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Snout Bettles that Injure Nuts

Fred E. Brooks

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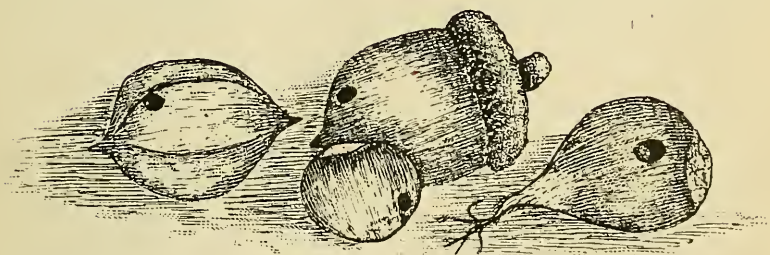
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WEST VIRGINIA UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
MORGANTOWN, W. VA.

BULLETIN 128

MARCH, 1910

Snout Beetles That Injure Nuts



BY FRED E. BROOKS

[The Bulletins and Reports of this Station will be mailed free to any citizen of West Virginia upon written application. Address Director of Agricultural Experiment Station, Morgantown, W. Va.]

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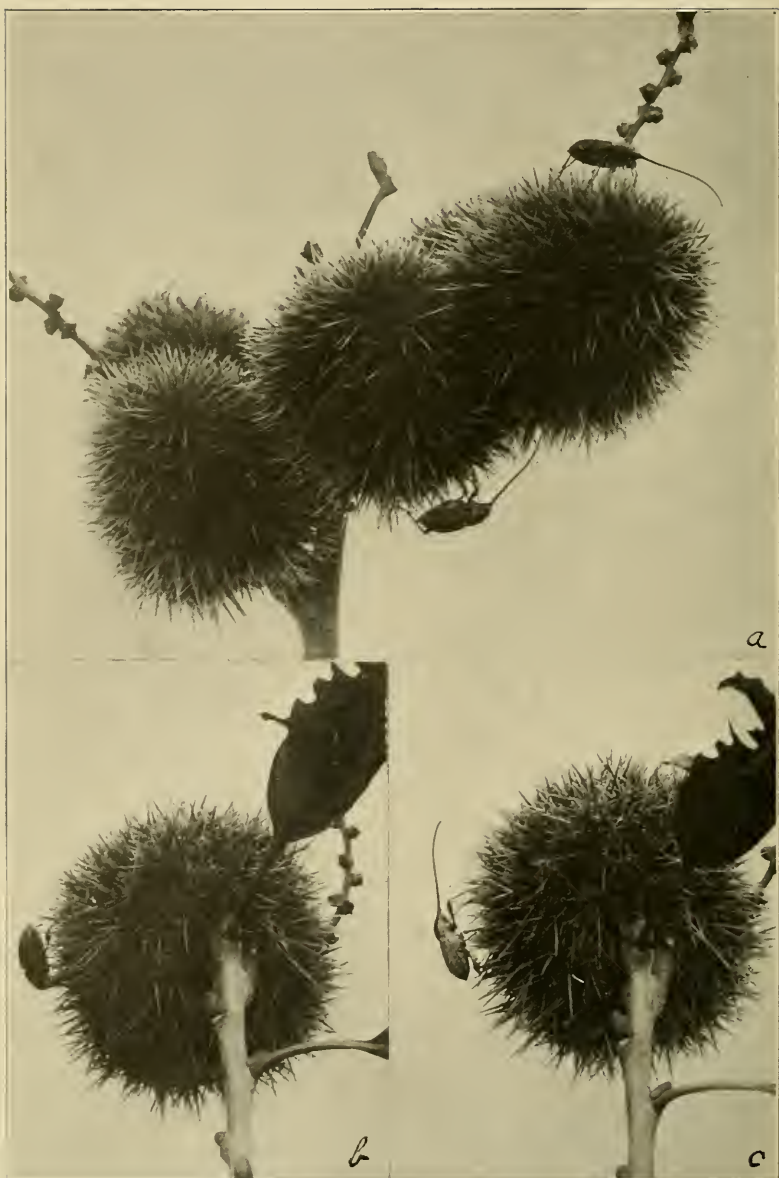
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Larger Chestnut Weevil. a and c, female Weevils; b, female boring hole in bur in which to insert an egg. All natural size.

Snout Beetles That Injure Nuts

FRED E. BROOKS

INTRODUCTION

The forests of West Virginia are rich in native nut-bearing trees and shrubs. At least twenty-seven species are found that bear nuts which are used as food by man or by the animals that are of value to man. The nut-bearing trees furnish also the bulk of hard-wood timber that is produced in the State.

With the probable exception of the beechnut, all the more common varieties of nuts, and, presumably, those that are less common as well, are attacked by the larvae, or grubs, of over a dozen different species of snout beetles. Some of these larvae feed on the husks and inner tissues of immature nuts and others on the kernels of nuts that are more nearly ripe. Young walnuts and hickorynuts are frequently attacked soon after the blossoms fall from the trees and the infested nuts drop to the ground before they are half grown. Chestnuts, acorns and some other varieties sustain the greatest injury as they approach maturity. It is not unusual for chestnuts that are kept a week or two after gathering to become from 50 per cent to 75 per cent "wormy" and acorns often suffer to even a greater extent. The infested nuts are rendered unfit for food and in many cases are so badly eaten that they will not germinate when planted.

The injury which these insects do to a valuable article of food and their direct detriment to natural forest development, in causing the failure of many nuts to germinate, make the group an important one from an economic standpoint.

This bulletin is published as a report of an investigation of this class of insects which has extended over a period of several years. Special effort has been made to acquire information regarding the egg-laying habits of the different species, their life histories, seasonal abundance, natural enemies, methods of reducing or preventing loss and to collecting a large number of specimens for systematic study. The work has been carried on in connections with other entomological investigations and the writer is aware that many phases of the study have been passed over too hurriedly to obtain accurate and final conclusions. It is especially desirable that in the future a more careful study be made of the larvae and pupae of the species considered.

THE NUT INDUSTRY IN WEST VIRGINIA.

The most important feature of the nut industry in West Virginia is the production of native chestnuts. There are several counties that, during favorable seasons, market from 40 to 75 tons each of these nuts. A portion of this crop is gathered from forest trees but most of it probably comes from chestnut groves consisting of second-growth trees that have been allowed to stand in old fields. The nuts bring, in the local markets, an average of about four cents a pound, or \$80 a ton, and are a source of considerable income in many localities.

The improved varieties of European and Japanese chestnuts are beginning to be grown in several places in the State and give promise of great success providing they can be kept sufficiently free from insects.

Shellbark hickory trees flourish in many sections and almost every neighborhood has its one or more famous, old hickory trees that are noted locally for the nuts which they bear. Although no great quantity of hickorynuts are marketed, the nuts are, nevertheless, gathered very carefully, often being regarded as too good to sell, and are kept for home and local use. Walnuts, butternuts and hazelnuts are also furnished to the market in a limited way and are gathered in larger quantities for home use.

There is much land in the State that is at present put to little use but which is admirably adapted to the production of various kinds of nuts. As the demand of the market for this commodity increases there is no good reason, apparently, why West Virginia should not undertake to furnish its full share toward supplying the wants of this market.

WHERE AND HOW THE INVESTIGATION WAS CONDUCTED.

Most of the observations herein recorded on the habits of these insects were made at French Creek, W. Va., where many of the important host of the different species abound. In the study of life histories the insects were kept under observation in their natural environment and in breeding jars in the laboratory. The most accurate knowledge of the insects was obtained by observing them in the ground under nut-bearing trees, where they undergo a part of their development, and by ascending into the branches of trees to observe their behavior there

ACKNOWLEDGMENTS.

The writer wishes to acknowledge his indebtedness to Dr. F. H. Chittenden, of the Bureau of Entomology, United States Department of Agriculture, for his courtesy in naming difficult specimens and for offering valuable suggestions regarding methods of studying the group. Thanks are also due Mr. Nathaniel Bacon, Talcott, W. Va., who has plantations of chinquapin and hazel and who took great pains to furnish data and specimens of the weevils that attack the nuts of these plants.

NATIVE NUT-BEARING TREES AND SHRUBS OF WEST VIRGINIA.

According to Millspaugh's "Flora of West Virginia" and to the unpublished notes of A. B. Brooks, Forester for the West Virginia State Geological Survey, the following native, nut-producing trees and shrubs are found within the State. Further study of our species may result in a few additions to this list.

With the probable exception of one or two species, all the nuts in the list are attacked by one or more of the insects under consideration.

- Butternut or White Walnut, *Juglans cinerea* L.
 Black Walnut, *Juglans nigra* L.
 Bitternut or Swamp Hickory, *Hicoria minima* Britt.
 Shellbark or Shagbark Hickory, *Hicoria ovata* Britt.
 King Nut or Bottom Shellbark Hickory, *Hicoria laciniosa* Sarg.
 Mockernut or White-heart Hickory, *Hicoria alba* Britt.
 Pignut or Broom Hickory, *Hicoria glabra* Britt.
 Little Pignut, *Hicoria glabra* var. *odorata* Sarg.
 Hazel, *Corylus Americana* Walt.
 Beaked Hazel, *Corylus rostrata* Ait
 Beech, *Fagus Americana* Sweet.
 Chestnut, *Castanea dentata* Borkh.
 Chinquapin, *Castanea pumila* Mill.
 Red Oak, *Quercus rubra* L.
 Pin or Swamp Spanish Oak, *Quercus plaustris* Muench.
 Scarlet Oak, *Quercus coccinea* Muench.
 Black or Yellow-bark Oak, *Quercus velutina* Lam.
 Bear or Scrub Oak, *Quercus nana* Sarg.
 Spanish Oak, *Quercus digitata* Sudw.
 Black Jack or Jack Oak, *Quercus Marilandica* Muench.
 Shingle or Laurel Oak, *Quercus inbricaria* Michx.
 White Oak, *Quercus alba* L.
 Post or Iron Oak, *Quercus minor* Sarg.
 Burr or Mossy Cup Oak, *Quercus macrocarpa* Michx.
 Swamp White Oak, *Quercus platanoides* Sudw.
 Chestnut Oak, *Quercus Prinus* L.
 Yellow Oak, *Quercus acuminata* Sarg.

“ANNUAL” AND “BIENNIAL” OAKS.

In this paper reference is made repeatedly to “annual” and “biennial” oaks, the distinction being between those in which the acorns ripen in one year and those which require two years to ripen their acorns.

It is scarcely necessary to explain that several of our common oaks blossom in the spring and set acorns that ripen the following fall. Other oaks form acorns at the time of blooming which grow but little until the following spring. They then begin to develop and during the ensuing autumn mature and drop from the trees. The following lists show our species of native oaks belonging to each class.

ANNUAL-FRUITING OAKS. White, Post or Iron, Bur or Mossy-cup, Swamp White, Yellow and Chestnut Oaks.

BIENNIAL-FRUITING OAKS, Red, Swamp Spanish or Pin, Scarlet, Black or Yellow-barked, Spanish, Bear or Scrub, Black Jack or Jack, and Laurel or Shingle Oaks.

CLASSES OF INSECTS THAT INJURE NUTS.

Nuts are attacked by a great variety of insects but the most serious injuries are done by moths and snout beetles. The larvae of several species of moths may be found in chestnuts, beech-nuts and acorns, particularly in nuts that have their shells broken so as to permit easy entrance to the kernel by the insects. The damage wrought by the class of insects known as snout beetles, however, is greatly in excess of that done by all other kinds combined.

The term "snout beetle" is applied to the adults of the group of insects which forms the subject of this paper on account of the peculiar structure of the head, the front part of which is prolonged into a snout or proboscis. In some species this snout is short and stout and in others it is long, slender and wire-like. In the females of some of the nut weevils it is longer than the rest of the body. The mouth, which is armed with a minute but strong pair of jaws, is situated on the apex of the snout and the appendage is used for piercing or puncturing various kinds of plant tissue to obtain food and to provide an opening in which to deposit eggs.

The fourteen species of snout beetles which have been found

feeding on nuts in West Virginia represents two groups, or genera; ten species belonging to the genus *Balaninus* and four to the genus *Conotrachelus*. For convenience, the species of *Balaninus* are referred to in this publication as "weevils" and those of *Conotrachelus* as "curculios".

NAMES OF THE INSECTS AND NOTES ON HOST PLANTS.

The following list gives the names of the nut-attacking snout beetles that have been studied in this State together with references to the nuts for which they show a preference. Common names have heretofore been given to but a few of the species and the names used here are merely suggested as possessing some degree of appropriateness. The common names of the first four species in the list have been used in the past but only that of the second has been officially adopted.

Larger Chestnut Weevil, *Balaninus proboscideus* Fab.
Chestnuts and chinquapins.

Chestnut Weevil, *B. rectus* Say. Chestnuts and chinquapins.

Hickorynut Weevil, *B. caryae* Horn. Hickorynuts of several species.

Hazelnut Weevil, *B. obtusus* Blanch. Hazelnuts.

Common Acorn Weevil, *B. quercus* Horn. Acorns of red, black, scarlet and other biennial oaks.

Mottled Acorn Weevil, *B. nasicus* Say. Found here most abundant on red oak, more sparingly on other biennials. Has been bred elsewhere from acorns of white and chestnut oaks.

Straight-snouted Acorn Weevil, *B. orthorhynchus* Chittn. Equally abundant on red, black and scarlet oaks.

Sooty Acorn Weevil, *B. baculi* Chittn. Common on red, black and scarlet oaks. Less common on white oak.

Confused Acorn Weevil, *B. confusor* Ham. Abundant on chestnut oak. Rare on white oak.

Spotted Acorn Weevil, *B. pardalus* Chittn. Abundant here on white oak and less abundant on chestnut oak. Has been reared in other localities from acorns of biennials and other annuals.

Walnut Curculio, *Conotrachelus juglandis* LeC. Black walnuts and butternuts.

Hickorynut Curculio, *C. affinis* Boh. Hickorynuts.

Larger Acorn Curculio, *C. naso* LeC. Acorns of annual oaks.

Lesser Acorn Curculio, *C. posticatus* Boh. Acorns of annual oaks. Has been bred elsewhere from galls on hickory and from hickorynuts.

TECHNICAL DESCRIPTIONS.

Students who desire technical description of the foregoing species are referred to the following named publications.

B. proboscideus, *B. rectus*, *B. caryae*, *B. quercus*, *B. nasicus*.

Horn, Geo. H. Proceedings, Am. Phil. Soc., Philadelphia, Vol. 13, p. 458-460.

Hamilton, John, Canadian Entomologist, Vol. 22, pp. 2-8.

B. obtusus.

Blanchard, Frederick, Bul. Brook. Ento. Soc., Vol. 7, p. 107.

Hamilton, John, Canadian Entomologist, Vol. 22, p. 6.

B. orthorhynchus, *B. baculi*, *B. pardalus*.

Chittenden, F. H., Proc. Ento. Soc., of Washington, Vol. 10, Nos. 1-2, p. 19-26.

B. confusor.

Hamilton, John, Canadian Entomologist, Vol. 25, pp. 309-310.

C. juglandis, *C. affinis*, *C. naso*, *C. posticatus*.

Le Conte, John L., Proc. Am. Phil. Soc., Vol. 15, pp. 226, 232.

Those desiring to consult works on the biologies of the species are referred to the following publications which are of special value.

Chittenden, F. H., The Nut Weevils, Cir. 99, Bureau of Entomology, U. S. Dept. of Agr., Washington. 1908.

Pierce, W. Dwight, The Biologies of the Rhynchophora of N. A. Ann. Rept. Neb. State Board of Agr., pp. 249-307, 1906-7.

THE NUT WEEVILS.

The nut weevils of the genus *Balaninus* are elongate beetles that measure, exclusive of the snout, from about one-fourth to nearly half an inch in length. The snout is stiff and slender and varies in length from half as long as the body in the males of some species to considerably longer than the body in the females of others. The prevailing color of the upper parts of the body is rich, light brown mottled and spotted with lighter shades. In a few species the color is dark brown to which the lighter-colored, scale-like hairs give a grayish appearance. The under parts of the body are uniformly lighter in color.

The nut weevils are represented in this country by more than twenty described species. About a dozen occur in the eastern part of the United States and of these at least ten are abundant in West Virginia. So far as is known at present, all the members of this genus feed on nuts. Of the species that have been studied in this State, two feed on chestnuts and chinquapins, one on hickorynuts, one on hazelnuts and six on acorns.

The fleshy, cream-colored grubs, or "worms", so abundant in freshly-gathered chestnuts, and less frequently noticed in other nuts, are the larvae of these weevils.

The different species of this group closely resemble one another. In a miscellaneous collection of the beetles, it is a difficult matter to arrange all the specimens specifically. While the beetles are alive, and their habits and movements can be observed on the trees, the resemblances are not so great. If one becomes familiar with the beetles while they are engaged in their occupation of egg-laying he soon discovers peculiarities which enable him to recognize the species on the trees without resorting to close examinations for structural differences.

LIFE CYCLE "IN A NUT SHELL."

The normal life cycle in this locality for all the weevils described in this bulletin is about as follows. Beetles issue from the earth in July and August, several weeks after blossoms have

disappeared from nut trees, practically all the individuals of one species leaving the ground at near the same time. Egg-laying continues from the time the meat in the nut begins to form until the nut is full grown. Eggs hatch in from one to two weeks. Larvae feed on kernel of nuts, some species reaching full growth before or near the time the nuts drop and others maturing much later. Full-grown larvae leave the nuts through large, circular holes which they eat in the shell. The larva, after leaving a nut, does not enter other nuts but penetrates the soil for an inch or more where it fashions a small cell, by twisting the body about, in which it passes the winter unchanged. In June, July and August the larvae change to pupae in which stage they remain for two weeks, more or less, and then transform to adults. They remain in their cells as adults for several days, or, often, until a warm rain softens the earth, and then emerge and go to the trees.

EXCEPTIONS AND VARIATIONS.

There are some very decided exceptions to the rule of the life cycle as given above. Occasionally individuals of at least two species will change from larvae to adults, either late in the fall or early in the spring, and issue from the ground in May. I have spent much time in searching in the ground under chestnut, oak and hickory trees in April and May for these early maturing beetles but so far have found examples of only the chestnut weevil and the confused acorn weevil. This act of early transformation seems to occur most frequently with the latter species as I have found, in all, about a dozen specimens in the earth under chestnut oak trees in May. I have also collected the beetles frequently during the same month in jarring plum trees to catch the plum curculio. Their occurrence on the plum trees has probably been accidental as the particular trees from which they have always been collected are growing near an oak woods where the beetles breed in great abundance.

On May 22nd, 1906, I found one female chestnut weevil in

the ground under a chestnut tree. This is the only adult of this species that I have taken in the field so early in the season but a little later I have captured several from the blossom catkins of chestnut. This is several weeks in advance of the appearance of the bulk of beetles of this species.

Another departure from the normal life cycle is the case of a small per cent of larvae which remain for two years in their cells in the earth and then transform to beetles and issue from the ground in company with those that develop from the previous season's generation of larvae. This provision is evidently an arrangement of nature to carry the species over a year when a total failure of the nut crop may occur. It is plain that if all the insects of a kind matured during any one year and found no nuts in which to lay their eggs the species would perish from the earth because there would be no means of reproduction. Such a fate does occasionally overtake a large per cent of the individuals of one generation but the few larvae that always remain unchanged in the ground over two winters are able to provide successors the following year. In breeding the insects in the laboratory it has been found that occasionally an individual will remain as a larva until the third summer after it quits the nut. This insures the perpetuation of the species even though all the nut trees should fail for a year or two to bear and furnish food for the insects.

EARLY STAGES OF THE WEEVILS.

The eggs, larvae and pupae of the different species bear a close resemblance to one another. The eggs are small, elongate, translucent white, with a polished surface and fragile shell. There are slight variations in the size and shape of the eggs of the different species but in most cases the distinctions are hardly perceptible. A considerable variation in the shape of the eggs produced by one individual is quite apt to occur.

The larvae differ somewhat in size and in the tints of color but they are all robust, white, creamy-white, or yellowish-white

grubs with red or brown heads. The pupae occupy cells in the earth made by the larvae and are usually of lighter color than the larvae. Both stages, in most of the species, need further study before they can be differentiated with any degree of certainty.

BEHAVIOR OF THE ADULT WEEVILS.

The beetles of some of the species of nut weevils may be met with in the field at any time from early in the spring till late in the fall. They are most abundant, however, in July, August and September. Both sexes feed, usually, on the husks or the kernels of the nuts in which they deposit their eggs, but they occasionally depart from this custom and obtain a little food from other parts of the plant. One male larger chestnut weevil was found at French Creek feeding on a Kieffer pear. The food is gotten by boring with the beak into the tissue and swallowing some of the juices and solids that are encountered in making the puncture.

The beak is stiff, and the mouth at the extremity consists in part of a strong pair of jaws. The head, to the front of which the beak is attached, is rounded behind and fits into a concavity in the front of the thorax forming a union like a ball and socket joint. The construction of this joint permits the head to revolve for more than a fourth of its circumference. In piercing a nut the beetle presses the point of the beak against the surface and by rotating the head drills an opening to the desired depth. This organ makes a surprisingly efficient instrument for this work for the insect is able to pierce even the horny shell of the mature pignut which may be a tenth of an inch in thickness and almost as hard as bone. The eggs are placed at the bottom of these galleries made with the snout.

Several writers on the habits of these weevils have believed that after a female has completed her egg-gallery in a nut she deposits an egg at the mouth of the opening and then turns around and pushes the egg into place with her snout. I have watched repeatedly the egg-laying operations of all the weevils

mentioned in this bulletin, with the exception of the hazelnut weevil, and have never seen any of the insects use the snout in placing the egg. All the species are provided with long, jointed ovipositors which can be inserted to the full length of any puncture which the snout may make and these ovipositors are used for placing the eggs in the exact spot where they are to remain during incubation. When not in use the ovipositor is telescoped together and withdrawn into the body. It is visible to the observer of the live weevils only for a moment preceeding its insertion into the egg-chamber and then quite frequently only the tip is shown.

The different species have their favorite kinds of nuts to which they adhere with considerable regularity. For example, the two species that feed on chestnuts and chinquapins do not appear to attack any other nuts in the east, although Hamilton records an instance of the chestnut weevil being bred from acorns in Arizona. (Canadian Entomologist, Vol. 22, No. 1.) The hickorynut and hazelnut weevils each infest only its one favorite class of nuts and among those that confine their attacks to acorns there are some species that show a decided preference for certain varieties of acorns. Several species prefer the biennial acorns and are rarely found on the annuals while just the reverse is true of other species. This peculiarity of taste among the acorn weevils is most noticeable in a locality where all the species of oaks are bearing at one time. Such a condition permits the beetles to exercise their special preferences to the fullest extent and each species will be found in greatest abundance on the one or more kinds of oak that it likes best. In years when a part of the varieties of oak fail to bear the beetles are less particular and all the different acorn-attacking species have a tendency to collect on the bearing trees, their prejudices of taste being overcome apparently by their desire to feed and oviposit.

In ovipositing the beetles exhibit characteristic differences of procedure which are interesting. Some species deposit their eggs in half-grown nuts while others wait until the nuts are nearly or quite mature. The different species select different

points on the nut for making their attacks and some place only one egg in a puncture while others make branched punctures which may contain a dozen eggs. Some are very shy and can scarcely be approached while engaged in egg-laying without becoming frightened from their positions while others are so unsuspecting that they will sometimes allow themselves to be handled with the finger without pausing in their work.

The beetles are slow to fly, preferring to drop to the ground and feign death or to scurry behind some object when disturbed. The operation attending egg-laying is a long and laborious one and when begun late in the afternoon I have seen the female leave her unfinished work at the approach of darkness and seek shelter for the night on the underside of the nut and then resume operations at the same opening on the following morning.

During cool, dark weather the beetles remain in their hiding places resuming activity only on warm days.

THE LARGER CHESTNUT WEEVIL, *Balaninus proboscideus* Fab.

This is the largest of the nut weevils and it is also one of our most abundant and destructive species. It attacks chestnuts and chinquapins, laying most of its eggs early in the season so that at the time the ripe nuts drop from the trees the full grown larvae, or "chestnut worms", as they are commonly called, are abundant in the nuts. I have found a few eggs of this species as late as the 30th of September. The larvae from eggs deposited so late in the season do not leave the nuts until late in the winter.

The beetle is yellow, spotted and mottled with rich, brown shades. The average length of the insect, not including the snout, is nearly half an inch. The snout is long and slender, measuring, in the female, about five-eighths of an inch and in the male about half that length. It is straight at the base with a slight curve at the point. As the insect moves about carrying the huge beak projecting forward it presents a rather grotesque appearance. The character distinguishing this from all other

species of the genus is the first joint above the elbow of the antenna which is longer than the second.

In the four years during which I have watched this insect the beetles have always appeared on the chestnut trees early in August, or about two weeks after chestnut blossoms disappear normally from the trees. By the middle of August they are usually abundant and may be found collected about the young chestnut burs. From the middle to the 25th of the month, or, at about the time the tender kernel begins to form in the nut, egg-laying begins and is continued for a period of from five to seven weeks. As the fall advances the beetles gradually decrease in numbers, the last of the generation disappearing late in October, often, not until several severe frosts have occurred. I have found two adults on the trees as early as August 8th and one year collected several from open chestnut burs on October 26th. These are my earliest and latest seasonal records of finding the adults.

The following table shows the dates and progress of the transformation from larvae to adults of over a hundred individuals under perfectly natural conditions. The table shows the state of development in which the insects were found at seven different times during the summer in the soil beneath bearing chestnut trees.

TABLE SHOWING DEVELOPEMENT OF LARGER CHESTNUT WEEVIL.

Date.	Larvae.	Pupae.	Adults.	Remarks.
July 1	18	0	0	(Pupation not begun.)
July 8	10	5	0	(Pupation begun.)
July 26	31	11	8	(Pupae beginning to change to adults.)
Aug. 1	12	0	9	(All pupae changed to adults.)
Aug. 10	29	0	4	(Adults leaving ground.)
Aug. 23	16	0	0	(All adults out of ground.)
Aug. 28	13	0	0	(All adults out of ground.)

The above records were obtained in 1906. There seems to be some variation in the time the insects mature and leave the ground in different years but this variation is not great. The table indicates that the change from larva to pupa begins about

July 8th and that pupation ceases before the last of July. In the year that the observations were made all the beetles had issued by the 23rd of August and for a few weeks thereafter only the biennial larvae occupied the ground. As the new generation of larvae does not begin to leave the nuts and enter the ground until October, the 70 larvae that were found in the ground from August 1st to August 28th must have been hold-over individuals that would not have changed to beetles until another year.

The beetles of this species are comparatively sluggish in their movements and are rarely seen in flight. In ovipositing, the female secures a foothold among the spines of the bur and proceeds to drill a hole which extends directly through all the coverings that envelop the forming kernel.



When the kernel is reached she withdraws her snout, turns around and inserts her ovipositor in the opening and passes an egg to the bottom where it reposes in the silken fiber immediately surrounding the kernel. After the egg is deposited the beetle crawls away and pays no further attention

to the puncture. One female was observed to spend 56 minutes in the acts attending the deposition of a single egg.

The attack may be made at any point on the surface of the bur but perhaps occurs more frequently near the stem. If the bur is opened after the egg is placed and the nut removed the egg may usually be seen through the opening in the shell. This slight wound in the shell soon heals over, however, and shows only as an obscure scar in the ripe nut.

When the larva is full grown it gnaws a circular hole, one-eighth of an inch in diameter, through the shell and escapes. This species breeds in chinquapins, native chestnuts and in the imported chestnuts which are now being grown in this country.

THE CHESTNUT WEEVIL, *Balaninus rectus* Say.

Chestnuts are frequently gathered that appear sound at first but within ten days or two weeks thereafter become excessively "wormy." Where these "worms" come from has often been a matter of conjecture on the part of those who handle nuts. It is a common belief that they originate from the "sting" of some insect administered at the time the trees are in bloom. As a matter of fact, they hatch from eggs that are in the nuts at the time the nuts are gathered. Most of these eggs are deposited by this chestnut weevil a short time previous to the dropping of the nuts from the trees.

This beetle resembles very closely in a general way the one just described. The shape and color are similar and the beak, like that of the other, is long and conspicuous. It may be distinguished from the larger chestnut weevil by its smaller size, slightly darker color, greater curvature of the snout, and by the first joint of the antenna beyond the scape which is longer than the second. On the tree, this beetle is shyer and more active than the larger species.

The length of the adult insect is from a fourth to a third of an inch. The snout is almost as slender as a horsehair and is curved from the base to the tip. The snout of the female is about four-fifths of an inch long and that of the male about half that length.

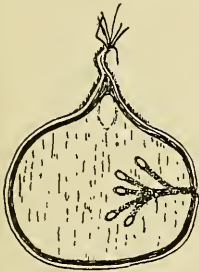
As previously stated, beetles of this species may be found occasionally early in the spring. It is not known that these early arriving individuals produce eggs. The bulk of the beetles come from the ground much later in the season; later, by several days, than the larger chestnut weevil. Observations of the insects in the field have shown that in this locality pupation usually takes place between the first and fifteenth of August. In 1906, I found three newly emerged males on the trees on August 28th and on the 30th of the same month two females were found. In 1907, several fresh males and females were found on the trees on August 26th. A few days after the dates given the beetles became very numerous. I have never found the sexes paired on the

trees before the middle of September and have not found eggs nor oviposition in progress before September 24th.

In the locality where these observations were made, the earlier chestnut trees begin to open their burs about September 25th and it has been on these trees that I have always found the beetles first engaged in oviposition.

When the four lobes which compose the spiny envelope, or bur, of the chestnut begin to separate, preparatory to turning back to release the ripe nuts, the first effect is a deep groove in the husk along the line where the lobes unite. In grooves of this kind, where the spines are out of the way and where the husk is thin, the beetles collect first to drill their holes into the nuts for the purpose of depositing their eggs. Later, when the burs are open, they get at the kernel, in which their eggs are deposited, by perforating only the brown shell of the nut.

The female, in ovipositing, first pierces the kernel of the nut almost or quite to the center and then turns around and inserts an egg to the bottom of the opening with her ovipositor. This done, she again turns and uses her beak to make a branch gallery within the kernel leading off from the first opening. This branch receives an egg, like the other, and the operation continues until from a single, minute opening in the shell a dozen branches may extend into the nut each containing an egg. In one case I found thirteen eggs in a set but the customary number is from five to eight.



In order to ascertain whether the egg is pushed into place with the beak, as has been claimed often, I removed females several times just after they had laid their first egg and before they had time to reinsert their beak into the opening. In every case I found the egg in its permanent position at the bottom of the gallery showing that after the nut is pierced the ovipositor alone is used in placing the egg.

The egg is similar to that of the larger chestnut weevil except that it is smaller and slightly more elongate. The shape is oval-oblong and the color shining, pellucid white.

The hole made through the shell in ovipositing and the galleries and eggs within the meat are so small that they are scarcely visible to the naked eye. No foreign flavor is imparted to the nuts by the fresh eggs, and, as their small size prevents their being seen except on close examination, they are often eaten unwittingly by those who go chestnutting in the fall. This is a case where ignorance is bliss, for the punctured chestnuts retain their sweet flavor for a while and no harm comes from the unconscious swallowing of the eggs which the nuts contain.

The larvae remain in the nuts until they have attained full growth and then make their exit through holes which they eat in the shell. The holes made by this species are circular, like those made by the larger weevil, but are smaller, the difference in size being sufficient to enable one to distinguish them from the others. Most of the larvae emerge from the nuts late in the fall but a few remain with their food until mid-winter or even until the warm weather of spring.

THE HICKORYNUT WEEVIL, *Balaninus caryae* Horn.

This enemy of one of our favorite nuts has been known for more than a quarter of a century but it has come into special prominence since the development of the pecan industry in the southern states. In the states farther north the insect attacks shellbark and other varieties of hickorynuts and seems to be more numerous than formerly. Dr. Chittenden has recorded that in some of the southern states the loss to pecan nuts amounted to 75 per cent of the crop in 1903 and 1904. The greatest injury to these nuts has probably occurred in Georgia, Mississippi and Texas.

The shellbark is the only native hickorynut that is used extensively as food in West Virginia, and this variety is seldom more than 20 per cent affected by the weevil. Other varieties, such as the pignut and mockernut, are often destroyed to the extent of from 50 to 75 per cent of the crop. The large, circular holes frequently found in the shells of hickorynuts are made by the larvae of this weevil in escaping.

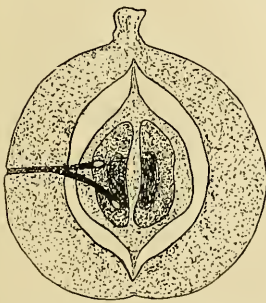


Nut Weevils. a and b, Hickorynut Weevils; c, Confused Acorn Weevil; d, Hazelnut Weevil. All natural size.

The beetle is intermediate in size between the two chestnut weevils. The beak is long and prominent but is a trifle shorter than in either of the species that attack chestnuts. The color of the beetle is dull, dark brown with a grayish tinge in fresh specimens due to a sparse covering of whitish, scale-like hairs. The larva is yellow with a red head and is similar in shape to those of the other species.

The beetles appear on the trees in July, my earliest record being for July 29th, 1908, when eleven were caught on the lower branches of a pignut hickory. On August 8th, 1906, I found the punctures of the weevils quite abundant in the husks of hickorynuts but these punctures were shallow and had evidently been made for feeding as they contained no eggs. My first observation of oviposition was on August 23rd, 1906, when a female was seen to deposit an egg in a nut of the white-heart hickory.

Oviposition has been observed on August 23rd, 25th, 27th, 30th and September 14th and 24th. Evidently, in this locality, most of the eggs are produced from August 25th to September 25th. At the time of oviposition the nuts are approaching maturity, and, as the eggs are placed within the meat of the nut, it is necessary for the beetle to make an opening through the husk and shell for the insertion of the egg. This it does, after the manner of its kind, by drilling a hole with its snout to the desired depth in the nut.



Other nut weevils in depositing their eggs have to contend with the spines of the chestnut bur, the glutinous involucre and hard shells of the hazelnut and the woody cups of acorns but this species has the greatest obstacle of all to overcome in the form of the thick, horny shell of some of its favorite varieties of hickorynut. Its manner of accomplishing the task is interesting and may be explained best by describing the operation as it was observed on September 14th

1909. At a few minutes past noon a female was seen to take a position about half an inch from the point of a nut of the pignut hickory. After turning around several times with the point of the beak moving over the surface of the nut she found a place for making a beginning that seemed to suit her. She then elevated her body by extending her legs to their full capacity and with the point of the beak pressed against the nut began a slight up and down motion at the same time rotating the head. Gradually the point of the beak sank into the husk. As she worked dust-like chips fell although the snout was not removed from the opening. At the end of an hour and 15 minutes the beak was buried to the eyes. When the hole could be made no deeper the beak was withdrawn for the first time and the beetle turned around, the tip of the ovipositor appearing as she turned. In two or three seconds, by an accurate sense of touch, the ovipositor found the spot and was thrust into the orifice. During the deposition of the egg, which occupied a little over a minute, the beetle remained motionless. After the egg was placed she resumed her former position and again inserted the snout into the opening. She immediately began the drilling motion, with the beak about two-thirds buried, and rapidly worked it in to its full length. This was done in forming a branch to the original gallery. In less than thirty minutes the branch was completed and a second egg deposited. The operation was again repeated and after the third egg was deposited the insect crawled away from the nut. The entire operation occupied 2 hours and 14 minutes. The husk of the pignut is thin but the inner shell is thick and almost as hard as bone. This shell was a tenth of an inch in thickness at the point where it was penetrated in the operation just described.

The egg is clear, translucent white, with a shining surface. It is exceedingly delicate in texture and can with difficulty be removed from its place in the nut without breaking. They vary considerably in size and shape. The length ranges from .027 of an inch to nearly .04 of an inch and the width is about .02 of an inch. All are oblong, some being elliptical and others ovate. Ir-

regularly-shaped and lop-sided specimens are frequently found. The time required for the egg to hatch was not ascertained.

I have not found more than three eggs in one nut though that number has been observed several times. Four or five larvae are frequently found in one nut and eight are recorded by Hamilton. It is likely that in some cases more than three eggs are deposited in a puncture but where as many as seven or eight larvae occur they probably represent more than one set of eggs.

The larvae begin to gnaw their way out at about the time the nuts are dropping but many do not escape until mid-winter and many others die within the shell. Several were observed leaving nuts, that had lately been placed in a warm room, on January 6th.

The beetles, when not engaged in feeding or oviposition, have a habit of hiding in dead leaves that are brown and curled and that can be found adhering here and there to the branches. I have examined infested trees on dark days when it seemed that practically every beetle present was hiding in these leaves. Almost every leaf that was in the proper condition contained one or more beetles. I tried hanging bunches of dead leaves to the lower branches and succeeded in trapping many of the insects by that means. Old gunny sacks were tried in the same way but to no purpose for they did not attract the beetles. It is possible that trapping with bunches of dead leaves, or some similar device, might be practiced with benefit in cultivated orchards of pecan and hickory. Other weevils of the group hide in much the same manner but not to the extent of this species.

THE HAZELNUT WEEVIL, *Balaninus obtusus* Blanch.

The hazelnut industry is not large in West Virginia and yet in some sections the nuts are gathered in considerable quantities from the wild bushes and are sold in the local markets or stored for home use. They are very highly prized on account of their rich flavor. Wherever the nuts grow, in this State, they are attacked in varying degrees by the hazelnut weevil. In some

cases the injured nuts amount to nearly half the crop and in others not more than 5 per cent are affected. The injury is similar in its nature to that done by the weevils attacking other nuts, the meat of the nut being eaten by the stout, whitish grub which, when full grown, escapes through a round aperture in the shell.

The work of this weevil has been recognized for many years but the species has been confused with others and it was not until recent years that it was found to make the hazelnut its exclusive food. The species was named and described by Frederick Blanchard, in 1884, from specimens secured in Massachusetts and New Hampshire. It has been found as far west as Minnesota and Texas and it probably occurs throughout the eastern states wherever the hazel grows.

The beetle is similar in color to the two that attack chestnuts but may be distinguished readily from them by its shorter, more robust form and by its very much shorter beak. It is about one-fourth of an inch in length, the beak of the female being half as long as the body and that of the male still shorter.

Most of the information which I have gotten pertaining to the habits of this species has been given to me by Mr. Nathaniel Bacon, of Talcott, W. Va., who has a hazel plantation and who is a careful observer of nature.

The beetles seem to oviposit earlier in the season and to be somewhat shorter lived than the other species. On July 29th, 1908, Mr. Bacon sent me a box of hazelnuts in which there were many larvae and a few eggs of the weevil. Three weeks later,—August 13th,—I visited Mr. Bacon's place and together we made a thorough search for the beetles by examining the bushes and by jarring them over sheets. We spent about half a day in the search and Mr. Bacon continued to look for the insects at intervals for several weeks thereafter but not a beetle was found. At the time I examined the bushes there were many larvae and a few eggs in the nuts but the beetles that had produced them had disappeared. On August 30th the infested nuts were dropping prematurely and the larvae issuing from them. On September 18th, Mr. Bacon wrote that he had just made a careful search

for the larvae in two bushels of nuts but that all had eaten their way out and disappeared.

In a lot of 26 "wormy" hazelnuts sent me by Mr. Bacon, 23 larvae had left the nuts on September 14th and only three remained. Eighteen of the exit holes were within one-eighth of an inch of the point of the nut and only two were directly on the side.

Mr. Bacon sent me one beetle which he collected from the bushes on July 23rd. Hamilton, writing of observations made at Allegheny, Pa., states that he did not obtain the beetles by beating hazel bushes previous to June 20th nor after July 15th. Harris records that paired adults have been found on hazelnuts in July. It seems from this evidence that most of the eggs are deposited in July and that the beetles disappear soon thereafter.



The eggs are elliptical in shape, the surface smooth and shining and the color translucent white. The single egg measured was .04 in. long and .028 in. wide. The act of oviposition was not observed in this species but eggs were found occupying small cavities in the shell, only one egg being found in a place. Feeding punctures were found extending into the kernel but the egg-punctures penetrated only through the shell and the eggs were found within the shell but nearer the inner than the outer surface. In most cases, but not always, the egg-punctures were found about the point of the nut where the shell is accessible without first boring through the involucre.

At the time the larvae hatch the tender kernel is just beginning to form and in several nuts larvae were found that appeared to have been feeding on the delicate fiber that occupies the cavity of the nut previous to the formation of the kernel. The hole made by the beetle in the shell to receive the egg does not entirely heal over and it was observed by Mr. Bacon that the full fed larvae in forming their exit holes enlarge these old wounds, where the shell is defective. After the larvae quit the

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nut they enter the ground where they remain until the succeeding summer.

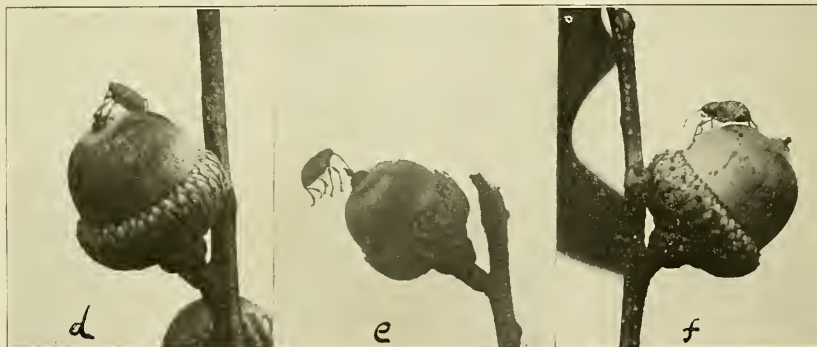
THE COMMON ACORN WEEVIL, *Balaninus quercus* Horn.

This is the largest of the weevils attacking acorns. In size, it is similar to the hickorynut weevil but in color it more nearly resembles the larger chestnut weevil. The spots on the back are smaller than in the latter species, however, and are not so bright and conspicuous. The snout is very slender and is curved at the point. In the female, it is nearly half an inch in length, or, about a fifth longer than the body. In the male, it is about two-thirds as long as the body. The pygidium, or last abdominal segment, of the male is deeply concave with the concavity smooth and shining and surrounded by a rim of silken hairs. This peculiar character enables the species to be separated very readily from all other members of the genus.

This species seems to attack only the acorns of the biennial oaks and in my collecting has always been found more abundant on red oak than on any other tree. The acorns which it attacks are late in maturing and the beetles are correspondingly late in appearing. My earliest record for adults is July 30th, when four newly transformed beetles were found in the ground under a red oak tree. My first specimen from the tree was taken August 23rd. During September and until the middle of October the beetles are abundant on biennial oaks. Egg laying beings about the first of September and continues very active for four or five weeks.



In ovipositing the beetle pierces the acorn to the full length of her long snout and then makes many branches leading off at an acute angle from the first puncture. Eggs are placed at the extremity of only a part of the branches and these are deposited at intervals during the long and tedious task of excavating. After the eggs are all in place the beetle deposits a small mass of ex-



Acorn Weevils. a, b, c and d, Straight-snouted Acorn Weevil preparing a place for its egg; e, Acorn Weevil that has lost its foothold on the nut and hung by the snout until dead; f, Sooty Acorn Weevil; g, Common Acorn Weevil and parasite *Urosigalphus armatus*; h, Common Acorn Weevils; i, Spotted Acorn Weevil. All natural size.

crement over the opening in the shell which is pressed and plastered down with the tip of the abdomen, thus sealing the entrance to the eggs. When the excrement is dry it is of a whitish color and forms a spot on the acorn which is easily seen. So far as I have observed, only one other of the weevils has this habit of sealing the egg-chamber. This is the straight-snouted acorn weevil which is described later.

The eggs are translucent white, like those of the other species, and are very irregular in shape. The drawing shows several forms that were produced by one beetle. Two eggs were measured, one being .02 x .03 inch and the other .02 x .04 inch. The larvae of this species devour the entire meat of the acorn, leaving the nuts late in the fall or during the winter through a circular exit hole and enter the ground for hibernation.

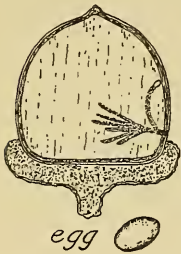
THE MOTTLED ACORN WEEVIL, *Balaninus nasicus* Say.

In the localities where I have collected this is the least common of all the acorn-infesting weevils. I have never seen more than two score of the beetles on the trees and these have all been on biennial oaks. Hamilton bred it from acorns of white and chestnut oak and more sparingly from those of scarlet oak. I have found it ovipositing in red oak and, more sparingly, in scarlet and black oak acorns but never in any other variety. The white and chestnut oaks are certainly not preferred in the locality where my observations were made.

The beetle is slightly smaller than in the species last described and the back of fresh specimens is brown, beautifully mottled with clay yellow. The spots are large and have a tendency to form bands across the wing covers. The beak of the female is from one-fourth to three-eighth of an inch in length, or, about the length of the body. The beak of the male is half as long as that of the female.

Hamilton, in Pennsylvania, took the beetles by beating oak branches from about the 10th of May till near October. I have taken them at French Creek from August 8th till September 28th. The beetles are quite likely present in this locality both

before and after the dates on which I have recorded them, but, being somewhat scarce, have been overlooked. They are more abundant on the trees, however, in September than at any other time and that is the season when oviposition is most rapid.



In disposition, this beetle is one of the shyest of the group and while engaged in egg-laying is easily frightened from her work. I have watched oviposition on three different occasions. Each time the side of the acorn was attacked. Twice the beetle bored through the edge of the cup into the kernel and the third time she made her entering puncture through the shell only, just beyond the border of the cup.

In preparing thus a place for its egg, the insect first bores a hole directly into the nut which reaches almost to the center of the kernel. It then makes several branches, beginning in the kernel and leading obliquely away from the first opening. This done, it makes another gallery which leaves the original opening just at the point where the kernel and shell meet. This gallery extends into the kernel but curves gradually until it arrives at the inner surface of the shell at a point about one-fifth of an inch from where it began. Into the farthest extremity of this curved gallery the beetle places a single egg and then departs. In one case the side-gallery in which the egg was placed was directed toward the base of the nut so that the egg rested beneath the cup and in the other two cases it extended toward the point of the nut.

The egg is pellucid white and its form may be elliptical, oval or pyriform. In one example the dimensions were;—length, .025 inch, width, .015 inch.

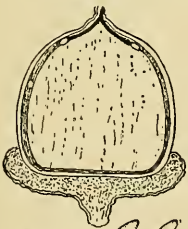
The time required for the egg to hatch was not determined and the larvae was not differentiated from those of the other species with which it associates.

THE STRAIGHT-SNOUDED ACORN WEEVIL, *Balaninus**orthorhynchus* Chittn.

This is one of our common species on biennial oaks. I have found it in about equal numbers on red, scarlet and black oaks but have never found it on the annuals. This species has been recorded from West Virginia and Texas only. It was first described in 1908 by Dr. Chittenden.

The color is dull, yellowish brown in fresh specimens and dark, reddish brown where the vestiture is rubbed off. There are usually numerous spots of lighter color on the back but these are very small and indistinct. The female is three-tenths of an inch in length and the snout, which is straight with the exception of a very slight curve near the point, is the same length as the body. The male averages distinctly smaller than the female and the snout is only half as long as the body.

The beetles are found on the trees from about the middle of August until the acorns drop in the fall.



In preparing a place in the acorn for her egg, the female has the peculiar habit of beginning her puncture on the side of the little tip or beak that projects at the apex of the nut. In more than thirty acts of egg laying that I have recorded this rule has not been departed from. The hole is drilled from the side of this beak directly to the kernel and at that point branches and extends between the kernel and shell as deep as the length of the snout will permit. After each branch of the egg-gallery is completed an egg is deposited at the bottom. A female that was watched on September 7th, 1907, spent 45 minutes in preparing a place for and depositing her first egg and then added other eggs at intervals of 21, 14, 9 and 23 minutes, the whole operation lasting for an hour and 52 minutes. Not more than six eggs have been found in one set. After the last egg is inserted the beetle deposits a liberal quantity of

excrement over the hole in the shell which hardens in drying and effectually seals the eggs against the attacks of enemies.

It is only with a good deal of difficulty that the beetles are able to get a hole started in the horny texture of which the point of the acorn is composed. In order to effect a beginning they are obliged to extend all their legs to the utmost and even then stand "tip-toe" to get the beak in proper position to use it to advantage. I have found two of the females that, while working in this strained position, had lost their foothold on the nut just after the point of the snout had become buried in the shell, and, not being able to regain their footing, they had hung by their snouts and died.

This species is unsuspecting and the females will allow themselves to be approached closely while egg laying without showing any signs of alarm. I have several times cut off a branch bearing an acorn on which a female was working, and, without disturbing the insect in the least, have carried it five hundred yards and obtained a photograph.

The egg is the same translucent white as in others of the group. It is more elongate than some of the others but varies considerable in size and shape. One measurement gave;—length .035 inch, width .015 inch and another, length .03 inch and width .015 inch. Eggs deposited on September 10th hatched on September 18th or in eight days after being laid.

The larva is white with a pale, reddish brown, sometimes almost white, head. When full grown it escapes from the acorn through a hole in the side and enters the ground.

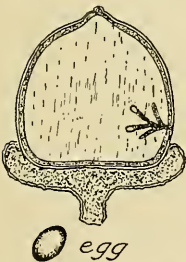
THE SOOTY ACORN WEEVIL, *Balaninus baculi* Chittn.

The dark gray or sooty color of this weevil, with the entire absence of yellow or brown, will serve to distinguish it from all others of the group that are found in this region. Dr. A. D. Hopkins found it on black oak at Kanawha, W. Va. and Chittenden on white oak at Ithaca, N. Y. I have seen it ovipositing in red, scarlet, black and white oak acorns but have always found it most abundant on the biennials.

The species is widely distributed in the eastern states and occurs as far west and south as Nebraska, Indian Territory and Mississippi. It was not differentiated from others, however, until in 1908, when Chittenden described it as a new species.

The beetle is almost black with a dusky gray aspect due to short, whitish hairs which are scattered thinly over the body and which form minute spots on the back. The length averages about a third of an inch and the beak of the female is two-thirds as long as the body, that of the male being half as long as the body.

I have found the newly developed beetles in the soil under red oak trees on August 18th and 19th and have observed the mature insects on the trees from August 28th to October 18th.



The egg-puncture is made through the side of the nut, either through the cup and shell or through the shell alone. The beak being short, the meat of the nut is penetrated only by a shallow wound, and, frequently, when the beetle bores through both cup and shell, the opening extends only to the surface of the kernel.

The gallery is made to branch several times and in the ends of from two to four of these branches eggs are placed. The egg is very delicate, transparent white, elongate, pointed at both ends and measures .03 inch long and .025 inch wide. The larva is similar to the others in appearance and behavior.

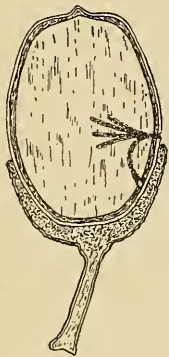
THE CONFUSED ACORN WEEVIL, *Balaninus confusor* Ham.

During the four summers which I have observed this species in an oak woods at French Creek it has always been very abundant on chestnut oak when that variety was bearing. The trees which it frequents are surrounded by four other kinds of oaks but I have found it only once on any of the varieties except chestnut oak. The one case was in 1906 when chestnut oak acorns were very scarce. At that time a few beetles were found ovipositing in white oak acorns.

Hamilton reared it from acorns of bear oak and there is little doubt that further breeding from infested nuts, which is the most accurate method of determining the host plants of any of the species, will show that other kinds of acorns are sometimes attacked. Hamilton records also the remarkable rearing of this species from a gall on a golden-rod.

The beetle resembles the mottled acorn weevil except that the beak is much shorter, it being, in the female, from a fourth to a third shorter than the body and in the male about half as long as the body.

On May 11th, 1906, I found three beetles of this species in the earth under a chestnut oak tree in the woods. A few days later four others were found in a similar situation. I have frequently jarred them from plum trees in May and early in June and have found them on chestnut oak on July 14th. They begin to oviposit in acorns about the middle of August and continue on the trees until the middle of October, the 16th of October being my record for the last adults on the trees.



In boring holes into the acorns for ovipositing, the cup is rarely, if ever, perforated. Most of the punctures are made through the shell just beyond the border of the cup. This is especially true of the punctures for the first eggs of the season. Later, the nut may be attacked near the point. Oviposition is performed by first making a branched gallery that extends into the meat of the nut as far as the beak will reach. After this, several side-galleries are made which extend into the kernel and then curve back to the shell, piercing it for about half its thickness. These lateral branches number from one to five and an egg is placed in the end of each. The point where the egg reposes shows as a slightly discolored spot on the outer surface of the acorn and if the shell be removed the eggs may be found sticking in its inner lining.

The egg is smooth, creamy white, irregular in size and

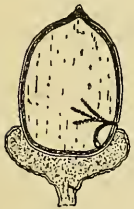
shape. It averages from .03 to .04 inch long and .02 inch wide.

The larvae often feed in the acorns until late in the winter and convert the meat of the nut into dust so that it will not germinate.

THE SPOTTED ACORN WEEVIL, *Balaninus pardalus* Chittn.

In this locality the beetles of this species show the same preference for acorns of the white oak that those of the last described species show for the acorns of chestnut oak. Frequently I have found this species swarming in white oak trees when not one could be found in nearby oaks of other kinds. Chittenden has reared it from acorns of swamp white oak and black oak.

In a general way, this beetle more nearly resembles the confused acorn weevil than any other species. The size and shape are very similar and the length of the beak is practically the same in both insects. The color of this species is a darker shade of brown and the spots on the back are smaller and more clearly marked. The large mandibles of the male are a distinguishing mark.



The beetles are common on white oak trees from about the first of August until the acorns drop in the autumn.

The operation attending oviposition is very similar to that of the species which attacks the acorns of chestnut oak. The female makes a branched gallery extending toward the center of the acorn and then, through the same opening in the shell, directs a branch to one side in which the egg is placed. So far as has been observed, none of the egg-punctures are made through the cup. The eggs are not distinguishable from those of several other species.

THE NUT CURCULIOS.

The group of snout beetles commonly known as curculios is made notorious by the habit which some of the species have of attacking orchard fruits. Several species of the group attack

nuts and some of these resemble very closely that formidable enemy of the fruit grower, the plum curculio. In their life histories and general characteristics the likeness of the different species is still further borne out.

As compared with the nut weevils, the curculios are smaller and the snout much shorter. The more important species pass the winter in the adult or beetle form and deposit their eggs in young nuts early in the summer.

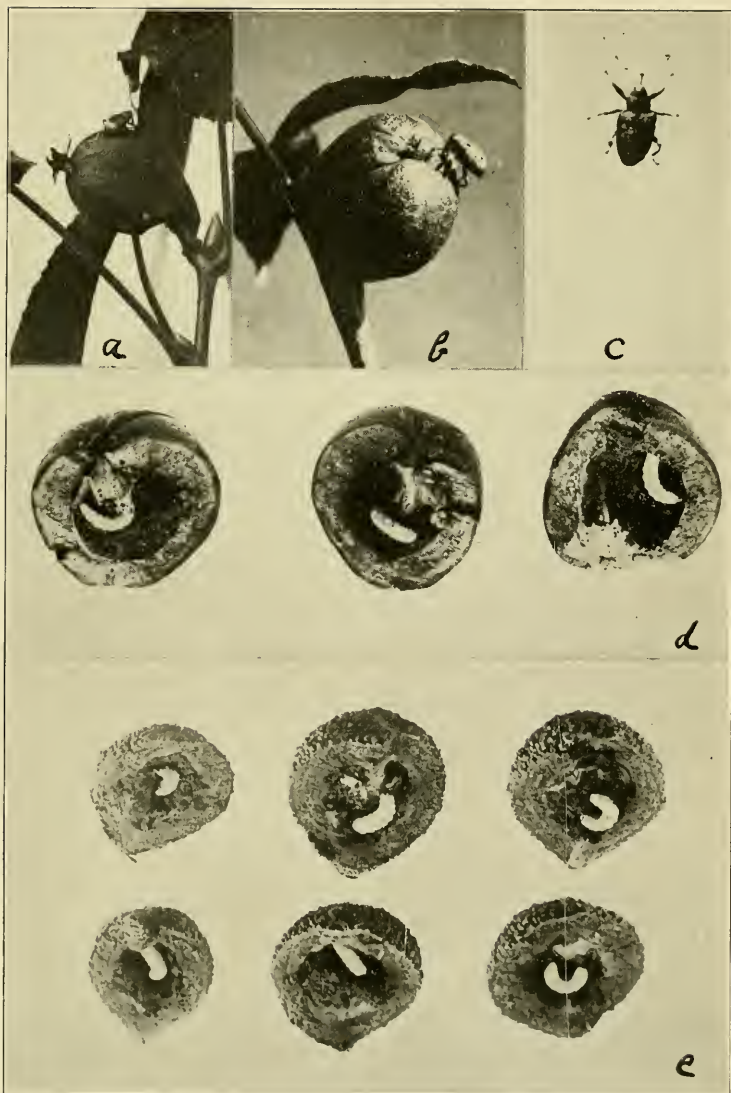
The two species that attack walnuts and hickorynuts often cause a heavy drop of the immature nuts. Very frequently trees of black walnut and of some varieties of hickory lose half their crop as a result of injuries inflicted by these insects. The infested nuts drop while they are quite small and for that reason the injuries are more apt to escape notice than when nuts are attacked that are more nearly mature.

THE WALNUT CURCULIO, *Conotrachelus juglandis* Lec.

During the month of July the ground beneath bearing black and white walnut trees will frequently be found well covered with little nuts that have recently fallen from the branches above. An examination of these nuts will show a crescent-shaped scar on the side of each and on cutting the nut open a small, whitish larva with a brown head will be found usually on the discolored tissue. A snout beetle known as the walnut curculio is responsible for this condition of the nuts.

The beetle is about one-fourth of an inch long and the snout, which hangs down or is folded back beneath the thorax, is less than half as long as the body. The back has a rough appearance which is due to several humps and ridges. The body is thinly covered with short, dingy-yellow hairs which form indistinct bands on each side of the prothorax and across the wing covers just behind the middle.

The first eggs of the season are deposited usually in young black walnuts about June 10th to 15th and oviposition continues for more than a month. In preparing a place for her egg, the beetle hollows out a cavity or pocket in the walnut about one-



Nut Curculios. a and b, Hickorynut Curculios; c, Walnut Curculio; d, larvae of Hickorynut Curculio in nuts; e, larvae of Walnut Curculio in nuts.

c, slightly enlarged. All the rest natural size.

tenth of an inch deep which extends obliquely beneath the skin. In this cavity the egg is placed and the beetle then proceeds to pack the space about the egg with bits of husk which she tears from the surface near where the opening was started. When the egg is well sealed in she enlarges the place from which she has torn the packing into a crescent-shaped incision, a little over an eighth of an inch long, which partly surrounds the egg.

As the beetle works she freely voids liquid excrement which forms a dark stain on the surface of the nut about a fourth of an inch from the wound. This stain on the nut is often more conspicuous than the wound.

Before the beetles have finished their egg-laying the walnuts are nearly half grown and the husk is so solid that excavating, as carried out so elaborately at first, becomes so difficult that the beetle, evidently to avoid labor, changes the form of her puncture and deposits the last of her eggs in shallow pits on the side of the nut. These eggs are placed in groups of three or four and have no crescent marks about them and are not protected with the plug of chips.

The egg is oblong-oval in shape, the color being creamy white. The surface is finely granular and has a ground-glass appearance. Length, .04 inch, width, .025 inch. Specimens that were observed hatched in four, five and six days, the average time being five days.

The larvae are dirty white with brown heads and are less robust and more active in their movements than those of the weevils. After the larvae have fed for about ten days or two weeks the nuts drop and the larvae complete their growth in from one to two weeks thereafter. They then abandon their feeding place, enter the ground for a short distance and soon pupate in small cells which they fashion in the earth. The beetles issue from the ground during August and September, and, presumably, spend the interval of warm weather about the trees. When fall approaches they hibernate, and reappear the following spring in time to attack the walnuts soon after the blossoms have dropped from the trees.

THE HICKORYNUT CURCULIO, *Conotrachelus affinis* Boh.

This insect injures hickorynuts in very much the same manner as the walnut curculio affects walnuts. As a rule the nuts when attacked are a little further developed than is the case with the walnuts, but the larvae appear and do their feeding before the kernel begins to form. The infested nuts drop when not more than two-thirds grown. The beetles seem to show a preference for the nuts of pignut hickory, and some of the other less valuable varieties, but they also injure shellbark nuts considerably.

Superficially, the beetle bears a close resemblance to the walnut curculio, the most noticeable difference being that the broad band across the wing covers of the former are much lighter, in some individuals being almost pure white. The size and general structure of the two are very similar.

Egg-laying begins near the last of June and extends over a period of about four weeks. In 1906, oviposition had ceased apparently on July 15th but in 1907, when the season was about two weeks backward, egg production seemed to be at its height on July 20th. The eggs are placed in small cavities which extend less than half way through the husk of the nut. In one operation of egg-laying which was observed, the beetle spent 47 minutes in preparing a pocket for the egg, one minute in depositing the egg and 15 minutes in filling the space about the egg with scrapings from the husk. The last part of the act was performed after dark and was observed by the aid of a lantern. The beetles seem especially active in the early dark of the evening and it is probable that many of the eggs are deposited at that time.

The egg is oblong, elliptical in shape, surface smooth and glossy and the color clear white, the embryo showing through the shell. The dimensions of several specimens averaged;—length .04 inch, width .025 inch. One egg kept under observation hatched in five days.

The larvae are yellowish white with brown heads. In their



Egg-punctures in hickorynuts made by the Hickorynut Curculio. Natural size.



Egg-punctures in young black walnuts made by the Walnut Curculio. Natural size.

feeding they convert the entire interior of the nut into fine, granular excrement.

Several nuts on the trees that were marked at the time eggs were deposited in them dropped in from 15 to 20 days thereafter. The larvae remain in the nuts for a week or two after they drop and then make their exit through holes eaten in the shell at the point where the wound was made in depositing the egg. They enter the ground to a depth of from one to two inches and soon change to pupae.

A few individuals were found that pupated in the nut. These were supposed, at first, to belong to another species but proved on reaching the adult stage to be the same as those that transformed in the ground.

Most of the young adults appear in August and September. My record for the first individual to issue in breeding jars is August 12th and for the last October 10th. The winter is passed in the beetle stage.

Mr. W. Dwight Pierce reared beetles of this species from fallen hickorynuts in Louisiana in July, 1906. (Entomological News, Vol. 18, 1907, p. 362.)

ACORN CURCULIOS.

In addition to the several species of *Balaninus* that depredate on acorns, a large number of two species of curculios were reared from infested nuts of white and chestnut oak. The habits of the two species are somewhat similar and in color and structure they are much alike. Both deposit their eggs in acorns in the fall and the larvae issue from the nuts during the succeeding winter and spring and enter the ground, where they transform to adults about mid-summer.

THE LARGER ACORN CURCULIO, *Conotrachelus naso* Lec.

This beetle is about the size and color of the walnut curculio, the most conspicuous difference being the longer and more slender snout. The color is dull brown mixed with black. On the

back are several small spots of a lighter shade due to the dirty, white pubescence that sparsely clothes the body.

On September 24th, 1907 I watched one of these beetles depositing eggs in a chestnut oak acorn. It had selected an acorn that had the shell cracked so that there was no covering to penetrate in getting at the meat. The insect spent 15 minutes in making an egg chamber of the desired depth. She worked with considerable energy and every few seconds her beak would be withdrawn from the opening with a chip of the meat held in the jaws. These chips were placed in a small heap by the side of the opening and, when the excavating was done and the egg inserted, the chips were packed loosely about the egg until the cavity was filled. One of the beetles was seen feeding on a chestnut but no eggs were deposited in this nut.

This species was reared from both white and chestnut oak acorns, the beetles issuing from the earth in June and July. It has been bred in Texas from acorns of post oak.

The egg is creamy white, oval, .03 inch long and .015 inch wide, the surface being delicately granular. A dozen or more eggs may be deposited in one acorn.

THE SMALLER ACORN CURCULIO, *Conotrachelus posticatus* Boh.

This beetle is smaller than the one just described, the snout being shorter and stouter. The color and general appearance of the two species are similar.

The adults were not observed on the trees and no eggs of this species have come under my observation. They were reared abundantly from chestnut oak acorns. The adults issued from the ground in breeding jars during June, July and August. F. M. Webster has reared this species from white oak acorns and E. A. Swartz records that the larvae dwell within the galls of certain *Phylloxera* on hickory leaves. W. D. Pierce has bred it from prematurely fallen hickorynuts in Louisiana.

NATURAL ENEMIES.

The nut-infesting snout beetles are preyed upon by several kinds of insects and larger animals, but these natural enemies are not sufficient to keep them within the bounds of inoffensiveness.

The habits of these snout beetles are such that it seems improbable that we will ever be able to carry on a very successful warfare against them, and, since we can do so little in the way of holding them in check, it is interesting to know what nature is doing to retard their multiplication.

One of the most important of their enemies is a medium-sized, four-winged fly, a bracon parasite, known technically as *Urosigalphus armatus* Ashm. This parasite is a foe of the nut weevils and issues from the ground along with the beetles in the summer. It seems especially fond of the larger chestnut weevil and while the beetles of this species are laying their first eggs in the young chestnut burs the parasites fairly swarm among the branches. On August 28th, 1906, from a low-hanging chestnut branch that bore about seventy-five burs, I collected, in thirty minutes, 24 of the weevils and 26 of the parasites. Since that time they have been seen in equal abundance on numerous occasions.

This parasite has a long, external ovipositor, almost equal in length to the beak of the weevil. After the weevil has pierced the nut and inserted its egg, the parasite finds the same orifice, thrusts in its ovipositor and deposits an egg. The grub that hatches from the egg of the parasite feeds internally on the "chestnut worm," and although it opens hostilities soon after the weevil is hatched, it appears to cause its victim no serious inconvenience until the following year at just the time the weevil larva would pupate. Then the parasite kills and almost entirely devours the weevil. In the cell which the chestnut worm prepared for its own transformation quarters the parasite constructs a cocoon, four-tenths of an inch in length, within which it changes to the winged stage. Having reached maturity, it soon

works its way to the open air and flies to the trees to prepare for another brood of parasites by laying its eggs in the weevils punctures.

The parasite has a wasp-like appearance but if caught in the hand it will not sting although it gives off a very offensive odor. About 25 per cent of the larvae of the larger chestnut weevil are parasitized by this species and, apparently, a considerably smaller per cent of these of the other species of *Balaninus*.

It seems probable that the habits of plastering over their egg-punctures and of hiding their eggs in the side branches of the main galleries, which are practiced by some of the acorn weevils, are devised for outwitting this parasite.

A smaller bracon parasite, known as *Sigalphus curculionis* Fitch, was reared in abundance from the larvae of the hickory-nut curculio and in lesser numbers from those of the walnut curculio.

A number of small, brown ants, *Lasius aliena* Fors., were found that had broken into the earthy cell of a larva of the larger chestnut weevil and were devouring the insect. Another species of ant somewhat larger than the one mentioned first and known as *Aphaenogaster aquia* Buck., was found with a number of partly eaten *Balaninus* larvae stored in its nest under a stone in the woods. Still another species, a small, red ant, *Solenopsis debilis* Mayr., was found attacking larvae of the walnut curculio within young black walnuts on the ground.

Several specimens of two parasitic flies, about the size of the common housefly, were bred from the nut enemies. One of these, *Metadexia basalis* G.-T., was bred from the larva of the hickorynut curculio and the other, *Myophasia aenea* Wied., was reared from white oak acorns infested with the larvae of *B. pardalus* and *C. naso*. From which species the fly came, was not determined.

The larva of an undetermined click-beetle was found feeding on a larva of one of the nut weevils, and on another occasion a nymph of the spined soldier-bug, *Podisus maculiventris*,



Larvae and pupae of Larger Chestnut Weevil. Natural size.



Cocoons of a parasite of nut weevils, *Urosigalphus armatus*. Natural size.



The Short-tailed Shrew. An enemy of nut insects.

was found with a live, adult larger chestnut weevil impaled on its beak, which it soon killed. ,

Perhaps the most important enemy of these snout beetles, especially of the nut weevils, is the short-tailed shrew, a little, insectivorous mammal that lives in the ground. These little shrews are not often seen but they are exceedingly abundant, especially in woods and in shady and weedy places in fields. They are very fond of the fat, juicy grubs of the snout beetles, and while these grubs are in the ground undergoing transformation or hiding for the winter, they are found by shrews and devoured by thousands. In the ground beneath nut-bearing trees a labyrinth of burrows will be found frequently that have been made by the shrews in their search for insects. In such places not more than 10 per cent of the larvae that enter the ground in the fall can be found the following spring. That the shrews are chiefly responsible for their disappearance is shown by the numbers of the mammals that can be trapped in such places and by their fondness of the larvae when in captivity. It has been found that a shrew in 24 hours will eat a quantity of the larvae greater in weight than that of its own body. On one occasion, I saw a shrew devour 70 large "chestnut worms" within a space of five minutes.

For further notes on this feeding habit of the shrews, see Bulletin 113, W. Va. Agr. Expt. Station.

METHODS OF CONTROL.

This is a difficult group of insects to deal with so far as remedial measures are concerned. The internal feeding habits of the larvae, and to a great extent of the adults also, together with the fact that most of the activities of the more injurious species are carried on in the tops of large trees, places them beyond the reach of our ordinary insecticides.

All the species, being native to this country and having their wild food plants, propagate their kind in the woods and furnish from that source an abundant supply of recruits to

take the places of any that may be destroyed in cultivated nut orchards and groves. The case is not hopeless, however, and some very satisfactory results are being obtained by a few persons who are producing and handling nuts on a large scale.

FUMIGATION WITH BISULPHIDE OF CARBON. This material may be obtained at most drug stores at a cost of about 25 cents a pint in small quantities. Fumigation with it is recommended for nuts when they are first harvested. The treatment kills many of the larvae within the nuts before they have attained much size, and renders the nuts more salable, although it may be a question as to whether or not the consumer should be pleased with this manner of hiding the defective kernels.

In using this treatment, a light box or barrel is provided of a size sufficient to accommodate the quantity of nuts to be fumigated. The nuts are placed in the receptacle and a shallow dish set on top of them. Into this dish the bisulphide is poured, from half an ounce to an ounce being used for each bushel of nuts. The receptacle containing the nuts should be furnished with a tight fitting lid and this should be put in place at once after the liquid is poured into the dish. The nuts should then be left undisturbed for from twelve to twenty-four hours.

The bisulphide of carbon volatilizes very rapidly and the gas which is thrown off, being heavier than the atmosphere, settles to the bottom of the vessel, penetrating the shells of the nuts and killing the insects within. The tighter the receptacle containing the nuts the less bisulphide will be required and the more effective will be the treatment. It may be necessary to repeat the fumigation in about ten days to kill the young larvae that hatch from eggs that were in the nuts at the time of the first treatment.

The bisulphide of carbon has a very disagreeable odor but this passes off quickly after the nuts are exposed to the air. In using this material care should always be taken to keep fire away as the gas is very inflammable.

DESTROYING INFESTED NUTS. The larvae of most of

the species of weevils and curculios remain in the nuts for some time after the nuts drop to the ground. If such nuts are gathered carefully and thoroughly and the worthless ones fed to hogs or burned many larvae will be destroyed and the generation of beetles that would injure the next season's nuts be greatly reduced.

CULTIVATION. Cultivation of the soil about nut trees is not often practiced in this section of the country, but, where practicable, spring and summer cultivation may be counted on to destroy many of the insects by breaking up their hiding places in the earth and exposing the larvae and pupae to the air and to natural enemies.

TRAPPING THE BEETLES. On a previous page of this paper the habit which the adult hickorynut weevil has of hiding in dead leaves that adhere to the branches is alluded to. The tendency to hide in these brown, curled leaves is so great that in at least one instance when a medium-sized bearing hickory tree was examined, practically every dead leaf on the branches that could be reached by climbing contained one or more beetles. On that occasion none was found in any other situation. In a small way, I experimented with hanging twigs covered with dead leaves to the branches and on the body of the tree at about the time the beetles were most abundant. I had no difficulty in trapping a considerable number of beetles in this way, and found that the insects could be destroyed very easily by dipping the leaf traps into hot water.

It is possible that in pecan and hickory groves much good might be accomplished by trapping in this way with bunches of dead leaves or with some other device that would afford shelter for the insects. The method might be extended to some of the other species of nut weevils but, from our knowledge of their habits, it may be said that the hickorynut weevil is the most promising species for experiments of this kind.



