Brief general account)

1875[1] **Riley, C. V.** Coleman's Rural World, Nov. 13, S. b. no. 10, p.188 (Timber trees near apple orchards increase the likelihood of attack by S. bivittata)

1876 **Bell, J. T.** Fruit Growers Ass'n Ont. Rep't, 1875, p.35-36 (Brief description with remedies)

1876 **Hoffmeister, A. W.** Ia. State Hort. Soc. An. Rep't, 1875, p.204-5 (Remedies, ravages and means against S. bivittata)

1876 **Perkins, G. H.** Vt. Bd Agric. 3d Bien. Rep't, p.599 (Brief general notice)

[1]Reference unverified.

1876[1] **Riley, C. V.** Coleman's Rural World, Aug. 9, S. b. no. 14, p.3-4, 55-56; extract in Cultivator and Country Gentleman Sep. 7, 1876, 41:566 (Answer to F. H. Chrysobothris femorata distinguished from S. bivittata [=candida])

1877 **Bethune, C. J. S.** Can. Ent. December, 9:224, pl. , fig. 6 (Injuries, beetles and larva described, abundant in Niagara district and about Montreal and Quebec)

1877 ——— Ent. Soc. Ont. Rep't for 1877, p.26-28, pl. , fig. 3, 6 (Same as above but with life history and remedial measures additional)

1877 **Fuller, A. S.** Moore's Rural New Yorker, May 19, 19:247 (Synonymy, brief account)

1877 **Provancher, *L'abbé* L.** Faune Ent. Can. 1 Coleopt. p.632, 633-34, fig. 48 (Description)

1877[1] **Riley, C. V.** N. Y. Tribune, Dec. 26, S. b. no. 14, p.234 (Ravages and means against S. bivittata)

1877 **Thomas, Cyrus.** Noxious and Beneficial Ins. Ill. 6th Rep't, p.35, 38, 44, 83, 84 (References), p.152-56 (Description, detailed life history, remedial measures, as S. bivittata)

1878 **Riley, C. V.** Acad. Sci. St Louis. Trans. Dec. 1877, Jour. Proc. cclxix-cclxx (Describes egg and manner of oviposition of S. bivittata [=candida])

1878[1] ——— N. Y. Wk. Tribune, Feb. 20, S. b. no. 19, p.193-94; reprint in Coleman's Rural World, Mar. 20, 1878, S. b. no. 14, p.267-68, with slight omission in the same, Mar. 12, 1879, S. b. no. 23, p.101-2; Mirror and Farmer, Ap. 6, 1878, S. b. no. 20, p.3 (New facts, describes egg, oviposition, seasons of oviposition, means against S. bivittata)

1878 **Zimmerman, C. D.** Can. Ent. 10:220 (Adults appeared June 2, 3—20 days earlier than usual)

1878-79 **Hoy, P. R.** Wis. State Hort. Soc. Trans. 9:233 (Rare as S. bivittata)

1878-79[1] **Osborn, Herbert.** Ia. State Hort. Soc. Trans. 13:368-402, 19 figures (Habits and natural history of S. bivittata)

1879 **Brackett, G. E.** Kan. State Hort. Soc. Rep't, 9:186-90, 198-200 (Description, life history and remedies with note replying to Riley)

1879 **Osborn, Herbert.** Coll. Quar. May, 2:8; Western Stock Jour. and Farmer, July 1879, 9:142 (Natural history of S. bivittata)

1879 ——— Ia. State Hort. Soc. Trans. 1878, 13:392-93 (Life history, remedies, figures, as S. bivittata)

1879 **Riley, C. V.** Kan. State Hort. Soc. Rep't, 9:196-98 (Habits and remedies)

1879 **Stout, O. E.** Kan. State Hort. Soc. Rep't, 9:87 (Brief notice)

1880[1] **Bateman, ——.** Country Gentleman, 45:246 (Wash for borers)

1880 **Clay, C. M.** Land and Home, Jan. 1, 1:139 (Sap-suckers destroy borers)

1880[1] **Osborn, Herbert.** Western Stock Jour. and Farmer, July 10, p.153 (Answer to inquiry: habits of S. bivittata)

1880 **Zesch, Frank & Reinecke, Ottomar.** List of Coleoptera of Buffalo and Vicinity, p.10 (Listed)

[1]Reference unverified.

1881 **Cook, A. J.** Can. Ent. 13:191 (Soft soap protects trees)
1881 **Osborn, Herbert.** Ia. State Hort. Soc. Trans. 1880, 15:111, 112 (S. cretata compared with)
1882 **Lintner, J. A.** Injurious and Other Ins. N. Y. 1st Rep't, p.58, 64 (Remedial measures), p.331 (Listed)
1883 **Atkins, C. G.** Rural New Yorker, 42:688 (Brief note, very abundant in Maine)
1883 **Cooke, Matthew.** Injurious Insects of the Orchard, Vineyard etc., p.65-67, fig.25 (Brief general account)
1883 **Harrington, W. H.** Ent. Soc. Ont. 14th Rep't, p.45, fig. 16 (Mention)
1883[1] **Riley, C. V.** Stoddarts' Encyclopedia Americana, 1:135-42, fig. 1-29 (Round-headed appletree borer, S. bivittata), p.137, fig. 7
1883[1] ——— Rural New Yorker, Oct. 20, 42:693; reprint in Am. Pomo. Soc. 19th Sess. Proc. 1884, p.45; Wis. State Hort. Soc. Trans. 1886, 17:2 (Corrects statements in regard to oviposition of S. bivittata [=candida])
1883 **Saunders, William.** Can. Ent. 15:203 (Oviposits in bored cavity)
1883-89 ——— Insects Injurious to Fruits, p.16-19, 160, 425 (Brief general account)
1883 ——— Ent. Soc. Ont. 14th Rep't, p.16 (Oviposits in bored cavity)
1884 **Atkins, C. G.** Rural New Yorker, Jan. 12, 43:19 (Notes on oviposition, as S. bivittata)
1884 **Dimmock, George.** Stand. Nat. Hist. 2:325 (Brief general notice, as S. bivittata)
1884 **Riley, C. V.** Insects in Relation to Agriculture, Encyclopedia Americana, 1:137 (Brief general account, figures)
1884 ——— Rural New Yorker, Mar. 1, 43:132, fig. 73 (Notice of paper of C. G. Atkins: confirms method of oviposition of S. candida, describes method; corrects statements by William Saunders, describes and figures egg of S. candida, figures, burrows and exit holes; figures, pupa and position of egg when deposited)
1884 ——— Am. Pomo. Soc. 19th Sess. Proc. 1883, p.46 (Reference to oviposition)
1885[1] **Atkins, C. G.** Home Farm. Mar. 5, 1885 (Notes on oviposition of S. candida)
1885[1] **Junkins, E. W.** N. Eng. Homestead. Jan. 3, 1885 (Notes on oviposition of S. candida)
1885 **Lintner, J. A.** Injurious and Other Ins. N. Y. 2d Rep't, p.27 (Mention)
1885 ——— Country Gentleman, July 16, 1:590-91 (Remedial measures discussed in detail)
1886 ——— State Ent. Rep't N. Y. State Mus. Nat. Hist. 39th Rep't, 1885, p.105-6 (Oviposition and remedies)
1887 **Bethune, C. J. S.** Ent. Soc. Ont. 17th Rep't, p.57-58, fig. 31 (Remedial measures)
1887 **Harrington, W. H.** Ent. Soc. Ont. 17th Rep't, p.30 (Mention)
1887 **Lintner, J. A.** Injurious and Other Ins. N. Y. 3d Rep't, p.105 (Mention)

[1]Reference unverified.

1887 **Stickney, J. S.** Wis. State Hort. Soc. Trans. 1886-87, 17:236-37 (Brief notice, advises shading south and southwest sides of trees)
1888 **Cook, A. J.** Mich. State Bd Agric. 27th Rep't, p.168 (Mention)
1888 **Harvey, F. L.** Me. Agric. Exp. Sta. An. Rep't, p.153-55, fig. 1 (Brief general account)
1888 **Lintner, J. A.** Injurious and Other Ins. N. Y. 4th Rep't, p.107 (Carbolic acid wash)
1888 **McMillan, Conway.** Agric. Exp. Sta. Neb. Bul. 2, 1:84-85 (Very injurious in Nebraska; natural history and remedies)
1888 **Weed, C. M.** Rural New Yorker, 47:333 (Carbolic soap wash and destroying eggs and young borers very successful)
1889 **Gillette, C. P.** Ia. Exp. Sta. Bul. 5, p.178, fig. 14 (Brief general notice)
1889 **Lintner, J. A.** Injurious and Other Ins. N. Y. 5th Rep't, p.269-71 (Method and duration of egg-laying), p.325 (Reference)
1889 **Tolman, Adams.** Insect Life, 1:343 (On elm)
1889 **Townsend, [C. H.] Tyler.** Psyche, 5:233 (Listed from lower Michigan peninsula)
1890 **Harrington, W. H.** Ent. Soc. Ont. 20th Rep't, 1889, p.52, fig. 35 (Mention)
1890 **Riley, C. V. & Howard, L. O.** Insect Life, 3:59 (Promachus saperdae [Cenocoelius populator Say] bred from)
1890 **Smith, J. B.** Cat. Ins. N. J. p.211 (On apple, pear and quince)
1890 **Strong, Woodbridge.** Country Gentleman, 65:228 (Preventives, grafting quince on borer-proof thorn, wrapping base of trunk with paper)
1891 **Beutenmuller, William.** N. Y. Micro. Soc. Jour. 7:31 (Bibliography of transformations)
1891 **Lintner, J. A.** Injurious and Other Ins. N. Y. 7th Rep't, p.313-14, fig. 31 (Newspaper wrapping and resistant stock)
1891 **McCarthy, G.** N. C. Agric. Exp. Sta. Bul. 78, p.27-28 (Brief mention)
1891 **Smith, J. B.** Ent. Soc. Ont. 22d Rep't, p.65 (Any part of trunk and branches of apple and pear may be attacked)
1891 ——— N. J. Agric. Exp. Sta. 11th Rep't, 1890, p.513-14, fig. 26 (Very injurious to young appletrees, more so to quince, remedies)
1891 ——— *& others.* Insect life, 3:249 (Not confined to quince. S. candida not confined to the trunk)
1891 **Weed, C. M.** Insects and Insecticides, p.29-31, fig. 9 (Brief general account)
1891 ——— Columbus Hort. Soc. An. Rep't, 1890, p.29-30 (Brief account, as S. candida)
1892 **Smith, J. B.** Insect Life, 4:43 (Parts of trees attacked)
1893 **Chambliss, C. E.** Tenn. Agric. Exp. Sta. Bul. 1, 6:6-8, fig. 2 (Brief general account)
1893 **Lintner, J. A.** Country Gentleman, 58:387 (Remedial measures)
1893 **Osborn, Herbert.** Ia. State Hort. Soc. Rep't, 17:115-16, fig. 25 (Brief notice)
1893 **Riley, C. V.** Md. Agric. Exp. Sta. Bul. 23, p.86-87, fig. 17, 18 (Brief general account)

1893 **Treat, M.** N. Y. Ent. Soc. Jour. 1:16-17 (Unusually injurious, parts of tree attacked and natural enemies)

1894 **Bruner, L.** Neb. State Hort. Soc. Rep't, p.161, 181-82, fig. 24, 25 (Listed, figured)

1894 **Davis, G. C.** Mich. State Hort. Soc. 24th Rep't, p.77-78, figure (Brief notice)

1894 **Jack, J. G.** Mass. Hort. Soc. Trans. p.137 (Food plants, habits and remedies)

1895 **Comstock, J. H.** Manual for the Study of Insects, p.572-73, fig. 690, 697 (Brief notice)

1895 **Hamilton, John.** Cat. Coleopt. Southwestern Pa., etc. Am. Ent. Soc. Trans. 22:369 (Not rare)

1895 **Lintner, J. A.** Ins. N. Y. 10th Rep't, p.488, 511 (Reference)

1895[1] **Weed, H. E.** Southern Cultivator, Jan. 1895 (Round-headed apple-tree borer, S. candida)

1896 **Beutenmuller, William.** N. Y. Ent. Soc. Jour. 4:80 (Attacks apple, pear, plum, quince, cherry, thorn, mountain ash and June berry, Amelanchier)

1896 **Fletcher, James.** Farmer's Advocate, London Ont. Nov. 16, p.480, figure (S. candida in appletrees)

1896 **Leng, C. W. & Hamilton, John.** Am. Ent. Soc. Trans. 23:147, 148-49 (Systematic account)

1896 **Lintner, J. A.** Country Gentleman, 61:949 (Remedial measures in detail)

1896 ——— State Ent. 11th Rep't, p.269 (On apple)

1896 **Smith, J. B.** Eco. Ent. p.209-10 (Remedial measures)

1897 **Bogue, E. E.** Okl. Agric. Exp. Sta. Bul. 26, p.12-14, fig. 8, 9 (Brief general account)

1897 **Fyles, Thomas W.** Ent. Soc. Ont. 27th Rep't, 1896, p.39-40 (Native food plants, thorn, moosemissa, shad bush)

1897 **Johnson, W. G.** Am. Gardening, 18:375 (Brief general notice)

1897 **Lintner, J. A.** Country Gentleman, 62:390 (Soap wash, cutting out)

1897 ——— Injurious and Other Ins. N. Y. 12th Rep't, p.239, 246, 356 (Reference)

1897 ——— Injurious and Other Ins. N. Y. 13th Rep't, p.365 (Reference)

1898 **Bruner, L.** Neb. State Hort. Soc. An. Rep't, p.121-212, 108 figures (Insect enemies of the apple and its fruit under S. candida)

1898 **Chittenden, F. H.** U. S. Dep't Agric. Div. Ent. Circ. 32, p.1-8, fig. 1 (Summary account)

1898 **Faville, E. E. & Parrott, P. J.** Kan. Agric. Exp. Sta. Bul. 77, March, p.50-52, fig. 23-25 (Brief general account)

1898 **Johnston, James.** Can. Ent. 30:71 (Taken June 4 on thorn at Hamilton)

1898 **Stedman, J. M.** Mo. Agric. Exp. Sta. Bul. 44, fig. 6, p.14-16, 18 (Brief general account, results with washes)

1898 **Wickham, H. F.** Can. Ent. 30:41, 42 (Specific characters, food plants)

[1]Reference unverified.

1899 **Beach, S. A., Lowe, V. H. & Stewart, F. C.** N. Y. State Exp. Sta. Bul. 170, p.389 (Brief notice)
1899 **Bruner, Lawrence.** Neb. State Hort. Soc. Rep't, 30:160-61 (Brief mention, figure)
1899 **Felt, E. P.** Country Gentleman, 64:917 (Protective bands and washes advised)
1899 **Fernald, H. T.** Pa. Dep't Agric. Bul. 47, p.12-14, fig. 14 (Brief general account)
1899 **Fyles, T. W.** Ent. Soc. Ont. 29th Rep't, 1898, p.47, fig. 16 (Brief mention)
1899 **Harvey, F. L. & Munson, W. M.** Me. Agric. Exp. Sta. Bul. 56, p.108-9, pl. 2, fig. 1 (Brief general account)
1899 **Lugger, Otto.** Minn. Agric. Exp. Sta. Bul. 66, p.210-15, fig. 133-34 (Brief general account); same in Ent. State Exp. Sta. 5th Rep't, p.126-31
1899 **Smith, J. B.** Ins. N. J. State Bd Agric. Rep't Sup. p.296, fig. 131 (Brief mention)
1900 **Felt, E. P.** State Ent. 15th Rep't. N. Y. State Mus. Bul. 31, p.554 (Unusually abundant), p.557 (Adults taken on mountain ash July 4), p.574 (Attracted to light), p.577-78 (Mention)
1901 **Webster, F. M.** Ent. Soc. Ont. 31st Rep't, p.83, fig. 44 (Adults gnaw young apples)
1901 **Felt, E. P.** Country Gentleman, Oct. 3, 66:803 (Remedial measures)
1902 ——— Country Gentleman Ap. 3, 67:291 (Injuries to young trees); State Ent. 17th Rep't. N. Y. State Mus. Bul. 53, p.734-35, 834 (Injuries and brief bibliography)
1902 **Patton, J. H.** Am. Agric. 69:357 (Cover infested spots with clay)
1902 **Slingerland, M. V.** Rural New Yorker, Oct. 11, 61:688 (Remedial measures)

Saperda calcarata Say

Poplar borer

This is the largest of our native species and is equaled in size only by the European S. carcharias. This species is of considerable economic importance on account of its serious injury to the trunks and larger branches of poplars. These trees rarely attain any size in New York State before showing the operations of this insect, and in not a few instances very serious injury is inflicted. This applies not only to neglected trees along road sides and in forests but also to magnificent specimens grown for ornamental purposes in parks. In Washington park, Albany, this species has recently caused a great deal of damage, breeding in large numbers in a group of magnificent white poplars. We have also observed similar injury in New York city and Brooklyn.

Early history. Dr Harris, in his classic report, *Insects Injurious to Vegetation,* states that this species in conjunction with the broad-necked Prionus, Prionus laticollis, nearly destroyed the lombardy poplars in the vicinity of Cambridge Mass. in the early 40's. In 1880 Mr Shelby Reed, of Scottsville N. Y., lost two fine trees on a lawn through the depredations of this pest. Dr Packard reports it as very injurious to poplars along the shores of Casco bay, Me., in 1884, and in 1892 it had caused great depredations among the silver poplars of Cincinnati O. according to Charles Dury. Professor Riley, in his early writings, states that this insect has been universally destructive to cottonwoods and poplars in the western states, and Professor Bruner, in his paper, "The Insect Enemies of Ornamental and Shade Trees," states that this borer is by far the most destructive enemy of poplars and cottonwoods in the west. He further adds that it is almost impossible to grow these trees of any size in cities and towns of Nebraska away from the friendly care of birds and parasitic insects.

Life history. The recorded life history of this insect is very meager indeed. Dr Harris states that the beetles [pl. 2, fig. 1] occur on the trunks and branches of various forms of poplar in August and September, and other writers notice the life history of the insect in a very brief manner.

The most obvious signs of infestation are the numerous blackened, swollen scars along the surface of the trunk and limbs. Sometimes these are open, and in early summer large quantities of borings are expelled from the inhabited galleries, and frequently occur in considerable piles about the base of the trees. This is very evident during the latter part of May and in early June. Our observations show that pupae [pl. 2, fig. 2] may be found in considerable numbers in early June in the vicinity of Albany, and that adults appear in early July and continue to emerge throughout that month and probably also during August and into September. In early June we have found full grown larvae [pl. 2, fig. 3] which apparently were nearly ready to pupate, and many pupae, though no beetles breed therefrom

till into July. This would therefore prove that the pupal stage lasts three or four weeks as a general rule. The pupal chamber [pl. 2, fig. 2] is invariably near the center of the smaller limbs and at some distance from the surface in trunks. The top is smoothly cut, and the other end is closely packed with coarse fibers which are attached to the side of the gallery at one end, and the portion next the pupa is packed with much finer borings and then coated with very fine sawdust. This pupal chamber appears to be made the previous season, but transformation to the pupa does not occur, as in other species, till spring. There are no records regarding oviposition habits, but this species, like S. candida, makes a small slit in the bark and deposits its eggs just underneath the surface. The young larva [pl. 10] works in the inner bark and the outer sapwood for a short time and before the approach of cold weather sinks its burrow to a greater depth. The borings of the second year are confined very largely to the interior of the wood, and during this stage the limb or trunk may be honeycombed by very large, somewhat irregular galleries. In the latter stages of their existence, the larvae not infrequently excavate broad shallow galleries in the sapwood and inner bark and appear to subsist to a considerable extent on the sap collected in such cavities. This insect probably requires three years to complete its transformations.

Food plants. This borer has been recorded as destructive to lombardy poplar [Emmons], cottonwood [Walsh], Populus tremuloides, the common aspen [Jack], cottonwood, poplars and willows [Lugger], is not rare on diseased Populus [Hamilton], on cottonwood and other poplars [Adams], very common [Provancher].

Description. Covered with gray hairs, diversified with patches of yellow hairs on the elytra, which latter end in a sutural spine. Thorax with a yellow stripe on top and sides, extending on the head, which is yellow in front; scutellum yellow; underside gray with yellow; legs gray; antennae gray. Sometimes the insect is entirely yellowish brown (var. adspersa).

Distribution. This species has been recorded by Leng and Hamilton, from the following localities: Canada, Wisconsin,

Lake Superior, Michigan, Ohio, Pennsylvania, New York, Massachusetts, New Jersey, Missouri, Kansas, Nebraska, Iowa, Vancouver island, British Columbia, and from Yakima Wash. by Professor Piper. We have seen specimens from Texas, South Carolina, Illinois, Black hills, and Bismarck N. D. It has been found by us at Fort Lee N. J., in New York city and also Brooklyn and Glendale.

Saperda adspersa Lec., a uniformly brown form described from Michigan, is a variety of this species. This variety has also been found at Albany [Joutel] and at Brandt lake in the Adirondacks [J. Doll].

Remedies. It is manifestly impossible to attempt to control this insect on other than valuable trees, and in such situations, digging out the borers, with possibly recourse to the use of repellent washes described on page 29, is about all that can be done and in the majority of instances should afford considerable protection.

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Saperda tridentata Oliv.

Elm borer

This species is of considerable economic importance, since it is sometimes very injurious to our American elms, where it may work in association with two small curculios, Magdalis barbita Say. and M. armicollis Say. We believe that this species is responsible in a large measure for the dying condition of some of our elms, though the curculios mentioned above undoubtedly aid materially in the work of destruction.

Early history. The earliest record of injury by this insect is that given by Harris in his report, *Insects Injurious to Vegetation.* He states that trees on Boston Common "were found to have suffered terribly from the ravages of this insect. Several of them had already been cut down as past recovery; others were in a dying state; and nearly all of them were more or less affected with disease or premature decay." Dr S. A. Forbes, state entomologist of Illinois, in his 14th report, states that, from the rapid progress which this pest has made among the elms during the last two or three years, it seems extremely likely that it will totally exterminate the trees unless it be checked by general action. Dr J. A. Lintner, late state entomologist of New York, in writing of this insect in 1893, characterizes it as being generally destructive throughout the State and one worthy of close attention in order to check or to prevent its causing serious injuries. Professor Garman, entomologist of the Kentucky Agricultural Experiment Station, records an instance of serious injury by this pest to trees about the streets of Frankfort. Several trees were dead and a number of other valuable elms dying, those affected being among the largest

and the finest in the city. A more recent outbreak at Berlin Mass. was brought to the writer's attention in 1898. Two long rows of rather young elms were seriously injured by this insect and the associated Magdalis armicollis Say and M. barbita Say, and a number of the trees were killed.

Signs of attack. The presence of this insect is not easy to detect till it has become well established, and the first signs are usually seen in the lighter, thinner foliage followed by a dead limb here and there. Indications of boring soon appear, and the dark sawdust collects in crevices of the bark, and, after the attack has progressed for some time, large portions of the bark may be easily pulled from the tree, revealing a condition beneath very much like that represented on plate 11, figure 2. The inner portion of the bark may be literally a mass of mines or burrows, and, if the work has not gone too far, numerous whitish, flattened, legless grubs may be found in the channels they have excavated. The junior author is of the opinion that this species normally feeds on dead or badly diseased tissues, and that from them it may invade living bark. A small portion of the work of this insect is shown on plate 3, figure 1, where it is seen that the grubs have made incursions into the living bark, working back to that which is dead. It is also able to live in the thick bark of older trees for a portion of its life. This is undoubtedly true in some cases at least, and in others it certainly appears as though this species was the initial cause of the trouble. The observations of Mr M. F. Adams on a large number of injured trees in the vicinity of Buffalo led him to attribute the primary injury to this species.

Life history. The time necessary for this insect to complete its life cycle is unknown, but from our breeding experiments it seems that probably only one and possibly two years are necessary. The larvae commence transforming to pupae in New York State about the middle of May or earlier, and the beetles begin to appear the latter part of that month and continue to emerge for some time, examples having been taken as late as Aug. 24. The eggs are deposited on the bark in June, according to the

observations of Dr Fitch, but it would seem very probable that oviposition may occur much later, as beetles are abroad till into August. The attack usually begins at the base of the tree. The young grub works its way under the bark and begins feeding on the tissues and making a serpentine burrow. The boring increases in size with the growth of the larva [pl. 3, fig. 1], and in the course of time the tree may be completely girdled and then it must soon die. Dr Packard, writing in 1870, calls attention to finding three sizes of larvae; and we found it comparatively easy to separate those taken from a badly infested piece of limb in a similar manner. But in our breeding from such infested bark all larvae transformed the same season. We have also found it working in dead as well as living tissues and have proved its ability to complete its transformations in the former.

Food plants. This insect appears to infest the white elm almost exclusively, though Dr Fitch records it as breeding in the slippery elm. We have seen no indications of its attacking the English or Scotch elms, so common in Albany. There is a record of this species having been reared from maple, but it would seem that the infestation must have been abnormal or else the record was founded on an erroneous observation.

Description. Black, sometimes fawn color, densely covered with a gray pubescence [pl. 3, fig. 3]. Thorax: twin black spots below lateral orange red bands which are joined together at the base and reach to the head, where each divides and encircles an eye; sometimes ornamented with two black spots on each side of median line. Elytra: submarginal ridge reaching from the humeral angle to near the apex, giving them an angulated appearance; ornamented by a more or less distinct submarginal, orange red band, from which arise three crossbars of the same color, the one nearest the base of the elytra nearly transverse, except at the tip, where it is sometimes oblique, it rarely reaches to the suture and has a black spot on either side where it joins the submarginal band; the middle band oblique and usually joined at suture; the apical one also oblique, with a black spot at its posterior side, usually reaches the suture and

continues to the apex, where it joins the submarginal band. The apex is truncate and usually sinuate in well developed examples.

Distribution. The elm borer is generally distributed in New York State and has been recorded by various writers from the following additional localities: provinces of Ontario and Quebec, Massachusetts, Rhode Island, New Jersey, Pennsylvania, Ohio, Kentucky, Illinois, Michigan, Wisconsin and Iowa. It was collected by Professor Bolles in Texas and at Tyngsboro Mass. by Blanchard. We have also seen specimens from the District of Columbia. It probably occurs in a number of other states.

Remedies. Badly infested trees should be cut and burned before the beetles have had an opportunity to emerge in the spring, that is before the latter part of May, in the latitude of New York. And in a like manner infested portions of others should be cut away and burned. The latter process was carried out on a lot of 1500 elms at Buffalo N. Y. by Mr M. F. Adams, who reports that the trees were benefited in a most gratifying manner.

Protecting the trees during the period of oviposition with a carbolic acid wash has been frequently recommended, but is of doubtful utility. Where this insect is very abundant and its injuries correspondingly serious, it would do no harm to try the effects of a wash. One of the best may be prepared as follows: thin a gallon of soft soap with an equal amount of hot water and then stir in 1 pint of crude carbolic acid, or ½ pint of the refined, and allow it to set over night. The next day add 8 gallons of soft water and apply to the parts to be protected, which in the case of this insect would be the trunk and base of the lower limbs. The bark should be kept moist with this substance from the latter part of May through July.

Removing portions of the bark has also been recommended. The badly infested portion should be cut away and the grubs destroyed, and, where a few are working in living bark, it might be well to remove the upper layers till the grubs are nearly exposed and then brush over the shaven surface with strong kerosene emulsion or whale oil soap solution, finally covering the wound with a paste formed of a mixture of fresh cow dung and lime or with a coat of cheap, red paint.

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Saperda cretata Newm.

Spotted appletree borer

This insect is the more common appletree borer in Michigan, where it inflicts serious injuries according to Professors Cook, Riley and Osborn. It is probably this insect that Mr L. J. Templin had in mind in 1877 when writing of the appletree borer in the *Practical Farmer* for Nov. 17. He states that in the West a "majority of the specimens have a spot on each elytron on the shoulder," and shows that it was quite injurious even at that early date. It also works in the lower limbs of Crataegus, as stated by Dr Hamilton. Professor Osborn has recorded this insect as inflicting considerable injury in Iowa.

Description [pl. 4, fig. 2]. Cinnamon brown with a white band on the side of thorax, and a large, oblong white spot twice as long as wide, at middle of each elytron, and another small spot before apex; neither reaching to suture or margin. There is sometimes a minute white spot at middle of base of thorax as well as at the humeral angles. The sides are white; underneath, brown.

Distribution. This species has been recorded from the following localities: Paris Ont. [E. B. Reed], New York and Pennsylvania [Hamilton], New Jersey and Ohio [Chittenden]; Mr Chittenden states that there are specimens of this insect in the United States National Museum from northern Illinois and Texas; Leng and Hamilton record it from the following localities: Massachusetts, Canada, Michigan, Wisconsin, Iowa, Illinois and Pennsylvania; and Mr Wenzel informs us that he has recently taken it at Philadelphia. Mr Blanchard took it at Tyngsboro Mass.

Food plants. This species, in addition to the apple, attacks wild crab apples, and it has been observed on Juneberry [Chittenden].

Life history. Professor Osborn has observed the work of this insect quite closely. He states that its attack is usually confined to branches of moderate size, and that its plan of work is somewhat peculiar. At intervals of half an inch or more along the branch double incisions are made in the bark; and, on cutting these away, it was found that they led to excavations of considerable size under the bark, in some of which small grubs could be found at work. The borers had the appearance of the common appletree borer and were evidently of one year's growth. This insect makes a longer, more tortuous burrow than c a l c a r a t a, in our experience. Its work in thorn is represented on plate 4, figure 1.

The pupa as described by Professor Osborn is similar to that of S. c a n d i d a but smaller and occupies the central portion of the branch. He further observes that the beetles issue about the middle of June, and, after pairing, the female lays her eggs in the bark, two in a place, distributing them along the branch at distances of half an inch to an inch. On hatching, the grubs work in opposite directions around the branch, living for the first year just beneath the bark and afterward entering the solid wood. Here, after becoming full grown, they pupate and in due time complete their transformations.

Remedies. The remedial measures advised by Professor Osborn are cutting out and destroying the grubs with as little injury to the bark as possible; and, as he observes, if this is done soon enough, two grubs may be killed at every incision. He also states that some of the smaller woodpeckers are likely to prove most effectual allies in controlling this insect, and their presence in an orchard should be encouraged. Professor Cook has advised the use of the carbolic soap wash, which he states should be applied about June 10.

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Saperda discoidea Fabr.

Hickory saperda

This species is remarkable in having the sexes so unlike that one unacquainted with it would certainly consider them distinct species. In a long series of males, however, there will be found individuals having the same color and markings as the females, and some very poorly developed females lack entirely the characteristic markings of the sex. This is a common insect and breeds abundantly in hickory, frequently following the work of the destructive hickory bark borer, Scolytus quadrispinosus Say. It is sometimes so abundant that a piece of bark 6 inches square may contain a dozen or more larvae.

Life history. The beetles have been taken abroad the latter part of June and in July. The larvae feed partly on the bark and partly on the wood and on approaching maturity, in our

experience, enter either the bark or the wood and transform to beetles. The work of this species is shown on plate 3, figure 2. Dr Hamilton has found more than 20 larvae, pupae and immature beetles, in the bark of a large hickory that had been killed about two years before. All were on the north side of the tree and none over 15 inches from the ground. In our experience they are equally abundant on all sides of the tree but appear to avoid any part infested by a dense white fungus growing between the bark and wood and often into the wood, and as very often only one side of the tree is so affected, this may account for the experience of Dr Hamilton. Dr Horn states that the larvae fed on the outer layers of the wood till they had attained nearly full growth and then retired into the bark, closing their burrows and transforming like a species of Urographis in oak.

Food plants. This insect appears to confine its attack to diseased or dying trees. We have reared it from trees killed by Scolytus quadrispinosus Say. It has been recorded on the hickory by Mr Harrington and as common on hickory and walnut in southwestern Pennsylvania by Dr Hamilton.

Description [pl. 3, fig. 5, 6]. Color above varies from black to light reddish brown in some examples; thorax and elytra strongly punctate; legs reddish brown, darker toward the tarsi. The under side is white in the males and light yellowish gray to light gray in the females.

Female. Head and thorax covered with olive yellow hair; scutellum yellow; the elytra denuded, except a small spot above and one below; a crescent-shaped fascia in the middle of each elytron, composed of dense yellow hair, which also forms a marginal band spreading over the apical end of the elytra.

Male. Uniformly ferruginous, black above, covered by a sparse gray pubescence that forms a whitish line on the sides and dorsum of the thorax, which is bordered by a denuded area.

Distribution. Middle states [LeConte]; Buffalo N. Y. [Zesch-Reinecke]; never plentiful about Hamilton Ont., though the females are usually the more numerous [Moffat]; very rare at Ottawa Can. [Harrington]; locally not rare throughout New Jersey [Smith]; and from Canada, New York, Pennsylvania,

New Jersey, Louisiana, Kansas, Nebraska, Illinois, Michigan [Leng-Hamilton].

Natural enemies. Mr Harrington has observed a species of Arotes ovipositing in infested hickories and it is possibly a parasite of this borer.

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Saperda vestita Say

Linden borer

This species is a serious enemy of lindens in this country and is therefore one of considerable economic importance.

Early history. Dr Harris has recorded extensive depredations on linden trees in Philadelphia by an insect supposed to belong

to this species, but, as the workings are very different from any we have met with, we question the identity of the depredator. The trouble was so serious that 47 trees were cut down by order of the authorities. The nature of the injury may be judged by the following. One of the infested lindens was very large, the trunk measuring 8 feet, 5 inches in circumference 5 feet from the ground. A strip of bark 2 feet wide at the bottom and extending to the top of the trunk was destroyed, and the exposed surface of the wood pierced and grooved with countless numbers of holes where borers had bred and where swarms of the beetles were supposed to have issued in past times. Some of the larger limbs and a portion of the tree broke off, apparently the consequence of the ravages of this insect. This pest has been very injurious to the European linden at Cambridge Mass., and Professor Webster has recorded it as damaging young lindens in nursery rows.

Life history. The beetles appear toward the end of the summer (we have taken them in August) and feed on the bark and the leaf petioles and also the larger veins on the under side of the leaves and on the green bark of the growing shoots, often killing the tips of the branches. When the beetles are very abundant, the injury caused by them is quite noticeable. Professor Smith has observed this beetle abroad in New Jersey during July, and Dr Packard states that one female may contain as many as 90 eggs. A female is said to deposit her eggs, two or three in a place, on the trunk and branches, specially about the forks, making slight incisions and punctures for their reception with her strong jaws. The larvae undermine the bark for a distance of 6 or 8 inches from the place where they hatch and often penetrate the wood to an equal extent, as stated by Dr Packard, who adds that this insect works at the base of young lindens, gouging two parallel rings around the trunk and forming annular swellings. We have observed the work of this species and seldom found it more than 12 inches above the ground; and in our experience it occurs very largely in exposed roots and subterranean parts, though Mr D. B. Young states that he has taken this beetle from galleries in the lower limbs of a large

tree. The method of work is shown on plate 5, figure 1, which represents the broad galleries of the larva and the exit hole of the beetle. Our observations are confirmed by Professor Webster, who also states that the pupal cell is made at about the level of the ground and is cut diagonally across the grain of the wood and at an angle of about 45° to the channel the larva makes when ascending to this level.

Food plants. Linden is the greatest sufferer from the ravages of this insect, though it has been recorded by Dr Packard as infesting poplar, as occurring on ? elm by Riley and Howard, and Rev. J. L. Zabriskie has taken the insect from appletrees. It is doubtful, in our judgment, if the insect breeds in other than the various lindens.

Description [pl. 5, fig. 5]. Black, covered by a dense olivaceous pubescence, usually with three denuded spots on each elytron, two placed obliquely above the middle and one below. One or all of these spots may occasionally be wanting.

Distribution. This insect has been recorded from localities as follows: Lake Michigan [Say]; rare in Massachusetts [Harris]; very abundant in Lancaster county, Pa. [Rathvon]; Middle and Western states [LeConte]; Amherstburg Ont. [E. B. Reed]; Buffalo [Zesch-Reinecke]; L' Original and Grenville Can. [Harrington]; rather common in New Jersey [Smith]; not rare on linden in southwestern Pennsylvania [Hamilton]; very common [Provancher]; Canada, Vermont, New Hampshire, Massachusetts, New York, Pennsylvania, Michigan, Wisconsin, Iowa, Illinois, Ohio, New Jersey [Leng-Hamilton]. We have also seen specimens from Missouri.

Natural enemies. Two enemies have been bred from this species, one, Bracon pectinator Say? from the insect in ? elm and another, B. charus Riley, which is given by Dr Packard on the authority of Riley's unpublished notes, and, as no food plant is given, it is possible that the latter is but a different name for the insect previously mentioned.

Remedies. It is manifestly impossible to attempt to control this insect on other than valuable trees, and in such situations, digging

out the borers, with possibly recourse to the use of repellent washes described on page 29, is about all that can be done and in the majority of instances should afford considerable protection.

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Saperda imitans n. sp.

This interesting species resembles our common elm borer, S. tridentata, with which it has frequently been confused. The junior author bred this insect some years ago from wood collected near the city of New York, but he did not notice that it was distinct from our common elm borer till too late to examine its workings. He had no elm in the breeding cage at the time, and so presumes that it lived in hickory, of which he had a quantity.

Description [pl. 3, fig. 4]. Black, densely covered with a gray pubescence, whiter below. Thorax: twin black spots below a lateral orange red band, extending on the head to the eyes, where it joins the line of the opposite side; median line light. Elytra: submarginal band of orange red running to the apex, from which arise three crossbars of the same color, each obliquely inclined toward the suture, the middle band usually not connected to the submarginal, the apical band usually rudimentary and then only transverse; apex rounded.

Types in collection of L. H. Joutel and New York State collection.

This insect is often mistaken for tridentata, but can be easily separated by the following characters, which show it to be

distinct and not even closely related. It is longer in proportion to its width than tridentata. The sides are parallel, while in tridentata the humeral angle is quite pronounced. The first crossbar is oblique, there are no spots on each side of it, and the spot is also lacking behind the apical crossbar; it also wants the submarginal carina present in tridentata, which has the first crossbar at right angles. The pygidium of the female is broader at the top, and the sides make a wider angle than that of tridentata.

Distribution. This species has been received from Montreal Can.; and Mr Fred Blanchard has taken a specimen at Tyngsboro Mass. Mr Roland Haywood has taken it near Boston; specimens have been seen from Virginia, Michigan, Pennsylvania and Wisconsin; and we have bred it from New York city and vicinity.

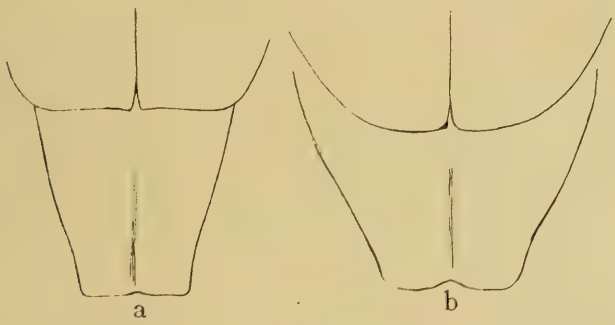

Fig. 5 Last dorsal segment and apex of elytra of S. tridentata (*a*) and S. imitans (*b*)

Saperda lateralis Fabr.

Red-edged Saperda

This species is about the same size as S. tridentata Oliv. and like it occurs in elm. Its principal food plant is hickory, on which it is partial to injuries near the roots and to the base of sprouts on recently cleared lands. It is rarely abundant enough, however, to cause serious injury.

Life history. Comparatively little has been published concerning the life history of this species. The beetles may be taken in June in northern localities, and, like most other Saperdas,

feed on the bark and petioles of the leaves at the ends of the shoots. Mr Tolman found them pairing in June on a fallen hickory near Philadelphia. We have bred this species from hickory stems in which the larvae lived at the juncture of the dead and living bark. Mr S. T. Kemp records the fact that he found the larvae of this species inhabiting the base of dead shoots of hickory, and, on breaking off the shoots, the borers were almost entirely exposed, sometimes falling to the ground. The infested shoots were invariably those which had been broken off 3 or 4 feet above the ground by the larvae of Elaphidion villosum Fabr. the previous season. The grubs of these work at the very base of the tree and burrow almost laterally and slightly upward. In addition to food plants mentioned above, Dr Packard records breeding the species from alder, but this appears to be exceptional.

Description [pl. 7, fig. 8]. Black, sometimes brownish black, coarsely punctured and covered with brownish black pubescence above and gray below. Antennae black; thorax with two black spots below, a lateral orange red band that extends on the head to the eyes and joins at the apex; the elytra have a submarginal band that connects with the thoracic one at the humeral angle and at the rounded apex joins a sutural band, which is sometimes wanting. This species is remarkable in that the male possesses a tooth or process on all its claws.

Connecta n. var. [pl. 7, fig. 9]. Like the species in color but lacks the sutural line; the submarginal band extends to the margin; and it has three oblique lines on the elytra, the apical one rudimentary and the middle one broad. Dr Fitch has described two varieties, abbreviata and suturalis, which are characterized simply on the width of the sutural and submarginal stripe. Types in the collection of L. H. Joutel.

The variety connecta is connected with the species by intermediate forms in all stages of development, from those that have a slight mark at the marginal band or at the sutural one or both, to those that have the two bands in various stages of development [fig. 6].

Like imitans, this variety has been confused with tridentata, which it somewhat resembles. It can be easily separated from that species and imitans by the punctures, the brownish black pubescence above, the shape of the elytra and the rounded head. This form occurs with the type and is more common westward.

Distribution. This insect has been recorded from the following localities: Cliftondale Mass. [Henshaw], Buffalo N. Y. [Zesch-Reinecke], Philadelphia Pa. [Tolman], Hull and Ottawa Can. [Harrington], Montreal Can. [Caulfield], Providence R. I. [Packard]; is not rare in southwestern Pennsylvania [Hamilton]; Canada, Vermont, Massachusetts, New York, Pennsylvania,

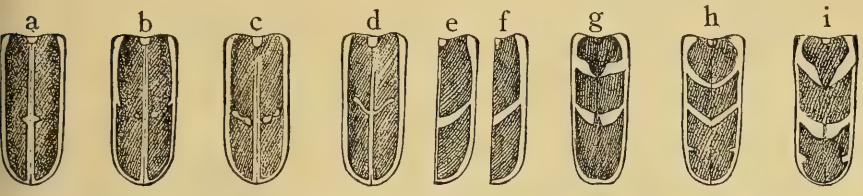

Fig. 6 *h*, *i* S. lateralis var. connecta. *a*-*g* intermediate variations between S. lateralis and var. connecta

New Jersey, Virginia, West Virginia, Ohio, Michigan, Wisconsin, Illinois, Iowa [Leng-Hamilton]. We have taken or bred it from Fort Lee N. J., Bronx park New York city, and Brooklyn N. Y.; it is also found in Nebraska and Massachusetts, and is common in Kansas. The variety connecta is occasionally found in New York and Massachusetts and in numbers in Kansas, Nebraska, Illinois and Wisconsin.

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Saperda fayi Bland.

Thorn limb borer

This species breeds in the small limbs and stems of wild thorn (Crataegus crus-galli and C. tomentosa), creating gall-like, gnarly swellings and weakening the branches so that they sometimes break off in the wind. This insect is widely distributed in New York State, though quite local. It displays a marked fondness for certain trees, in which it will breed year after year while others near by will be practically unaffected. Should this species, like its allies, acquire a taste for our cultivated fruit trees, it would never prove as dangerous an enemy

as the round-headed appletree borer (S. candida Fabr.) as the galls would indicate the injury and could easily be cut off.

Life history. The beetles [pl. 6, fig. 4] appear in New York State during the month of June, the exact date varying according to the season, the males preceding the females by three or four days. They do not appear to eat and are short-lived, while the whole brood, excepting the stragglers, appear and disappear within the space of 10 or 12 days, so that close observation is necessary in order to capture many. The late Dr J. A. Lintner has taken this species June 25 at Schenectady, and Mr Moffat collected beetles at Hamilton Ont. June 15, while Mr Zimmerman records the capture of a female Aug. 15.

The males watch for the appearance of their consorts and pairing usually lasts three or four hours, according to Dr Hamilton. The beetles fly but little and usually oviposit on the tree they inhabited as borers, which explains the local character of the species. The insects are sluggish and, when suddenly approached, drop to the ground and endeavor to conceal themselves. Egg-laying probably occurs during the night, though the process has not been observed. Small limbs, varying in size from $\frac{1}{3}$ to $1\frac{1}{4}$ inches in diameter, are selected for this purpose, and, according to the thickness of the limb, the female uses her mandibles to make from three to six longitudinal insertions through the bark, each being about $\frac{3}{4}$ inch in length, parallel to one another and dividing the circumference of the trunk or limb into nearly equal sections. An egg is deposited in each of these slits, and as soon as hatched the larva at once makes a burrow beneath the outer layer of the wood, perhaps $\frac{1}{8}$ inch in length, and uses this as a retreat from which it issues to feed on the wounded tissue caused by the irritation. These slits and the irritation caused by so much cutting produce an increased flow of sap to the wound and a consequent thickening of the portions between the slits, so that the affected part soon assumes a gall-like appearance.

The work of this species is shown on plate 6, which represents a twig on the lower portion of which are two old galls with irregular, decaying, overgrown cavities [fig. 1], which are quite different from more recent galls [pl. 6, fig. 2]. The borings of

the larva in a young gall are shown in section on plate 7, figure 2, and the manner in which the stem may be eaten by a larva working in its center at figure 2a [*See also* pl. 13].

The larvae are ¼ inch long on the approach of winter, according to Dr Hamilton's observations, when they retire into the wood a little farther and close the opening of their burrows with borings. One of the larvae, and in thick limbs two or three, bore obliquely till one of them reaches the center of the limb, up which it proceeds often two or three inches. The others parallel this gallery but maintain a partition between the burrows. The larvae near the center are much larger, often twice the size of those inhabiting the outer wood, and are the only ones that produce beetles, as stated by Dr Hamilton. In our experience the different sized larvae indicate male and female and unless parasitized all emerge.

We can not entirely agree with the following observations regarding this species also by Dr Hamilton:

The whole of the interior of the limb is now dead wood inclosed by a growth of living but unsound woody tissue, through which some openings remain. Many of the larvae in the outside wood perish during the winter, and the survivors, after feeding a while in the spring, likewise die, their mission seeming to have been merely to insure a sufficiency of dead wood to sustain the life of the favored few destined for full development.

The larvae in the deep wood return in the spring and feed on the dead tissues, which are now abundant enough for all their wants, and by autumn they are nearly full grown. Some of the larvae do not return in the spring of the second year to feed on the dead wood at the entrance of the burrow, but bore directly up and down the center of the limb for a distance of 16 to 24 inches before pupating. Those which feed on the dead wood near the entrance to the wound are nearly full grown by autumn. They again retire for the winter and in the spring, after opening up communication with the outside world, feed for a short time and when full grown measure about ¾ inch in length. They now return to their burrows for the final transformations. Some of

them bore for at least six inches, while others scarcely go from the entrance more than twice their own length. The outer ends of the burrows are closely packed with borings without and soft fibers within, which also fill the inner ends. The head of the larvae may be either toward or away from the opening, seemingly a matter of indifference. In the former case the beetle emerges from the place of entrance and in the latter, from a round hole at right angles to the burrow, probably made by the beetle itself, as no such hole has been detected in the many limbs Dr Hamilton examined, containing pupae with their heads turned from the opening. Pupation occurs after the middle of April. We have found them transforming at Albany Ap. 16. The beetles may be found in the limbs about the first of May, though but few of them emerge till the latter part of the month.

Description [pl. 6, fig. 4]. Cinnamon brown, below gray, white at sides, being of the same color as cretata. Thorax with lateral white band that extends on to the base of the elytra, which also have two crescent-shaped, white spots at middle, divided by the suture, and two smaller circular ones near the apex, also divided by suture. These spots may be nearly or quite obsolete, usually in the male. The antennae darker than cretata.

Distribution. This insect has been recorded from Buffalo N. Y. [Zimmerman]; Hamilton Ont. [Moffat]; and Dr Hamilton reports it as common in Crataegus limbs in southwestern Pennsylvania. The types were described from Ohio; Dr Smith has recorded it from Greenwood Lake and Delaware Gap N. J., and it has been listed by Messrs Leng and Hamilton from Canada, New York, New Jersey, Pennsylvania and Ohio.

This species is not related to cretata, which it resembles in color, but has more of the characters of the less specialized species, as is shown by the short, rounded head and the but slightly developed process on the claws, that on the first pair being very rudimentary. This relationship is further emphasized by its gall-producing larva working in the same way as concolor.

Natural enemies. There are no records of any, but the species appears to be a favorite with some woodpeckers, since we have found a number of empty galls showing the characteristic work of these useful birds [pl. 13, fig. 1]. We have no clue to the identity of the species.

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Saperda puncticollis Say

Woodbine borer

This is one of the smallest and also the prettiest species belonging to this important genus. It is a rare form in most collections in spite of the fact that the insect lives in the dead branches of the common Virginia creeper, pupating in the wood. The manner in which the larva works just under the bark is shown on plate 6, figure 6. The entrance to the pupal chamber is stopped with a plug of borings

[pl. 6, fig. 8, 8a]. The general appearance of the larva is also represented. This species seems to be somewhat retiring in habit, and, while it has been collected on the leaves of its food plant, specimens are much more easily obtained by rearing the insects from infested twigs. We have often bred the species from Virginia creeper and have frequently examined much poison ivy where the insect was abundant, but have been unable to find it in that plant. We have taken it in June and July, and Mr Zimmerman records its capture at Buffalo in June. It is probably abroad during most of the two months.

Food plants. It has been recorded on poison ivy [Zimmerman], grape and probably Virginia creeper [Harrington], Rhus toxicodendron and R. radicans [Smith], as not common on Rhus radicans in southwestern Pennsylvania [Hamilton], as bred from the larger living stems of Virginia creeper [Harrington], and as in the stems of poison ivy and oak [Lugger].

We find that the larvae feed on the inner bark of the branches and stems of Virginia creeper. This species is very subject to attack by woodpeckers, and we have seldom found the workings without evidence that a number had been destroyed by the birds.

Description [pl. 6, fig. 9]. Black, with a sparse black pubescence above and a dense gray one underneath. Head yellow with a round black spot in front and one on the vertex, antennae black; thorax yellow with a black spot at the side and four quadrately arranged on its dorsum; elytra with a broad, yellow marginal and a sutural band. The process is found only on the anterior claws of the middle pair of legs.

Distribution. It was described by Say from Arkansas; it has been taken about Buffalo by Zimmerman; about Ottawa Can. by Harrington; is reported by Smith as occurring throughout New Jersey; and by Hamilton as not common in southwestern Pennsylvania. LeConte gives its distribution as the Middle, Eastern and Western states; and Leng and Hamilton record it from the following localities: Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Louisiana, Arkansas, Kansas, Nebraska.

We have bred it from stems of Virginia creeper gathered in and around New York city and also at Fort Lee N. J. It was described from Cambridge Mass. as S. trigeminata by Randall.

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Saperda populnea Linn.

This European species is found on the Pacific coast, and the examples from different localities now before us can not be distinguished in any particular from European specimens. With this species we include as subspecies the S. moesta of LeConte and a new form that differs from either, under the name tulari.

They differ from populnea as well as from each other in the punctures on the elytra as well as in the punctulations on

the intervals, also in color and vestiture, and while some specimens come very close to each other, we have seen no intergrades of color and vestiture. Tulari in character seems to us to be intermediate between moesta and concolor.

It may be well at this point to remember that our species have originated in the East, where all are found except two, populnea and hornii. Of these, populnea has not specialized from the Old World form, as has hornii, which is evidently descended from and is still closely related to similis. Calcarata is the only one of our species that extends to the west coast, where it has been found by Professor Piper in Washington.

Bearing this in mind and remembering that moesta, as a

Fig. 7 Elytral characters of females: *a* tulari, punctures scattered; *b* moesta, punctures contiguous; *c* populnea, punctures confluent

unicolorous form, as we know it in the East, has not crossed the Sierras and has not yet been found on the coast, there can be no question of its being distinct.

Tulari, like moesta, is evidently of American origin and not an emigrant from the Old World. The punctures and dense punctulations in the elytra show a wider divergence from populnea than moesta and connect that species and moesta with concolor.

Description S. populnea Linn. [pl. 7, fig. 4]. Black, shining, coarsely and deeply punctured, the punctures often contiguous and confluent on the elytra; a few punctulations which are sometimes wanting occurring between the punctures; sparsely covered with a light gray or fulvous pubescence; thorax with a lateral band of dense fulvous or yellowish gray hairs; elytra

with eight small spots of dense fulvous or yellowish hair, arranged in pairs, the first and third nearer the suture, the third pair being the largest; one or more pairs often obsolete, the third pair being the most permanent; antennae black, annulated with gray, first joint black.

S. moesta Lec. like populnea; but the vestiture is a uniform light gray without spots, and the lateral line on the thorax only faintly shown.

The punctulations on the intervals between the punctures are more numerous than in populnea.

S. tulari n. subsp. [pl. 7, fig. 6] like populnea and moesta; but the punctures, which are larger and deeper and usually with an edge, are not so numerous as in the other two species and seldom confluent; the intervals are densely punctulate as in concolor. It is densely covered with red or fulvous hair. Thorax with a stripe on side and a median band on top. Types in collection of L. H. Joutel and National Museum, Washington.

The above discriptions apply more particularly to the females.

Distribution. S. populnea, moesta and tulari. With the material before us, it may be well to revise the distribution of these species, which have been confused. As stated, moesta does not occur on the Pacific coast and so must be dropped from the lists of that section.

S. populnea. Well marked examples have been seen from Washington, Oregon, California, Spokane Wash. and Los Angeles county, Cal. In Europe it feeds in poplar and willow stems forming galls.

S. moesta. Canada to Wyoming, Idaho, Montana, Colorado, New York, Wisconsin, Pennsylvania, Buffalo, Montreal, Toronto, Lake Superior. It feeds in balsam poplar. Moesta has never been found in the vicinity of New York city to our knowledge; and the one from Staten Island cited by Smith in *Insects of New Jersey*, was probably concolor.

S. tulari. Tulare county, Cal., Yosemite Cal., Arizona, Nevada, Oregon, Washington.

Saperda moesta Lec.

This insect [pl. 7, fig. 5] confines its operations to the balsam poplar or balm of Gilead so far as known, and occasionally it is quite injurious to this tree.[1]

Life history. The beetles appear in June. Two sizes of larvae in gall-like swellings from 1 to 2 inches apart and in shoots about ½ inch in diameter were found by Mr Harrington in June. The late Dr D. S. Kellicott bred Sciapteron tricincta Harr. from enlargements in the branches and stems of the balm of Gilead and the common willow[2] which were caused by this species and its associate, Saperda concolor. Mr Saunders states that he received a bundle of balm of Gilead twigs on Mar. 25 which were infested with this insect. The larvae were very thickly set in the branches, in many places not more than an inch or two apart, and located chiefly at the base of the buds, where the presence of the occupant was indicated by a swelling in the branch which was surmounted by a dark brown patch of partly decayed bark. The castings and debris of the borer were of a light orange color and were pushed forward, stuffing the swollen part. The whole length of the excavation made by each larva did not usually exceed an inch, and so much of this was filled with debris that the clear space left was very little larger than its body. Mr Saunders describes the larvae as follows:

Body above deep yellow, with a glossy surface, sprinkled with very minute, short yellow hairs, invisible without a lens. Second segment above and below a little deeper in color and more horny looking than the other segments; interspaces between segments strongly indented. There was a depressed dorsal line not different in color from the rest of the body, but sunken, and on each side of it the projecting rings of the body were somewhat flattened. Spiracles pale brown, rather small. Terminal segment a little more hairy than the others.

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[1] Mr Charles Stevensen, of Montreal, kindly sent us some fresh galls of Saperda moesta, from which the illustrations were made and a number of specimens reared.

[2] Moesta probably caused the galls in balm of Gilead, and concolor those in the willow.

The bunch of twigs received Mar. 25, as above stated, were examined by Mr Saunders May 2, when he found that no pupal inclosure was to be seen, though the head, antennae and legs of the beetle were fully developed, while the wings and wing cases were only partially so. On May 16 the wing cases of one beetle were full length but not fully expanded, while in another case they were fully developed. The twigs containing these insects had been kept in a dry room and hence they were quite dry and brittle. Fresh twigs received May 24 showed that a considerable number of the occupants had been eaten by woodpeckers, though some five or six specimens were found in pupal cells, one of which was occupied by the pupa of a parasite. The pupa of this Saperda has been described by Mr Saunders as follows:

Body semitransparent; color uniform pale yellow, except the eyes and mandibles, which were black; the jaws were faintly tipped with brown and a faint brown line down each side of the scutellum. All the parts of the insect were plainly visible throughout the pupal case. The wings were very small and diverged to each side of the scutellum.

May 29 two of the pupae from the fresh lot of twigs had become perfect beetles, and early in June all had completed their transformations and escaped through neat round holes.

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[1]This also comprises what was formerly referred to moesta and includes populnea and tulari.

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Saperda concolor Lec.

This species, which requires but one year to complete its transformations, so far as our observations go, girdles the trunks of sapling poplars by running a mine around them, which causes a swelling often nearly twice the size of the diameter of the tree, as described by Dr Packard. It infests dwarf willow canes as stated by Dr Hamilton; and the following is from his account of the insect.

Life history. The beetles appear from the last week in May till after the middle of June. The smaller canes, ¼ to ¾ inch in diameter, of Salix longifolia growing along water courses are usually selected by this insect for breeding places. The beetle gnaws a longitudinal incision through the bark, about ¾ inch in length, and deposits an egg in each end. Several are usually made in the same cane some distance apart and these often cause its death the following year. A warty, gnarly swelling occurs around each incision [pl. 6, fig. 14]. The young larvae [pl. 6, fig. 12, 13] follow the same course as those of S. fayi, only they burrow deeper into the wood, and there are no supernumeraries, as there is no need of them, since the wood of the willow dies much more quickly than that of Crataegus.

The beetle, however, does not always select the smaller canes for oviposition, sometimes choosing those from 1½ to 2 inches in diameter, when the larvae pursue a different course, for, instead of boring up and down, they take a transverse direction and girdle the stem ⅓ to ½ its circumference, causing a rough annular swelling and frequently killing the cane.

The head of the pupa is toward the opening from which the perfect insect emerges. Salix concolor appears to be its natural food, and, did this beetle confine its attention to this shrub, it could hardly be classed as injurious; but in the vicinity of Providence R. I., at least, it has inflicted considerable damage on the common poplar. Two parasites, Pimpla pedalis and a species of Bracon, have been reared from the galls of this insect by Professor Davis.

Description. Black, finely punctulate, and with numerous small, shallow punctures; entirely covered by a dense gray or yellowish gray pubescence except at the top of the thorax, where it is less dense, this giving it a darker appearance and increasing the effect of the lateral band; a slight median line on the thorax; antennae black, annulated with gray. Var. unicolor n. var. [pl. 6, fig. 15]. Like type, but pubescence uniformly dark gray and finer. The punctures are much more numerous than the type and are apt to be confluent. This variety is the eastern form and is named as we believe it to be the ancestral form of the species.[1]

Distribution. This insect has been thus recorded: Sante Fe N. M. [LeConte], Cliftondale Mass. [Henshaw], Buffalo [Zesch-Reinecke], Providence R. I. [Packard], Allegheny Pa., Texas, Michigan, Canada and New York [Hamilton], New Jersey [Smith], Ohio [Kellicott]; rare [Provancher], Canada, Massachusetts, New York, New Jersey, Pennsylvania, Michigan, New Mexico [Leng–Hamilton] Arizona.

[1]This insect is often confused in collections with moesta and Mecas inornata. The type form is from New Mexico, and the same form has been received from Arizona. Var. concolor is from the other localities above and also from Idaho, from which an intermediate form has been received. There is no question of their being forms of one species, the change being due entirely to climatic influences. It is very close to tulari.

Remedies. Dr Lugger advises the use of a soft soap and paris green wash as a preventive of oviposition. He states that the presence of the larvae is also easily discovered by the discolored blotch on the bark and by the little heaps of sawdust that are pushed out by them during their boring operations.

The grubs may be killed by means of a wire or with a pruning knife.

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EXPLANATION OF PLATES[1]

PLATE 1

Saperda candida

Appletree borer

1 Beetle at rest on the bark
2 Scar indicating the presence of a young grub beneath and also showing a characteristic oviposition slit
3 Sawdust or borings ejected by half or two thirds grown larva. This is usually found very close to the base of the tree.
4 Exit hole of the beetle, in section
5 Borer or grub preparing its pupal chamber
6 Pupal chamber with exit hole of beetle shown at 7
8 Blackened old burrow seen in trees attacked a year or two earlier

PLATE 2

Saperda calcarata

Poplar borer

1 Beetle at rest on the bark
2 Pupa in its chamber, and below it a mass of long fibrous tissues, partly torn from the sides of the burrow
3 Larva or borer in its gallery. This illustration shows the expanded character of the burrow near the orifice through which the larva ejects its numerous borings. The blackened appearance of old galleries is also represented, as well as their occurrence at different depths in the wood.

[1] Executed from nature by the junior author, L. H. Joutel, New York.

PLATE 3

1 Portion of elm bark illustrating the work of the larva of the elm borer, Saperda tridentata. It will be seen that many of the borings are in dead tissues, and that a few extend into the living bark, which apparently gradually dies and permits the insect to extend its operations over a considerable area.

2 Piece of hickory bark illustrating the work of the larva of S. discoidea. The white sawdust excavated from a pupal chamber made in the wood is shown at *a*, and a pupal chamber in the bark is represented at *b*.

3 S. tridentata

4 S. imitans

5 S. discoidea, female

6 S. discoidea, male

PLATE 4

Saperda cretata and **concolor**

Spotted appletree and *willow borers*

1 Work of S. cretata in thorn, showing the irregular character of its galleries, and the different depths at which they occur

2 Adult beetle

3 S. concolor, enlarged

4 Work of this species or possibly S. tulari in Arizona willow. This illustration represents the peculiar gall, the general form of the galleries and pupal cell, with the exit hole in section.

PLATE 5

Saperda vestita and **obliqua**

Linden and *alder borers*

1 Portion of the base of a linden, showing the work of the larva of S. vestita, and at *a* the circular exit hole of the adult

2 A small alder stem, showing the enlargement produced by the larva of S. obliqua a year after the stem had been deserted

3 An alder stem showing the external appearance, indicating recent operations of the larva of S. obliqua and at *b* the pupal cell with the mass of borings blocking one end

4 Section of alder stem showing the method of work of the larva of S. obliqua

5 S. vestita, female

6 S. obliqua

PLATE 6

Saperda fayi

Thorn borer

A Branch of the thorntree showing the galls and work of this species

1 An old gall with a larger one just below it

2 Section of a fresh gall showing the work of the larva

2a Borings in the stem

3 Exit hole of the beetle in section

4 Adult, enlarged

Saperda puncticollis

Virginia creeper borer

B Portion of Virginia creeper, representing the galls and work of this species

5 Section of the stem, showing the pupal chamber

6 Larva at work under the bark

7 Exit hole in section

7a Exit hole

8 Section of thin bark and sawdust stopper closing opening to pupal chamber

8a Same shown in a surface view

9 Beetle, enlarged

Saperda concolor var. **unicolor**

Willow borer

C Branch of poplar, showing the galls and work of this insect

11 Fresh galls and exit holes of beetles

12 Fresh gall cut open and showing the pupal cells: one empty, one occupied, and one extending up and the other down

13 Section of old gall showing the internal appearance of the tissues

14 External appearance of old galls

15 Beetle, enlarged

PLATE 7

1 Saperda calcarata var. adspersa
2 S. mutica
3 S. hornii
4 S. populnea, enlarged
5 S. moesta. The long line at its side shows the average length of Idaho specimens, the short one, that of New York, Canadian, and west of Wisconsin to Michigan specimens.
6 S. tulari, enlarged
7 Galls of S. moesta
   A Young gall shows wound caused by female
   B Exit hole
8 S. lateralis, enlarged
9 S. lateralis var. connecta, enlarged
10 Galls of S. moesta, with one cut open showing the pupal chamber
   A Oviposition scar
   B Exit hole of the beetle

PLATE 8

Early work of **Saperda candida**

Appletree borer

1 Oviposition scars made by the female
2 Borings or frass thrown out by young grubs working under the bark
3 Bark cut away, showing the young larva in its gallery and its method of work
4 Scar showing old, overgrown exit hole
5 Upper portion of the wound caused by the insect, which emerged several years before at 4

The number of grubs in this small stem, which is only about 1¼ inches in diameter, is sufficient to kill a tree.

PLATE 9

Advanced work of **Saperda candida**

Appletree borer

This represents the appearance in section and lower portion of a very badly infested stem of a young tree, and shows

that it may be practically riddled before death ensues. The exit holes seen in the upper portion are by no means unusually abundant and such severe injury is certain to result in the death of the tree.

PLATE 10

Advanced work of **Saperda candida**

Appletree borer

1 Base of two year old tree killed by borers

2 Young tree entirely girdled by two borers, showing two exit holes, and at *A* the only connection with the root

3 Young tree killed by borers: *AA* shows the only connection with the root and *B* is a bare area which the tree has tried to cover with living tissue.

PLATE 11

Early work of **Saperda calcarata**

Poplar borer

1 This represents the early galleries and illustrates how a few larvae can easily girdle a young tree, because of their running a portion of their burrows transversely in the inner bark and outer sapwood.

2 Advanced work of S. tridentata, elm borer

PLATE 12

Advanced work of **Saperda calcarata**

Poplar borer

This illustration shows the irregular character of the galleries, the closed pupal cells with the coarse fibers stopping the free end, and the expanded character of the burrows about the exit.

PLATE 13

Saperda fayi

1 Gall in thorn branch, also holes made by woodpeckers searching for grubs

2 Typical, fully developed gall

PLATE 14

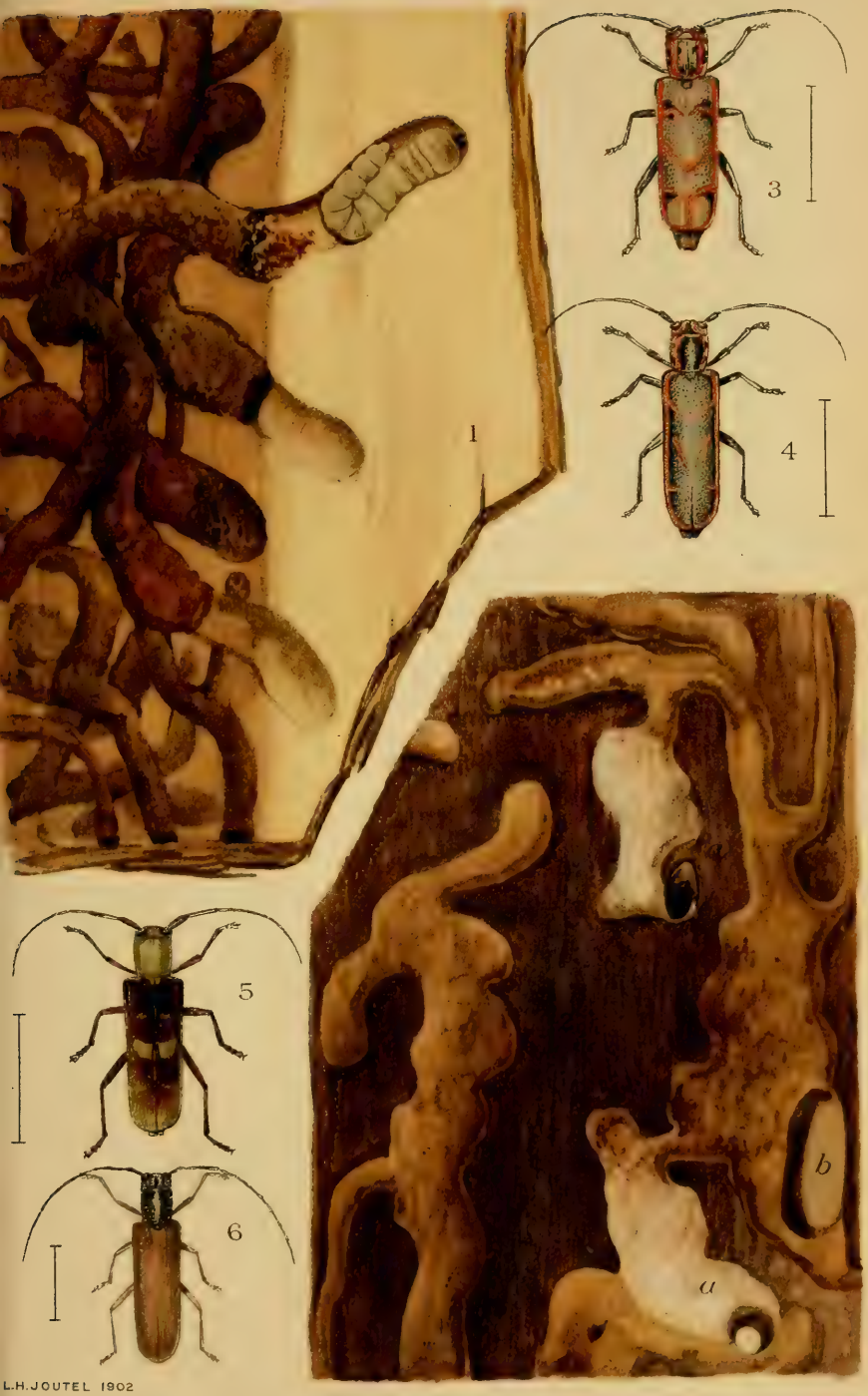
Holes of woodpeckers in alder, made in search of the larvae of Saperda obliqua

L.H.JOUTEL 1902

Saperda candida, appletree borer

L.H. JOUTEL 1902

Saperda calcarata, poplar borer



Saperda tridentata, imitans and discoidea
Elm and hickory borers

L.H.JOUTEL 1902

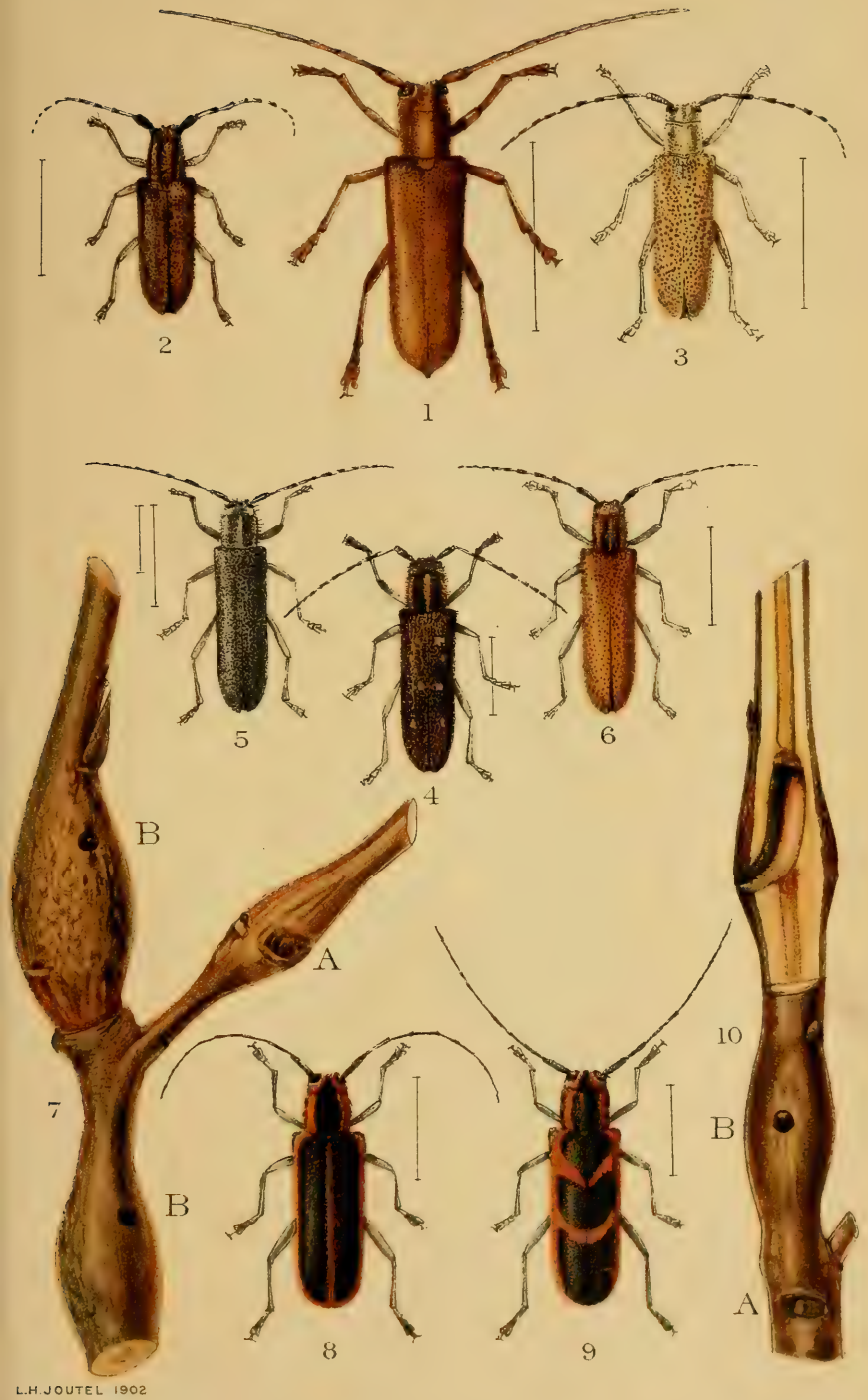
Saperda cretata and concolor
Spotted appletree and willow borers

L.H. JOUTEL 1902

Saperda vestita and obliqua
Linden and alder borers

L.H.JOUTEL 1902

Saperda fayi, puncticollis and concolor
Thorn, virginia creeper and willow borers



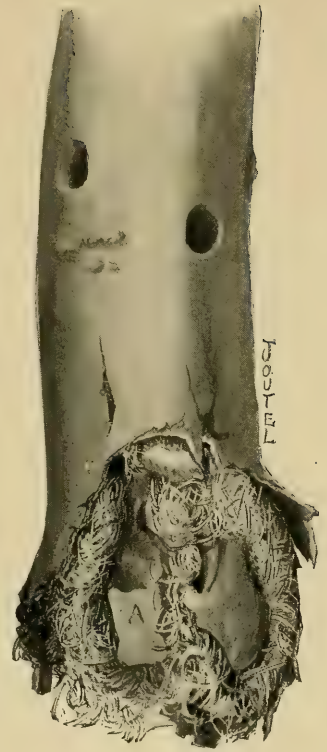
L.H.JOUTEL 1902

Saperdas

Early work of Saperda candida, appletree borer

Advanced work of Saperda candida, appletree borer

1

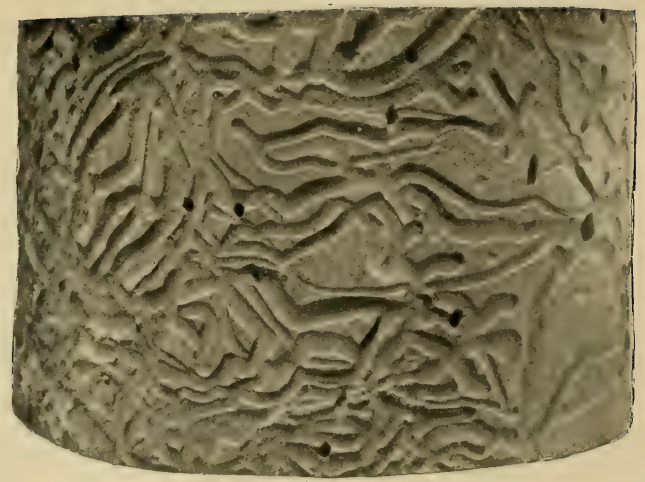


2

3

Advanced work of Saperda candida, appletree borer, at base of young trees

1



2

1 Early work of Saperda calcarata, popular borer; 2 Advanced work of Saperda tridentata, elm borer

Advanced work of Saperda calcarata, poplar borer

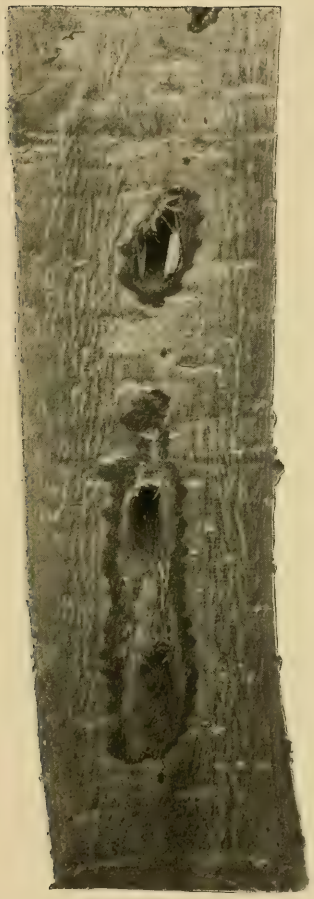
Plate 13

1

2

Woodpecker work and galls of Saperda fayi, in thorn

Plate 14



Woodpecker work in alder stem bored by *Saperda obliqua*

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New York State Museum

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The annual reports of the early natural history survey, 1837-41 are out of print.

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Botanist's annual reports 1867-date.

Bound also with museum reports 21-date of which they form a part; the first botanist's report appeared in the 21st museum report and is numbered 21. Reports 21-24, 29, 31-41 were not published separately.

Separate reports 25-28, 30, 42-50 and 52 (Botany bulletin 3), are out of print. Report 51 may be had for 40c; 53 for 20c; 54 for 50c. Since the 55th these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have been published in volumes 1 and 3 of the 48th museum report and in volume 1 of the 49th, 51st, 52d, 54th and 55th reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum memoir 4.

Museum bulletins 1887-date. O. *To advance subscribers, $2 a year or 50c a year for those of any one division:* (1) *geology, economic geology, mineralogy, general zoology, archeology and miscellaneous,* (2) *paleontology,* (3) *botany,* (4) *entomology.*

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	20–25	52, v. 1	35–36	54, v. 2
16–17	50 "	26–31	53 "	37–44	" v. 3
18–19	51 "	32–34	54 "	45–48	" v. 4
				49–54	55, v. 1

The figures in parenthesis indicate the bulletin's number as a New York State Museum bulletin.

Geology. G1 (14) Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co. N. Y., with notes on the iron mines. 38p. 7pl. 2 maps. Sep. 1895. *10c.*

G2 (19) Merrill, F: J. H. Guide to the Study of the Geological Collections of the New York State Museum. 162p. 119pl. map. Nov. 1898. [*50c*] *New edition in preparation.*

G3 (21) Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sep. 1898. *5c.*

G4 (48) Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 9pl. map. Dec. 1901. *25c.*

G5 (56) Merrill, F: J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Oct. 1902. *10c.*

G6 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. *In press.*

——— Crystalline Rocks of the Northeastern Adirondacks. *In press.*

Kemp, J. F. Crystalline Rocks of Warren and Washington Counties. *In preparation.*

Woodworth, J. B. Glacial Geology of New York. *In preparation.*

Economic geology. Eg1 (3) Smock, J: C. Building Stone in the State of New York. 152p. Mar. 1888. *Out of print.*

Eg2 (7) —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 6+70p. map. June 1889. *Out of print.*

Eg3 (10) —— Building Stone in New York. 210p. map, tab. Sep. 1890. *40c.*

Eg4 (11) Merrill, F: J. H. Salt and Gypsum Industries of New York. 92p. 12pl. 2 maps, 11 tab. Ap. 1893. *40c.*

Eg5 (12) Ries, Heinrich. Clay Industries of New York. 174p. 2pl. map. Mar. 1895. *30c.*

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Eg9 (35) Ries, Heinrich. Clays of New York; their Properties and Uses. 456p. 140pl. map. June 1900. *$1, cloth.*

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Paleontology. Pa1 (34) Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C: S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 10pl. map. May 1900. *15c.*

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