SB

945

B478

UC-NRLF

SB 79 225

THE PAINTED HICKORY BORER

by

E.H. Dusham

Cornell Univ. Ag. Exp. Sta. Bulletin 407
August 1921

YC 69414

Agric. - Forestry. Main Library

AUGUST, 1921

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

THE PAINTED HICKORY BORER

E. H. DUSHAM

11

ITHACA, NEW YORK
PUBLISHED BY THE UNIVERSITY

UNIVERSITY OF
MICHIGAN

SB945
B4D8

Vol. 1. Forestry. Main Library

CONTENTS

Classification, history, and synonymy	180
Distribution	181
Food plants	182
Economic importance	184
Descriptions	186
The adult	186
The egg	187
The larva	187
The pupa	188
Life history and habits	188
The adult	188
Appearance of the adults	188
General activities	188
Feeding habits	189
Mating habits	190
Oviposition	190
The egg	191
Time of hatching	191
The larva	192
Activities of the newly hatched larva	192
Larval burrows	192
The pupal cell	193
The prepupal stage	194
The pupa	194
Pupation	194
Activities of the pupa	194
Transformation to adults	195
Seasonal history	195
Natural enemies	195
Recommendations for control and prevention of injury	196
Bibliography	198

THE PAINTED HICKORY BORER

Cyllene caryae Gahan

Order, *Coleoptera*

Family, *Cerambycidae*

E. H. DUSHAM

The hickory is one of the most important of our American hardwoods, not only on account of its fruit, but especially because of the valuable qualities of its wood. "Tough as hickory" is not only a familiar expression but an apt phrase as well, for its wood is heavy, hard, strong, and exceedingly tough. It is on account of these qualities that, more than any other wood, hickory is used in the manufacture of such commodities as are subject to excessive strain. Consequently, more than one-half of the hickory cut today is used in the construction of vehicles or their parts, and at least one-third is made into handles for articles in which strength and toughness are the main considerations. In addition to these, agricultural implements consume three per cent of the entire cut, while the remaining five per cent is used in the manufacture of athletic goods, porch furniture, and various other commodities. The factory uses of hickory as given by Kellogg (1914)¹, may be summarized in percentage as follows:

Vehicles.....	61
Handles.....	31
Agricultural implements.....	3
Sporting and athletic goods.....	1
Other uses.....	4

Like most other trees, the hickory is subject to various insect injuries which reduce the amount of timber suitable for manufacturing purposes. It harbors a large host of different pests, some attacking the foliage, fruit, and wood of living trees; others the wood of recently dead and felled trees, sawlogs, handles, poles, and other unseasoned products from which the bark has not been removed; while still others inflict serious injury on the sapwood, even after seasoning, causing what is commonly known as the "powder post" injury.

Prominent among the insects of the second category is the painted hickory borer, *Cyllene caryae* Gahan.

CLASSIFICATION, HISTORY, AND SYNONYMY

The painted hickory borer belongs to the order Coleoptera, suborder Phytophaga, family Cerambycidae, and subfamily Cerambycinae. The

¹Dates in parentheses refer to *Bibliography*, pages 198 to 203.

family Cerambycidae includes medium- to large-sized beetles, of graceful form, and, in most cases, with very long antennae, whence the common name Longicorns; or long-horned beetles. For the most part their larvae are wood borers, some of the most important enemies of our forest and shade trees being found among their number.

The genus *Cyllene*, to which this species belongs, together with several other groups now ranking as distinct genera, was formerly included in the old genus *Clytus*. Because of definite, well-marked characters, Newman (1840) described it as a distinct genus as follows:

Facies Clyti: caput parvum, ferè pronum, antennae maris corpore longiores, feminae valdè breviores, 11-articulatae; articulis externis manifestò crassioribus, 3-6 apice spinâ brevi armatis: prothorax latus, dorso convexus, lateribus rotundatis dente postico armatis: elytra convexa, apice 1-spinosa: pedes simplices.

Cyll. spinifera. Fusca, obscura, lanuginosa: prothorax maculis duabus glabris ornatus: antennarum articuli basi cinerei: elytra fusca, maculis fasciisve lanuginosis cinereis ornata. (Corp. long. .7 unc. lat. .225 unc.)

Inhabits South America. Specimens taken by Mr. Darwin are in the cabinet of the Entomological Society. I find no description of this insect in Serville's "Nouvelle Classification", but it is by no means uncommon in collections: it bears as close a resemblance to *Clytus*, as *Phacodes* to *Callidium*.

This genus includes about thirty-five species, all of them inhabitants of the new world. Their distribution is shown in table 1.

TABLE 1. THE DISTRIBUTION OF THE SPECIES OF CYLLENE

Place	Num- ber of species	Place	Num- ber of species	Place	Num- ber of species
Brazil.....	13	Argentina.....	3	Patagonia.....	1
Mexico.....	5	United States...	11	Bolivia.....	1
Chile.....	2	Venezuela.....	3	Nicaragua.....	1
Costa Rica.....	1	Honduras.....	1	Panama.....	2
Hawaiian Islands..	1	Cuba.....	1	Guatemala.....	1
Paraguay.....	2	Canada.....	2		

Much confusion has existed regarding the identity of the species in question. The earliest writers confounded it with the locust borer (*Cyllene robiniae* Forster), it being then the common supposition that the latter species had two broods annually, the first emerging in spring and attacking the hickory, and the second emerging in late summer and attacking the locust. Not only were the insects confused, but, until quite recently, the hickory species itself was incorrectly named, being known as *Cyllene pictus* Drury, a synonym of *Cyllene robiniae* Forster. Consequently Gaylord (1843), Harris (1862), and other writers mentioned this species as being found on goldenrod in late summer, and attacking the locust, while Fitch (1859) and Rathvon (1860) stated that the locust

borer (*Clytus robiniae*) was a common borer in the trunks and limbs of black walnut, and was also quite destructive to hickory hop poles and firewood.

Kirkpatrick (1856) seems to have been the first to realize that the locust and hickory borers were two distinct species. He stated that two species of *Clytus* were found in Ohio, one the locust borer and the other the hickory borer. Furthermore, he said that *Clytus pictus* was found only in hickory wood, where it generally bored parallel with the grain, causing powder post. He gave brief data concerning the time of pupation and the emergence of the adult. However, he says that he never found the adult depositing eggs in wood cut more than a year, even when it had no other wood in which to deposit the eggs.

Horn (1863), referring to the hickory borer under the name *Arhopalus pictus* Drury, described the character of the larval galleries in hickory wood.

The next reference to the hickory borer was made by Walsh (1864). Discussing the spread of the locust borer westward, he mentioned that as much as six years previous to the arrival of that insect he had split an adult male *Clytus pictus* out of a stick of hickory in Rock Island, Illinois, and that in the course of the next two or three years, he had found two more specimens in the same neighborhood. He believed this was proof that the locust and hickory species were distinct, for the hickory species had evidently been in existence in Illinois all the time, but had fed on hickory and walnut quite unnoticed until the arrival of the locust borer. He also added that Professor Sheldon, of Davenport, Iowa, had told him that for many years back he had repeatedly discovered *Clytus pictus* in hickory wood, and that, so far as he was aware, the locusts of Davenport had not been attacked by this insect.

Later, Walsh (1864) definitely showed, by anatomical characters, that the locust and the hickory species were distinct. In studying the adults of both species, he found that there were quite remarkable differences in the males, but none in the females. These differences in the males he tabulated as follows:

Hickory feeding ♀

1. Antennae, when relaxed and laid close and straight along the back, reaching beyond the tip of the elytra by the whole length of the terminal joint (11).

2. Antennae from $\frac{1}{2}$ more robust to twice as robust, especially towards the base.

Locust feeding ♀

1. Antennae, when relaxed and laid close and straight along the back even in the specimen which has the longest ones, not attaining the tip of the elytra by a space equal in length to the two terminal joints (10 and 11).

2. Antennae much less robust, except the few last joints, and less tapered from base to tip.

Hickory feeding ♂

3. Terminal or 11th joint of antennae full $\frac{1}{2}$ longer than the penultimate, and composed of two portions connected by an indistinct connate suture foreshadowing a 12th joint, (as in *Purpuricenus* ♂ and in *Tragidion annulatum* ♂ Lec.,) which suture is more distinct on the inferior surface. The basal portion of the 11th joint as long as joint 10, the terminal portion, which is suddenly slenderer from base to tip, more than $\frac{1}{2}$ as long as joint 10.

4. Elytra widened at base and tapered towards their tip, so that the two together just before the extreme tip equal the basal width of one of them.

5. The 2nd or W-shaped band on the elytra in two of the Philadelphia specimens and the Illinois specimen whitish, in the other Philadelphia specimen centrally whitish, but decidedly varied with yellow on the two exterior arms of the W.

6. Legs proportionally $\frac{1}{3}$ - $\frac{1}{2}$ longer and stouter than in ♀.

The ♀ antennae are exactly alike, being in both races a little more than $\frac{1}{2}$ as long as the body, with the terminal joint equal in length to the penultimate or perhaps very slightly longer, and no perceptible difference in the robustness of the whole antenna. The general appearance of the two ♀ ♀ and of the ♂ of the locust-feeding race is very similar, but, owing to the shape of the elytra, the ♂ of the hickory-feeding race has a different and *Leptura*-like habit. So closely indeed does the ♂ of the locust-feeding race resemble the ♀ of both races that until a recent period I had always supposed that all my specimens of that race—some 30 or 40 in number—were ♀ ♀, and that the unique ♂ which I possessed of the hickory-feeding race, was the normal ♂ of the species. In all the ♀ ♀ of both races the W-shaped band on the elytra is as yellow as the other bands. Whether there is any distinction in the larva state is unknown, as the larva of the locust-feeding form has never yet been critically examined. * *

* * * It is a doubtful and disputed question in Entomological Archaeology, whether Drury's name *pictus* or Forster's name *robiniae* has the priority, as Drury was the first to describe the insect, and Forster the first to name it. We may therefore, with even-handed justice, appropriate the name *robiniae* to the locust-feeding race with short and slender ♂ antennae and leg, which appears in September, and the name of *pictus* to the hickory-feeding race with long and robust ♂ antennae and legs, which appears in May and June.

Both Forster's and Drury's descriptions, however, show that the species they refer to are identical, and are the ones which inhabit the locust. The names *Cyllene robiniae* and *Cyllene pictus* are, therefore, synonymous, and Walsh's application of this name to the hickory species was accordingly unjustified.

Riley (1876) gave a brief description of the larva and imago of the hickory borer, together with a few notes on its life history, and mentioned the characteristics distinguishing it from *Cyllene robiniae*.

Locust feeding ♂

3. Terminal or 11th joint of antennae scarcely $\frac{1}{2}$ or $\frac{1}{4}$ longer than the penultimate, the division into two portions barely discoverable, and the terminal portion not suddenly slenderer from base to tip.

4. Elytra much less tapered and shaped exactly as in the ♀ of both the two races, i.e., with the lateral edges subparallel.

5. The W-shaped band on the elytra colored yellow, exactly like the other bands, in all my 15 specimens.

6. Legs proportionally no longer or stouter than in ♀.

Horn (1880) differentiated the hickory-boring species from the locust-boring species as follows:

C. pictus Drury

The prosternum is longer than wide, truncate at tip and not prolonged. The second joint of hind tarsus glabrous at middle. The elytra are obliquely truncate at tip but not prolonged. The antennae of the male are always longer than the body resembling in this respect *antennatus*.

Lives in Hickory wood and appears early in Spring, and is abundant wherever that tree occurs and is often very destructive.

C. robiniae Forst.

Closely resembles *pictus* in form and coloration but differs in the antennal characters of the male and the structure of the hind tarsi. The prosternum is as broad as long being wider than in *pictus* and also truncate at tip. The legs are also shorter than in that species, the hind thighs not reaching the tip of the abdomen in the male.

Infests Locust wood (*Robinia pseud-acacia*), and appears in the Autumn. I have seen a variety of this species with the W-shaped band entirely obliterated.

Moffat (1882) in speaking of the confusion that existed in literature between the hickory and locust borers, differentiated the two species as follows:

In *pictus* the body is uniformly more slender and tapers more behind than *robinia*. In *pictus* the antennae [sic] decidedly longer, that of the females reaching to the end of the body, and that of the males beyond. The third or W-band on the wing covers is noticeably more delicate than in *robinia*, and quite white in contrast to the yellow of the other's markings, a characteristic I have never seen in any *robinia* I ever met with (and I see them here in hundreds every fall feeding on the Goldenrod), and one which would of itself make it quite easy to pick out my *pictus*, male or female, from amongst any quantity of *robinia* they might be mixed with.

That same year, Horn (1882), fearing that there might be some difficulty in properly distinguishing the species by the characters mentioned by Moffat (1882), again referred to the more definite characters for distinguishing the two species as given by him in 1880, and added, as another distinguishing character, that in *pictus* the W-shaped band rarely joins the transverse band, while in *robiniae* this band nearly always joins the transverse band at the suture.

Riley and Howard (1892) mentioned specimens of the hickory borer having been sent to them with the complaint that they were abundant in dwelling houses. The insects had emerged from hickory wood that was used for fuel.

Bruner (1893) stated that hickories in Nebraska were subject to attack by this beetle. He gave a brief description of the adult, also mentioning the time of its emergence, and suggested control measures.

Hopkins (1895) mentioned finding a hickory log containing a great number of the larvae and pupae of the hickory borer, and having numerous holes in the bark, indicative of the emergence of the adults. However, no adults were found in the wood altho larvae and pupae were abundant.

Webster and Mally (1897) reported the receipt of a section of an osage-

orange post, one and one-half feet long and four inches in diameter, together with a complaint that a worm was destroying many fence posts of this kind of timber. The insect causing the damage was the hickory borer, and, in all, twenty-seven adults emerged from this one piece of wood.

Hopkins (1898), referring to the developing of broods for three years in succession in hickory by the Cerambycidae, mentioned the hickory borer as one of them. He supposed that the late arrivals were the result of retarded development, but an examination of the wood showed that new wood was being continually infested.

Webster and Mally (1898) discussed this insect at length. They described the adult, and gave brief notes on the life history. They talked of the destructive work of the insect on osage-orange fence posts and offered suggestions for the prevention of injury.

The next discussion of this species was furnished by Felt (1905) who reviewed the history of the insect up to that time, gave notes on the life history, described the adult and larva, and listed the natural enemies attacking it.

Until 1908 the insect had been called *Clytus* or *Cyllene pictus*, which, as has already been stated, was a synonym of *Cyllene robiniae*. Realizing this mistake, Gahan (1908 a) described the hickory borer as a new species, giving it the name of *Cyllene caryae*. He further stated that it could be distinguished from *Cyllene robiniae* as follows:

From *C. robiniae*, Forst., which they greatly resemble in markings, *C. caryae* and its varieties may be distinguished by the thicker, longer, and usually darker-coloured antennae, by the two widely separated yellowish or whitish spots on each of the metathoracic episterna, the limitation of the sexual puncturation of the male pronotum to the anterior part, and in having the intercoxal process of the prosternum nearly parallel-sided.

In *C. robiniae* the antennae are generally reddish brown in colour, somewhat slender, as a rule distinctly shorter (never longer) than the body in the male; the yellow pubescence forms an almost continuous band on each of the metathoracic episterna, when it is broken up into two spots the interval between the spots is always narrow; the intercoxal process of the prosternum widens out posteriorly, its sides being curved instead of almost parallel. The sexual puncturation of the pronotum of the male is much more extensive than in *C. caryae*; it covers the greater part of each side, forms an anterior transverse band, and two bands running backwards on the disk, diverging a little behind and dilating each into an oval or rounded spot between the middle and the base; it is similar in character to that occurring in the North-American species *C. decora*, Oliv., and the Brazilian *C. mellyi*, Chev.

Daecke (1910) mentioned a character which would help to distinguish the two species at a glance. He stated that he was not aware that the upper side of the abdomen of beetles had been used as a means of differentiating closely allied species, and accordingly exhibited two specimens of *Cyllene pictus* and *Cyllene robiniae* with the wings spread. The upper side of the abdomen of *pictus* showed reddish, with the anal segment black, while that of *robiniae* was all black. Both species had two rows

of golden yellow lunules along the abdomen, caused by yellow pile; but the anal segment of *pictus* showed one median, dorsal, narrow and oblong spot of gold, while the corresponding spot in *robiniae* was obtusely triangular.

Another somewhat extensive discussion of this insect was set forth by Webb (1911). A list of the trees attacked was given and also, the range of the insect. Brief notes were furnished concerning the life history of the species and recommendations were made for preventing the injury which it causes.

The synonymy of this species is as follows:

Arhopalus pictus Drury

1863 Horn, G. H. Proc. Ent. Soc. Philadelphia, vol. 1, p. 30.

Clytus pictus Drury

1864 Walsh, B. D. Proc. Ent. Soc. Philadelphia, vol. 3, p. 420-422.

1882 Moffat, J. A. Can. ent., vol. 14, p. 200.

1883 Packard, A. S. Guide to the study of insects, p. 497.

Cyllene pictus Horn (nec. Drury)

1880 Horn, G. H. Trans. Amer. Ent. Soc., vol. 8, p. 135-136.

1882 Horn, G. H. Can. ent., vol. 14, p. 240.

1887 Leng, C. B. Entomologica Americana, vol. 2, p. 196.

1897 Wickham, H. F. Can. ent., vol. 29, p. 149.

Cyllene picta Drury

1884 Harrington, W. H. Rept. Ent. Soc. Ontario, 1883, p. 46.

DISTRIBUTION

The distribution of the hickory borer is in all probability coextensive with that of its food plants, the hickories. Kirkpatrick (1856) recorded it from northern Ohio as breeding in hickory. Walsh (1864) stated that about six years previously he had split this insect from hickory at Rock Island, Illinois, while Professor Sheldon, of Davenport, Iowa, informed him that he had found it in hickory at that place for many years back. Walsh (1866) reported the insect rare in Illinois, having taken only three specimens during a seven-years collection. He stated, however, that it was common near Philadelphia, Pennsylvania, in walnut and hickory. Larvae of this species were sent to Walsh from Kansas in 1867, for identification. Rogers (1885) reported that it was one of the common species in Ontario. Smith (1890) reported the insect as being generally distributed, tho rare in New Jersey. In 1892, C. C. Black sent several specimens from Connecticut to Riley, stating that they had emerged from hickory firewood. Bruner (1893) mentioned it as being very destructive

in Nebraska. The same year, Hopkins (1893) reported it from West Virginia, where it was boring in mulberry and hickory. Johnson (1898) mentioned its time of appearance at Philadelphia, Pennsylvania, while Dr. Hamilton reared it in the southwestern part of that state. Webster and Mally (1897) recorded it as being injurious to fence posts in Ohio. That same year, Lintner (1897) received specimens from Brooklyn, New York, where they had emerged from firewood. Wickham (1897) listed it from Ontario and Quebec. Lugger (1899) recorded it among the beetles injurious to fruit-producing plants in Minnesota. Smith (1900) stated that it was found thruout the state of New Jersey. Moffat (1902) received specimens of this insect from London, Ontario. Felt (1905) reported it as common in New York State where it was found frequently on hickory. Gahan (1908 a) recorded a variety of this species from Texas, and another variety from Villa Lerdo, Durango, Mexico. Douglass (1912) stated that it was not a very common species in Indiana. Webb (1911) believed that its range was coextensive with that of the hickory. The writer has taken this insect at State College, Pennsylvania, at Welland, Ontario, and at Ithaca, New York. In all three localities, it was abundant during May and June.

According to the above data the insect has been reported from Ontario, Quebec, Connecticut, New York, Ohio, New Jersey, Pennsylvania, West Virginia, Minnesota, Illinois, Iowa, Kansas, Nebraska, Indiana, Texas, and Durango, Mexico.

FOOD PLANTS

The hickory borer is injurious mainly to the hickories, especially the shagbark variety (*Carya ovata* [Mill] K. Koch). In 1862, T. B. Ashton bred it from black walnut (*Juglans niger* L.) in Pennsylvania, where he said the larvae were not uncommonly found in that tree. Riley (1880) stated that it also attacked pecan (*Carya illinoensis* [Wang] K. Koch) and butternut (*Juglans cinerea* L.). Hopkins (1893) recorded it as attacking the dead branches and small trees of mulberry (*Morus* sp.) in West Virginia. Beutenmüller (1896) added honey locust (*Gleditsia triacanthos* L.) to its list of food plants. [Webster and Mally (1897) said that it had developed a fondness for osage orange (*Maclura pomifera* [Raf.] Schneider) hardly second to its partiality for hickory. Moffat (1902) received from A. Morde, London, Ontario, specimens of the insect which had been reared on a stick of bitternut hickory (*Carya cordiformis* [Wang] K. Koch). Fisher and Kirk (1912) stated that they had reared this insect from wild grape (*Vitis* sp.). Blatchley (1910) said that it occurred on the elm (*Ulmus* sp.) and that the larvae bored in the wood of that tree. In July, 1917, Henry Dietrich, of Ithaca, New York, reported

THE PAINTED HICKORY BORER

1, Male and female. 2, Eggs (slightly enlarged). 3, Eggs (much enlarged). 4, Larva (natural size). 5, Work of larva in hickory.

finding a female with her ovipositor inserted in a branch of black birch (*Betula lenta* L.). The same year J. N. Knull, of Harrisburg, reported that he had bred the insect on hackberry (*Celtis* sp.). At State College, Pennsylvania, the writer has observed this insect running over the trunks of dead pitch pines (*Pinus rigida* Mill), and has seen the females inserting their ovipositors into crevices in the bark. An examination of such places, however, failed to show that any eggs had been deposited. The writer has taken this insect in shagbark hickory, osage orange, and honey locust. Attempts were made to rear it in elm, but the females would not oviposit in it, even tho no other material was supplied.

In brief, then, the hickory borer has been reported as breeding in the following kinds of wood: shagbark hickory, black walnut, pecan, butternut, mulberry, honey locust, osage orange, bitternut hickory, elm, wild grape, and hackberry.

ECONOMIC IMPORTANCE

The hickory borer is capable of causing considerable damage. While it is never present in very great numbers, and does not attack healthy trees, its work on recently killed, standing trees and on felled timber, as well as on unseasoned products from which the bark has not been removed, makes it of considerable economic importance on account of the value of the wood destroyed.

It attacks recently killed, standing timber and felled material from which the bark has not been removed. However, the writer has never found it boring in such material after it had been dead for more than one year, altho repeated attempts were made to have females oviposit in such material. It enters not only the trunks of recently dead and felled material but also the branches, even those as small as one and one-half inches in diameter. In fact, it seems to prefer the smaller trees and branches to the large trunks, for the galleries are always more numerous in such material. In all cases the most severe injury is due to the pupal cells which penetrate the larger trunks and branches to a depth of from one to two inches, while in smaller branches they extend to the heartwood.

Hickory is particularly injured by this borer, for the sapwood, which until recently has been considered the only part of the tree suitable for the manufacture of vehicles, agricultural implements, and various other commodities, is so riddled by the larval galleries that the manufacturer's profit is considerably reduced, resulting in a higher price for the finished product. Years ago, when the hop industry consumed large numbers of hickory poles, the wood for this purpose was often seriously damaged, especially if it was left standing in the woods during the danger season.

THE PAINTED HICKORY BORER

6, Larva (enlarged). 7, Holes to exterior made by larva before pupation. 8, Pupa (natural size). 9, Pupae (enlarged). 10, Pupa in pupal cell. 11, Pupal cells showing plugs of splinters and sawdust.

But now that elm has supplanted hickory for this purpose, the economic loss has been considerably reduced. Material used in the manufacture of porch furniture is frequently so injured by these larvae that it is very easily broken.

The damage inflicted by the hickory borer on black walnut, a wood used to a considerable extent at the present time in the manufacture of furniture, and especially, of gun-stocks, is bound to result in an increase in the cost of this material.

The effect of the insect's work on osage orange is almost as injurious as on hickory. This wood possesses much natural durability, and posts and poles made of it remain sound for many years, even under conditions favorable to decay. This natural durability is greatly decreased by the hickory borer's work. Fence posts of this wood, lying in piles, are often actually so honeycombed that they are fit only for firewood.

Invariably, severe damage results when the cut material is left in the woods during the danger period. Not only do the burrows in the wood decrease its value, but they also afford a means of access to fungus diseases and moisture, which soon render the wood useless except for firewood, and its value for even this purpose is much reduced.

DESCRIPTIONS

The adult

Gahan (1908 a) described the adult insect as follows:

Dark brown above, marked with pale yellow or yellowish-white pubescent bands — two on the head, four on the prothorax, and seven on the elytra; the first thoracic band placed at the anterior border and very narrow; the first and second elytral bands almost directly transverse, the third W-shaped, the fourth and fifth angulated and interrupted, the sixth consisting of a rather strongly arcuated band on each elytron, the seventh forming a border to the apex; body beneath banded with yellowish pubescence; meta-thoracic episterna marked each with two yellow spots, the interval between which is of a dark brown colour and as wide as or wider than either of the spots; legs reddish; antennae dark brown, sometimes more or less reddish in parts.

♂ Antennae rather thick, extending past the apex of the elytra; third to sixth joints subdentate posteriorly at the apex; pronotum with a small punctate area on each side rather close to the anterior border; sides of prothorax very finely and densely punctate.

♀ Antennae extending to the middle of the elytra, not quite so thick as in the male. Length 10-22, breadth 3-7 mm.

The females are easily differentiated from the males by the shorter legs and antennae, and more robust, compactly built body.

Gahan recorded two varieties of this species: one from Texas, with pubescent bands an ashy white instead of yellow, and with the pronotum of the male marked anteriorly with a small punctate area on each side of the mid-line in addition to the lateral punctate area; and the other from Villa Lerdo, Durango, Mexico, with the pubescent bands ashy

white or pale yellow, and the pronotum of the male marked anteriorly with a median sub-rotundate area, which is joined, by means of a transverse punctate band, with each of the punctate areas.

The egg

The egg is elongate-oval in shape, milky white in color, and measures 2 millimeters in length by .85 millimeters at its broadest point. The chorion is very delicate and smooth, lacking ridges or other characteristic markings. There is a considerable difference in the curvatures of the dorsal and ventral surfaces, the ventral surface being noticeably more convex. However, the shape may vary considerably, since the chorion permits them to be easily modified to fit the crevices in which they are deposited.

The larva

Packard (1881) described the larva as follows:

Body thick; mouth-parts black; head reddish behind the antennae. Prothoracic segment (first behind the head) large and broad, being one-half as long as broad; flat and broad above, the upper surface being lower than that of the succeeding segment; the anterior edge thickened, being slightly corneous; a mesial deeply impressed line, especially on the hinder two-thirds, where it becomes a broad, deep angular furrow, dividing the tergum into two quadrant-shaped halves; the outer edge of the segment rises above the flattened tergal portion, which is sparsely covered with hairs; the latter thicker along the sides of the body. The body contracts in width behind the 4th abdominal segment; the upper side of each of the first six abdominal segments (corresponding to those segments in the beetle) is raised into blister-like swellings, especially on the 5th and 6th segments, which are much narrower than the four preceding segments. These dorsal swellings are smooth and free from fine hairs. Abdominal segments 7-9 convex above, not swollen, and the abdomen is narrowest between the 5th and 6th segments. A pair of large spiracles on the mesothoracic segment, and a pair on each of the first eight abdominal segments.

Antennae 3-jointed; the two basal joints being of the same length; the basal one being one-third stouter than the 2nd; the third joint filiform, and one-half as long as the 2nd joint, and ending in two or three hairs. The thin membranous labrum is divided into two parts, the basal solid, the terminal portion forming a moveable flap, overlapping and reaching nearly to the end of the mandibles when closed; the basal portion is shorter than broad, being broadly trapezoidal and smooth; the outer division is broader than long, the edges being rounded, so that it is almost broadly ovate (transversely) and smooth, covered with long hairs. It is pale membranous, of a testaceous hue. Mandibles black, very thick and stout, with obtuse, rounded edges; they are almost as long as the base is broad. Maxillae membranous, flattened; maxillary palpi 2-jointed. Labium membranous, with a transverse chitinous band near the insertion of the 2-jointed palpi; both joints short; second one-half as thick as the first; edge hairy, the hairs reaching to the ends of the palpi. Length of body 0.50 inch; breadth of prothoracic segment, 4.2 mm.; breadth of head, 3.2 mm.

There is considerable variation in the length of the full-grown larva, the range being from $\frac{1}{2}$ to $1\frac{1}{8}$ inches. The larva also shortens considerably just before changing to the pupa. In all the larvae examined by the writer, the maxillary palpi were three-jointed, instead of two-jointed as described by Packard (1881).

The pupa

The pupa is a typical, naked, coleopterous, Cerambycid pupa, brownish in color, and measuring from 9 to 22 millimeters in length. The femur and tibia of each leg are folded against each other, and lie transversely on the ventral surface of the body with the tarsi projecting backward, along the center. The wing pads are folded backward, passing under the prothoracic and mesothoracic legs, with the tips covering the inner parts of the mesothoracic legs on the ventral side. The antennae project forward dorsad to the first two pairs of legs and then curl inward and are held close against the body. There are numerous pointed granulations on the dorsal side of the prothorax, and similar sharp spines on the abdominal segments. On the penultimate segment, these spines are somewhat larger, and are recurved anteriorly at the tip. There are seven in a row near the posterior margin, two others more anteriorly situated, and three more in front of these. The last segment has four similar projections in a row.

LIFE HISTORY AND HABITS

*The adult**Appearance of the adults*

The cold and rainy spring of 1917 without doubt considerably retarded the emergence of the adults, for the material kept in the insectary and the records of the insects emerging from hickory used for firewood during the winter show that warmth has a considerable influence on the time of emergence. Observations were made on material kept at the insectary, where normal conditions were simulated as much as possible, and on a pile of hickory trunks and branches in the field which had been infested the preceding spring. The first adults emerged June 6, in the insectary, when three males were observed. The writer's records show that at State College, Pennsylvania, in 1915, the first adults were observed on May 12. As the weather became warmer, the number emerging gradually increased until June 27. From then until July 5, the number of adults appearing gradually decreased, no more being found after that date. In the field, the males were the first to appear, several days elapsing between their first appearance and that of the females.

General activities

The hickory borer is a sun-loving insect. On bright, sunny days during May and June they may be found on the trunks and branches of recently killed trees or on felled timber, running rapidly back and forth. Rarely are they found on such material when it is well shaded. When disturbed, they either drop suddenly to the ground and hide among the herbage,

or else fly swiftly away, for their powers of flight are well developed. On bright, warm days they work from about ten o'clock in the morning until about half past five in the afternoon, with a maximum activity between three and four o'clock. At night, and during cool, cloudy, or rainy days, they hide under flakes of the bark, and are quite inactive. At such times the pieces of bark covering them can be removed without causing the beetles either to take flight or to drop to the ground, tho they sometimes run about slowly until they again find shelter under some other piece of bark.

During the period of activity the males are always more numerous than the females. The males also appear earlier in the day than the females and are much more active than the females, coursing up and down the trunks and branches, chasing away ants or other insects which may alight, and frequently fighting with each other. The females, on the other hand, move about rather slowly, possibly due to their shorter legs and greater bulk. At intervals they stop to examine places on the bark or to try crevices with their ovipositors. Both sexes, when handled, make the characteristic squeaking sound so common to beetles of this family.

Feeding habits

Like many of the Cerambycids, the adults of this species are pollen feeders. For some time the writer was puzzled as to what the food plants of the beetles could be, for while males and females, confined in cages, copulated freely, yet oviposition did not occur, and both sexes died in three or four days when no food was supplied. Finally, the alimentary canal of a female, taken while ovipositing in the field, was dissected and was found full of pollen. An examination of all the flowers in bloom at that time was then made, with the result that the beetles were found actively feeding on the pollen of the flowers of hawthorn (*Crataegus* sp.). From then on, no difficulty was experienced in breeding the insects in captivity. With a supply of these blossoms in the cages, copulation took place and eggs were deposited as usual. This would seem to indicate that food is necessary before oviposition takes place. This also agrees with the observations of Garman (1916) on *Cyllene robiniae*, a closely related species. In feeding on the pollen, these beetles clamber over the flowers, and at a distance are often mistaken for wasps which are also common on flowers at that time, and which they much resemble in coloration. After feeding, they usually clean off their antennae and tarsi by drawing them thru the mouth parts. While *Crataegus* was the only flower on which the writer found the beetles feeding, yet Mr. V. R. Haber, of Ithaca, New York, mentioned having found them feeding on the pollen of alder catkins in Ohio.

Mating habits

Mating occurs shortly after emergence, as adults which emerged June 6 were found copulating the following day. The males are very aggressive in seeking the females, often fighting vigorously among themselves for possession of the female, biting each other about the head and appendages. On June 13, a small-sized male attempting to copulate with a female, and being roughly pushed aside by a larger male, seized his larger opponent by the hind leg and held on for several seconds until vicious bites on the head and legs caused the smaller male to loosen his hold. In mating, the front legs of the male are clasped around the female's abdomen, the middle and hind legs trailing on the ground. In this position, the female drags him about with her over the trunks and branches, stopping only during the act of copulation. Copulation occurs frequently and lasts but a few seconds. On June 13, mating occurred eight times in fifteen minutes. When copulation is completed, the penis and ovipositor pull away with considerable difficulty, both being considerably extended from the abdomen in the process. Several males may mate with a single female.

Oviposition

Oviposition takes place very soon after copulation, as females which were observed mating on June 13 deposited eggs the following day. The eggs are always placed in crevices or under scales of the bark. Smooth branches are rejected unless there are rough spots or crevices present where eggs may be laid. To facilitate observations, the writer obtained branches with very smooth bark, and cut slits in them at various intervals which provided favorable places for the deposition of eggs. These were placed in cages which each contained a single fertilized female, and observations were made. Before ovipositing, the female walked around, exploring the slits with antennae and ovipositor. Having found an apparently suitable place, the female inserted her ovipositor into it, moving it about in a manner suggesting the movements of a house-fly's mouth parts in exploring a bit of food. If the crevice was unsuitable for depositing an egg, the ovipositor was withdrawn and another crevice explored. This process was continued until a suitable place was found and then the eggs were deposited.

The number of eggs laid in a single crevice varies. In the insectary, where artificial scars were made in very smooth bark, the number of eggs placed in a single crevice varied from one to fourteen. Under normal conditions, in the field, the greatest number of eggs found in a single crevice was five.

Observations were made at the insectary on the total number of eggs laid by a single female. Of the twelve specimens observed, the maximum number of eggs deposited by a single female was fifty-six, the minimum being thirty-eight. While large cages were used and conditions as natural as possible were provided, yet dissection of the abdomens of these females at death showed that not all the eggs had been deposited, quite a few remaining in the ovaries in different stages of development. Whether the entire number of eggs is deposited under natural conditions in the field was not determined. Most of the eggs are deposited on the first day. For example, the female which deposited a total of fifty-six eggs laid forty-six the first day, eight the next, and two on the third day.

After copulation, the males become inactive and die in about a week's time. The females, as a rule, die within three to five days after oviposition.

The egg

Time of hatching

The eggs hatch in from six to ten days. Observations were made on a batch of one hundred and fourteen eggs deposited by three females on separate branches, on June 19. These were collected and placed where conditions would be as natural as possible. The results of the experiment appear in table 2.

TABLE 2. THE TIME OF HATCHING OF 114 EGGS, DEPOSITED ON JUNE 19

Date of hatching	Number of eggs hatched
June 25.....	18
26.....	24
27.....	33
28.....	30
29.....	9

From the above data it will be seen that the first eggs hatched six days after they were laid, while the last to hatch required ten days. The majority of them, however, hatched eight days after they were laid. Observations made on a batch of eggs kept in the laboratory, where conditions were more dry and warm, showed that the eggs hatch in from five to seven days.

A few days before hatching, the fully formed larvae may be seen thru the chorion, actively twisting about. Just prior to hatching, the egg enlarges slightly at the anterior end, due to the size of the larval prothorax. The chorion is undoubtedly broken by the muscular contractions of the

larva, for suddenly it bursts at the anterior end, and as the larval head is pushed thru, the opening is gradually enlarged until a slit extends more than one-half the length of the egg. No egg burster of any kind was found on the larva.

The larva

Activities of the newly hatched larva

The newly hatched larva has the appearance of most Cerambycid larvae. It measures 1.8 millimeter in length, while the prothorax, which is the broadest part of the larva, measures .9 millimeters in width. The mouth parts are black, while the head, behind the mouth parts, is brownish in color. The different segments are sparsely covered with delicate, long hair.

Immediately after hatching, the tiny larvae migrate in under the scales of the bark, where the eggs have been deposited, as far as the size of the prothorax will allow, and then, using the scale of bark as a brace, begin to burrow in towards the wood. It takes about twelve hours to burrow deep enough so that they are completely concealed and during this time fine, powdery sawdust is pushed out behind them. Under natural conditions, where the eggs are laid in clusters of only four or five, there is but little mortality among the young larvae, each individual being able to establish a burrow by itself. But when a large number of eggs are laid in a single crevice, as was done by the specimens kept at the insectary, there is not room enough for all of them to get started. Accordingly, two or more penetrating into a single burrow, one is punctured by the mouth-parts of the other and is killed. Out of fifty-two larvae hatching in a single piece of hickory, only twelve were able to survive and establish burrows. Moreover, when the bark is smooth and no crevices or scales are present to serve as braces for them in beginning their burrows, they are unable to penetrate the bark and soon die. In like manner, the larvae are unable to burrow into material from which the bark has been removed.

Larval burrows

Having penetrated the bark, the young larvae drive their long, linear burrows with the grain of the wood, grooving the inner bark as well as the sapwood. Each burrow usually begins as a small gallery $\frac{1}{8}$ inch wide and of about the same depth. Gradually increasing in width and depth, it may extend for a distance of from 8 to 12 inches or even more, after which it usually bends on itself to form a long, narrow, irregular U, whose arms may be either in contact with each other or slightly separated; on the other hand, the gallery may consist of several loops which are either

distinct or else cross each other in places. From beginning to end, however, all the galleries increase in width and depth, until, just before the pupal cell is formed, they measure from $\frac{1}{2}$ to $\frac{7}{8}$ inch wide and $\frac{1}{4}$ inch in depth. In small branches, in which a large number of larvae are at work, the sapwood may be entirely honeycombed to a depth of an inch or more, the different burrows being indistinguishable from each other. The nature of the wood seems also to have a decided influence on their shape, those in wood free from knots being more or less regular and linear, while those in knotty material may be very irregular. On felled material, the galleries may extend in either direction with the grain of the wood, but in standing timber the majority of them first extend downward.

The burrows are firmly packed with the coarse, sawdust-like borings chewed off by the larvae, whose gnawings can be heard for a considerable distance and resemble the noise made by the so-called "sawyers" in pine. The writer was unable to determine whether all of the gnawed material passed thru the body of the larvae. That dissections showed the alimentary canal full of sawdust-like particles, and that the material filling the burrows was so tightly packed and stuck together that it took considerable work to dislodge it, are facts tending to confirm this view. Furthermore, it is not easy to see how the larvae could store the loose sawdust so compactly, were it not previously moistened by passage thru the alimentary canal. Here and there along the course of the burrows, air holes are eaten thru the bark to the exterior, the number of these for a single burrow varying from one to four.

The pupal cell

The larva becomes full grown in from ten to twelve weeks. At the end of that time it gnaws a large, oval-shaped hole thru the bark to the exterior, and begins the construction of the pupal cell. This extends into the solid wood to a depth of from 1 to $2\frac{1}{2}$ inches, and then parallel with the grain of the wood for about 2 inches. In making the pupal cell, the larva apparently does not eat the sawdust, for as soon as an appreciable amount is chewed off, the larva, using its head as a scraper, pushes it to the exterior thru the hole previously made in the bark. After pushing out one load, the larva backs down into the burrow again and soon reappears with another supply. This process is continued until the entire pupal cell is completed. Evidence of the borer's attack on timber is therefore seen at this time in the large, oval holes in the bark and in the great amount of sawdust pushed out, which accumulates in small heaps beneath infested material. The making of large holes thru the bark before pupating seems rather unusual, as many of the Cerambycid larvae

do not make them. These were evidently the holes to which Hopkins (1897) referred when he stated that the numerous holes in the bark indicated that the adults had emerged, altho nothing but fully matured pupae were found in the wood.

When the pupal cell is hollowed out, the larva, by means of its mandibles, splits off some splinters very much resembling short pieces of excelsior, $\frac{1}{2}$ to $\frac{3}{4}$ inch long, from the sides of the burrow. With these it closes up the pupal cell a short distance below the point where it begins to run parallel to the grain of the wood. After these splinters have been packed firmly in place, so as to form a compact plug, they are reinforced on the inside with a plug of sawdust.

In fallen timber, the pupal cells may extend in either direction, but in standing timber all those examined by the writer extended downward.

The prepupal stage

When the pupal cell is completed, the larva ceases activity and passes into the prepupal stage, during which it is found at the further end of the cell, always facing the plug of splinters and sawdust. However, if the plug is damaged or destroyed, more sawdust will be gnawed to repair the damage. During this stage both the length and bulk of the larva slightly decreases. The duration of the prepupal stage varies with the temperature and humidity. In the laboratory, where it was warm and dry, this period lasted, on an average of fifteen days, while in the insectary, under normal conditions, it was much longer, lasting from twenty-three to sixty-three days. During the latter part of the prepupal stage, the color of the larva varies from a yellowish white to a brownish color, and the antennae and various other appendages become faintly discernible thru the transparent cuticula.

The pupa

Pupation

In the laboratory, pupation began as early as August 23, while in the field the first pupae were found on September 11. Pupation continues from this time until November 12, by which time all the larvae have changed to pupae, the majority of them transforming during the month of October. The last larval skin may remain attached to the end of the pupa, or else lie free in the pupal cell.

Activities of the pupa

Thruout this stage the pupa remains at the further end of the pupal cell, facing the plug of splinters and sawdust. It remains quiescent unless disturbed, at which time the abdomen is moved back and forth.

If placed at the plugged end of the cell, it quickly moves itself back to the opposite end by means of the spines on the thorax and abdomen.

Transformation to adults

In the laboratory the pupa began to show the characteristic markings of the adult by the middle of October. However, they did not transform to adults until the following February. In the field, the winter is passed in the pupal stage. All of the pupae under observation at the insectary were killed by the extremely cold weather during the winter of 1917, so that records on the transformation to the adult stage were not obtained. Likewise it was found that pupae in infested material in the field had also been killed by the unusually cold winter of that year. This agrees with the observations of Craighead (1918) and other workers on forest insects, who also reported a great mortality among wood-boring insects, due to the severe cold.

However, pupae obtained from infested material, late in the winter of 1919, transformed to adults during that spring and emerged. The exact time of transformation from pupae to adults was not determined.

SEASONAL HISTORY

The adult insects emerge during May and June, and sometimes, during the first few days of July, depending on the season. They feed on the pollen of *Crataegus* and probably on that of other flowers. The elongate-oval, whitish eggs are deposited in crevices or under flakes of the bark. These hatch in from six to ten days, and the young larvae, burrowing thru the bark, then construct an irregular, U-shaped burrow, which grooves both the bark and the solid wood, and is tightly packed with the sawdust-like borings. The larvae become mature in from ten to twelve weeks, at the end of which time they construct the pupal cell, first opening a hole to the exterior thru which the borings are to be expelled. When the pupal cell is hollowed out, the larva retreats into it, plugs up the entrance with splinters and sawdust, and enters into a prepupal stage lasting from twenty-five to sixty-three days. The transformation to pupae begins about the middle of September, and by November 12, all are in the pupal stage. In Ithaca, the winter is therefore spent as pupae. The transformation to the adult beetles takes place in the spring.

NATURAL ENEMIES

The hickory borer has very few natural enemies. Riley (1874) mentioned finding the larva of an Elaterid (*Hemirhipus fascicularis* Fabricius) following the burrows of the hickory borer in hickory and

pecan trees probably with the purpose of feeding on the larva of the borer. Packard (1881) figured a Nitidulid larva which he stated probably preyed on this and other hickory insects. Chittenden (1893) reared *Bracon erythrogaster* Brulle and *Doryctes radiatus* Cr. from hickory wood infested almost exclusively with the hickory borer. The writer has found *Bracon erythrogaster* Brulle in considerable numbers ovipositing in the galleries of this insect. Infested material has also yielded quite a few adults of *B. erythrogaster*. This parasite seems to be quite effective in checking the borer, as a large number of specimens split out of wood had been killed by these parasites. The borers are killed during the larval stage, and when parasitized, turn blackish in color and are much wrinkled and flattened, due to the fact that their contents have been eaten out by the parasite.

Very often that part of the pupal cell outside of the plug of splinters and sawdust, is utilized by a small Eumenid wasp which there constructs its nest of clay and rears its brood. These clay nests block the entrance effectively and doubtless prevent parasites from gaining access to the pupal cells during this vulnerable stage of the insect's life.

RECOMMENDATIONS FOR CONTROL AND THE PREVENTION OF INJURY

Since the hickory borer attacks only recently dead and felled material, all attempts should be centered on methods of preventing injury as much as possible. As previously stated, this insect is a sun-loving species, rarely being found in well shaded places. To test this out, the writer piled branches of hickory in the woods where there was abundant shade, and in relatively close proximity to infested material from which the adults were emerging. None of this material was attacked by the hickory borer, and were it not for the fact that other species caused much damage to the wood in such a location, the piling of hickory in shady places would be an effective means of preventing injury.

Standing dead timber should be felled as soon as possible, preferably within a few weeks or months after it has died. Such timber should be utilized at once, or, if this is not possible, the logs should be barked or else put in water. Where either of these methods are employed injury will be prevented, for the larvae cannot breed in the barked logs, and water will kill whatever stages of the insect may be present, or will equally well prevent oviposition.

Unbarked logs, posts, poles, and such material should never be left lying in the woods during the danger season, which extends from May 1 to August 1. They should either be utilized at once, or barked, or placed in water.

Infested material which cannot be used by the manufacturers should be utilized as soon as possible for firewood, preferably before the insects have had time to emerge. In this way large numbers of them may be destroyed.

All material which cannot be used, such as slashings, should be burned as soon as possible, for it is in such places that the insect finds excellent breeding places. When such useless material has been left in the woods until it has become infested, it should be burned before the beetles have had an opportunity to emerge the following spring.

The destruction of *Crataegus* in the vicinity of large tracts of hickory would also be beneficial, in that it would destroy the food supply of the adult beetles at the time of emergence. The elimination of such trees would be beneficial in any case, as they are the native hosts of many of our most injurious insect pests.

BIBLIOGRAPHY

- BEUTENMÜLLER, WILLIAM. Food-habits of North American Cerambycidae. New York Ent. Soc. Journ. 4:73-81. (Reference on p. 76.) 1896.
- BLAND, JAMES H. B. Catalogue of the Longicorn Coleoptera taken in the vicinity of Philadelphia. Ent. Soc. Philadelphia. Proc. 1:93-101. (Reference on p. 95.) 1861.
- BLATCHLEY, W. S. An illustrated descriptive catalogue of the Coleoptera or beetles (exclusive of the Rhynchophora) known to occur in Indiana, p. 1-1386. (Reference on p. 1033.) 1910.
- BRITTON, W. E. The painted hickory borer. Ent. news. 7:141. 1896.
- BRUNER, LAWRENCE. Locust and hickory borers. Nebraska State Hort. Soc. Rept. 1893:166-235. (Reference on p. 196-197.) 1893.
- CHITTENDEN, F. H. Observations of some hymenopterous parasites of Coleoptera. Insect life 5:247-251. 1893.
- CRAIGHEAD, F. C. Emergency entomological service. U. S. Agr. Dept. Mimeographed sheet, no. 12:1-16. (Reference on p. 11.) 1918.
- CURRIE, R. P. Catalog of the exhibit of economic entomology at the Lewis and Clark Centennial Exposition, Portland, Oregon. U. S. Ent. Bur. Bul. 53:7-127. (Reference on p. 94.) 1905.
- DAECKE, V. A. E. Doings of societies. Ent. news 21:332. 1910.
- DOUGLASS, BENJAMIN W. Fourth Annual Report of the State Entomologist of Indiana, p. 1-266. (Reference on p. 112-113.) 1912.
- DRURY, DRU. Illustrations of natural history, 1:—. (Reference on p. 91.) 1770.
- FELT, EPHRAIM P. Insects affecting forest trees. Forest, Fish, and Game Com. New York. Rept. 7:479-534. 1902.
- Painted hickory borer. In Insects affecting park and woodland trees. New York State Mus. Memoir 8, 1:264-266. 1905.
- FISHER, W. S., AND KIRK, H. B. Cerambycidae from Harrisburg, Pennsylvania, and vicinity, with notes (Coleop.). Ent. news 23:308-316. (Reference on p. 311.) 1912.
- FITCH, ASA. The hickory. In Third report on the noxious, beneficial, and other insects of the State of New York, p. 438-461. 1859.

- Borers in the honey locust. New York State Agr. Soc. Trans. 22:117-118. 1863.
- FORSTER, J. R. Novae species insectorum centuria 1, p. 1-100. (Reference on p. 43.) 1771.
- FULLER, A. S. The enemies of our forest trees. Moore's rural New Yorker, p. 201, 247, 299. 1877.
- GAHAN, C. J. Notes on North-American Longicornia, with descriptions of some new species. Ann. and mag. nat. hist., ser. 8:1:140-145. (Reference on p. 140-142.) 1908 a.
- Proceedings of the New York Entomological Society. New York Ent. Soc. Journ. 16:1-261. (Reference on p. 242.) 1908 b.
- GARMAN, H. The locust borer (*Cyllene robiniae*) and other insect enemies of the black locust. Kentucky Agr. Exp. Sta. Bul. 200:99-135. (Reference on p. 104-110.) 1916.
- GAYLORD, WILLIS. A treatise on insects injurious to field crops, fruit orchards, vegetable gardens, and domestic animals: with a description of each, and the best methods of destroying them or preventing their ravages. New York State Agr. Soc. Trans. 3:127-174. (Reference on p. 164-165.) 1843.
- GOSSARD, H. A. The painted hickory borer. Florida Agr. Exp. Sta. Bul. 79:311-312. 1905.
- GREENE, GEORGE M. Doings of societies. Ent. news 21:331-340. (Reference on p. 332.) 1910.
- HARRINGTON, W. H. Injurious insects infesting the hickory. Ent. Soc. Ontario. Rept. 1883:42-52. (Reference on p. 46.) 1884.
- HARRIS, THADDEUS W. A report on the insects of Massachusetts, injurious to vegetation, p. 1-459. (Reference on p. 85-87.) 1841.
- A treatise on some of the insects injurious to vegetation, p. 1-640. (Reference on p. 103-104.) 1862.
- HOPKINS, A. D. West Virginia forest and shade tree insects. West Virginia Agr. Exp. Sta. Bul. 32:194. 1893.
- Notes on some discoveries and observations of the year in West Virginia. Insect life 7:145-153. (Reference on p. 146.) 1895.
- Indications that *Cyllena picta* emerges in the fall. West Virginia Agr. Exp. Sta. Rept. 9:131-132. 1897.

- Cerambycid and buprestid beetles, breeding in seasoned hickory. *In* Proceedings of the tenth annual meeting of the Association of Economic Entomologists. U. S. Ent. Div. Bul. 17:46. 1898.
- Catalog of the exhibit of insect enemies of forests and forest products at the Louisiana Purchase Exposition, St. Louis, Missouri. U. S. Ent. Div. Bul. 48:7-56. (Reference on p. 36.) 1904.
- Insects injurious to the wood of dying and dead trees. U. S. Ent. Div. Circ. 127:1-3. 1910 a.
- Insect injuries to forest products. U. S. Ent. Div. Circ. 128:1-9. 1910 b.
- HORN, GEORGE H. *Arhopalus pictus*, Drury. Ent. Soc. Philadelphia. Proc. 1:30. 1863.
- Notes on some genera of Cerambycidae with descriptions of new species. Amer. Ent. Soc. Trans. 8:115-154. (Reference on p. 135-136.) 1880.
- Correspondence. Canad. ent. 14:1-244. (Reference on p. 240.) 1882.
- JOHNSON, CHARLES W. The hickory borer. Pennsylvania Agr. Dept., Forestry Div. Ann. rept. 3² (1897):95. 1898.
- JUNK, W. Coleopterorum catalogus, part 39, p. 1-574. (Reference on p. 382-384.) 1912.
- KELLOGG, R. S. Lumber and its uses, p. 1-392. (Reference on p. 270.) 1914.
- KINGSLEY, JOHN S. The standard natural history, 2:1-555. (Reference on p. 330.) 1886.
- KIRKPATRICK, J. Notes on a few of the insects of northern Ohio injurious to the farmer or horticulturist. Ohio State Bd. Agr. Rept. 10 (1855):243-248. (Reference on p. 244-245.) 1856.
- LECONTE, JOHN L. The coleopterous parasites of the common hickory (*Carya tomentosa*). Amer. ent. 3:236-237. 1880.
- LENG, CHARLES W. Cyllene, Newm. [sic]. Entomologica Americana 2:195-197. 1887.
- LINTNER, J. A. The hickory borer. Country gent. 47:189. 1882.
- *Cyllene pictus* (Drury). *In* Eighth report on the injurious and other insects of the State of New York for the year 1891, p. 175-176. 1893.

- *Cyllene pictus* Drury. In Thirteenth report of the State Entomologist on the injurious and other insects of the State of New York, p. 360. 1897.
- LUGGER, OTTO. The painted hickory-borer. Univ. Minnesota Agr. Exp. Sta. Bul. 66:202-204. 1899.
- MOFFAT, J. ALSTON. Correspondence. Canad. ent. 14:200. 1882.
- Acknowledgments. Canad. ent. 34:170. 1902.
- NEWMAN, EDWARD. Entomological notes. Entomologist 1:1-424. (Reference on p. 7-8.) 1840.
- OSTEN SACKEN, R. *Arhopalus pictus* Drury (Robiniae Först.). Ent. Soc. Philadelphia. Proc. 1:121-122. 1863.
- PACKARD, ALPHEUS S. Guide to the study of insects, p. 1-702. (Reference on p. 496-497.) 1869.
- The common hickory borer. U. S. Ent. Com. Bul. 7:70-71. 1881.
- The hickory borer. U. S. Ent. Com. Rept. 5:1-957. (References on p. 287-288, 329, 342.) 1890.
- RATHVON, S. S. Entomological essay. Gard. mo. 2:299-301, 356-359. 1860.
- Entomology and its relations to the vegetable productions of the soil, with reference to both destructive and beneficial insects. Report of the Commissioner of Patents for the year 1861 (Agriculture), p. 585-620. (Reference on p. 616-617.) 1862.
- RILEY, CHARLES V. Borers and canker worms. Prairie farmer, p. 151. 1867.
- Noxious insects. In Sixth annual report on noxious, beneficial, and other insects of the State of Missouri, p. 9-122. (Reference on p. 101.) 1874.
- The hickory vs. the locust borer. Coleman's rural world, August 9, p. 45. 1876.
- Food habits of the Longicorn beetles or wood borers. Amer. ent. 3:237-239, 270-271. 1880.
- RILEY, C. V., AND HOWARD, L. O. A wood-borer mistaken for a household pest. Insect life 4:396. 1892.

ROGERS, R. VASHON, JR. Entomology for beginners. Canad. ent. 12: 148-152. (Reference on p. 150-151.) 1880.

——— On some long-horned beetles. Ent. Soc. Ontario. Rept. 11 (1880):33-34. 1881.

SLINGERLAND, M. V. The painted hickory borer. Rural New-Yorker 55:303. 1896.

SLOSSOM, ANNIE T. A few memories. New York Ent. Soc. Journ. 23:85-91. (Reference on p. 85-86.) 1915.

SMITH, JOHN B. Catalogue of insects found in New Jersey. Final report of the State Geologist, 2:1-486. (Reference on p. 203.) 1890.

——— Economic entomology, p. 11-481. (Reference on p. 208.) 1896.

——— Insects of New Jersey, p. 1-755. (Reference on p. 289.) 1900.

THOMSON, JAMES. Essai d'une classification de la famille de Cérambycides et matériaux pour servir à une monographie de cette famille, p. —. (Reference on p. 215-217.) 1860.

WALSH, BENJAMIN D. *Clytus* (Arhopalus) *pictus* Drury. In On phytophagic varieties and phytophagic species. Ent. Soc. Philadelphia. Proc. 3:403-434. (Reference on p. 420-422.) 1864.

——— Graduation [sic] from "individual peculiarities" to species in insects. Ann. and mag. nat. hist., ser. 3:16:383-384. Also, Amer. journ. sci. and arts, ser. 2:40:282-283. 1865 a.

——— On certain remarkable or exceptional larvae, Coleopterous, Lepidopterous, and Dipterous, with descriptions of several new genera and species, and of several species injurious to vegetation, which have been already published in agricultural journals. Boston Soc. Nat. Hist. Proc. 9 (1862-63):286-318. (Reference on p. 296-297.) 1865 b.

——— *Arhopalus robiniae* Forst. Walsh and *A. pictus* Drury Walsh. In On phytophagic varieties and phytophagic species, with remarks on the unity of coloration in insects. Ent. Soc. Philadelphia. Proc. 5:204-206. 1865 c.

——— Borers. Pract. ent. 1:25-31. 1866 a.

——— Answers to correspondents. Pract. ent. 1:89-90. (Reference on p. 89.) 1866 b.

——— Answers to correspondents. Pract. ent. 2:83-85. (Reference on p. 85.) 1867 a.

- Answers to correspondents. Pract. ent. 2:107-110. (Reference on p. 107.) 1867 b.
- WALSH, B. D., AND RILEY, C. V. Insects named. Amer. ent. 1:148. 1869.
- WEBB, J. L. The painted hickory borer. U. S. Agr. Dept. Yearbook 1910:349-350. 1911.
- WEBSTER, F. M. Warning colors, protective mimicry, and protective coloration. Ent. Soc. Ontario. Rept. 27:80-86. (Reference on p. 81.) 1897 a.
- *Cyllene picta* Drury. Notes on various species of Coleoptera. New York Ent. Soc. Journ. 5:204. 1897 b.
- WEBSTER, F. M., AND MALLY, C. W. Insects of the year in Ohio. U. S. Ent. Div. Bul. 9:40-46. (Reference on p. 42.) 1897.
- The painted hickory borer. Ohio Agr. Exp. Sta. Bul. 96: 19-20. 1898.
- WICKHAM, H. F. *Cyllene*, Newm. Canad. ent. 29:149. 1897.

Photomount
Pamphlet
Binder
Gaylord Bros.
Makers
Syracuse, N. Y.
PAT. JAN 21, 1908

496025

SB945

B418

UNIVERSITY OF CALIFORNIA LIBRARY