HARVARD FOREST

BULLETIN NO. 3

RICHARD T. FISHER, *Director*

THE LIFE HISTORY AND CONTROL OF THE PALES WEEVIL

(HYLOBIUS PALES)

BY

H. B. PEIRSON

HARVARD FOREST, PETERSHAM, MASS.

1921

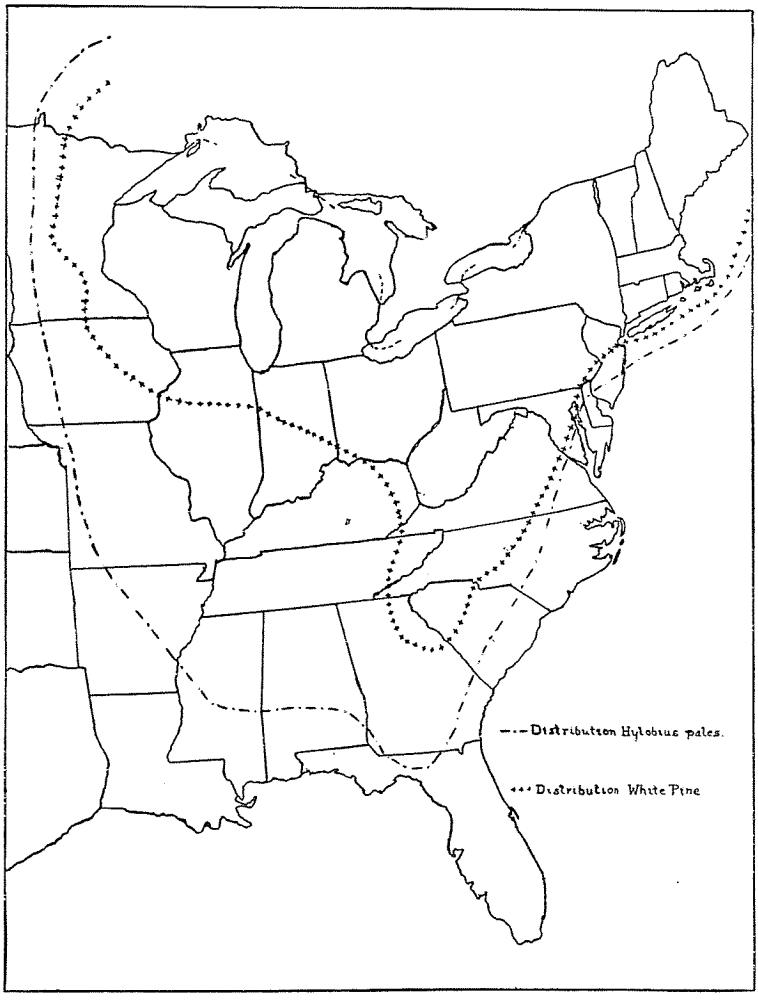

FIGURE 1. Distribution of *Hylobius pales* and the White Pine (*Pinus strobus*) in the United States.

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CONTENTS

THE LIFE HISTORY AND CONTROL OF THE PALES WEEVIL (*HYLOBIUS PALES*)[1]

INTRODUCTION

It is a notable fact that in spite of the serious damage caused by *Hylobius pales*,[2] it escaped all notice as an economic forest pest, in its adult stage, until 1914, although it is a native of the United States. At this time Professor E. E. Carter of the Harvard Forest School, made an effort to ascertain the reason for the almost universal failure of coniferous plantations on recently cut-over pine woodlots. He found that the failures were due, not to climatic or other natural causes, as has been supposed, but to the presence of *Hylobius pales* Herbst, a snout beetle which feeds voraciously upon the bark of coniferous seedlings. Furthermore, he found that the beetles have a wide range of coniferous food plants and that an infestation lasts for several years. The reason for overlooking the seriousness of the pest is very apparent when one considers that dead two or three year old pine seedlings, amongst the vast amount of both growing and decaying vegetation, are very inconspicuous even when one is looking for them. Once girdled, the seedlings rapidly deteriorate and in falling over are covered up with dried leaves and other vegetation. Previously this beetle had been recorded as breeding in stumps and logs of recently felled trees, but, as far as can be determined, never as feeding on coniferous seedlings.

The present study of the life history and control of the pales weevil was started in September of 1919. It is based almost entirely upon results obtained at the Harvard Forest,

[1] Work done in coöperation with the Entomological Laboratory of the Bussey Institution. Contribution No. 180.

[2] Classification according to Blatchley and Leng. Order, Coleoptera; Family, Curculionidae; Sub-family Curculioninae; Tribe, Hylobiini.

Petersham, Mass. Here an admirable set of conditions exist for the study of such a problem. Yearly cuttings with consequent reproduction and plantations offer advantages which otherwise would require a series of years to obtain. Varying conditions of moisture, soil, and exposure have also helped materially in dealing with the problem. Nearly all trees native to New England are found either in the Forest or in close proximity to it, so that the range of food-plants in different latitudes was apparent without recourse to other localities, although verifications were obtained wherever possible.

The author is indebted to both Professor C. T. Brues and Director R. T. Fisher of the Harvard Forest School, for their aid in carrying out the following work. Thanks are also due Mr. E. E. Carter, of the U. S. Forest Service, for turning over notes made on the destructiveness of the pales weevil while he was connected with the Harvard Forest School, as Assistant Professor of Forestry.

HISTORY AND DISTRIBUTION

Hylobius pales is undoubtedly a native of the United States and apparently occurs no where else except in Canada. It was first recorded as a destructive insect about 1840 by Wilson in "American Ornithology." He records the larvae as killing large areas of conifers by burrowing in the trees. His record is undoubtedly an exaggeration or mistaken identity, due to his lack of acquaintance with the pales weevil. The next record of note is contained in Harris's "Insects Injurious to Vegetation," (1852) in which he states that he "found the beetles in large numbers during May and June, on board fences, the sides of new wooden buildings, and on the trunks of pine trees." Numerous later writers mention collecting the beetles. Packard (1890) collected larvae and pupae from pine and saw the adults flying. Felt (1906) records the presence of the adults on pine and in mill yards.

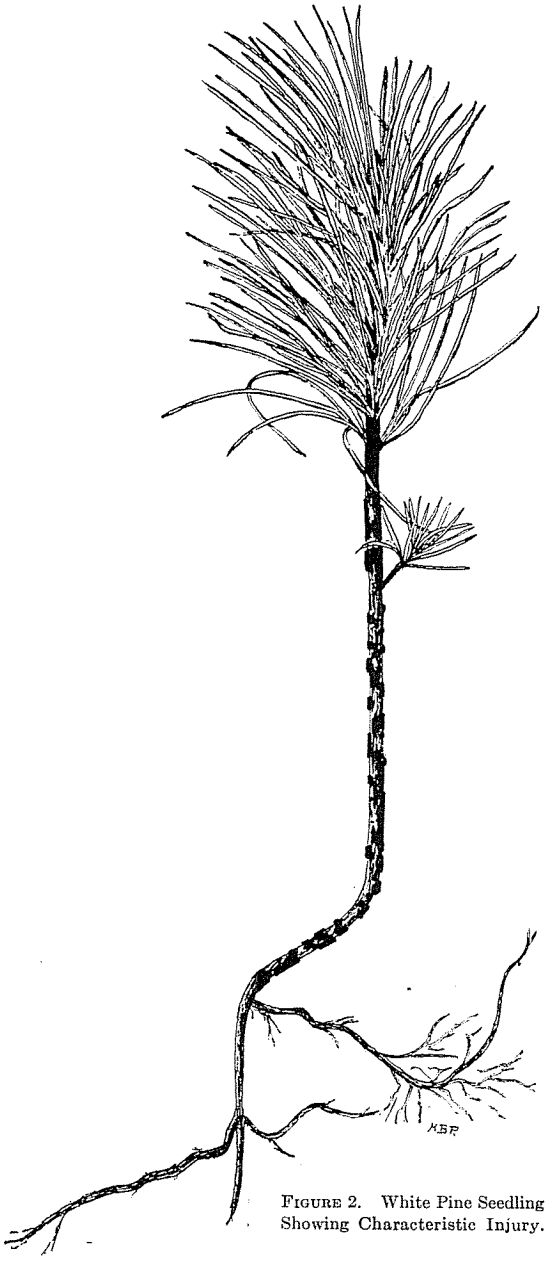

FIGURE 2. White Pine Seedling Showing Characteristic Injury.

A very similar species, *Hylobius abietis*, occurs throughout Europe, and to quote Gillander in his account of the beetle in his book entitled "Forest Entomology," "This is considered one of the worst insect enemies the forester has to deal with; in fact, it may be said to be the most dreaded beetle." The habits of the European species are almost identical with those of *Hylobius pales*. No method of control has been found in Europe which will permit the planting of seedlings on cutover areas until three years after cutting. Numerous methods of control are mentioned by English, German, and Russian entomologists, but all conclude in stating that plantations should not be started for two or three years after the tract has been cut over.

The distribution of the pales weevil seems to be general throughout the Eastern half of the United States and in South-eastern Canada. Specimens have been collected from Minnesota, Michigan, Indiana, Illinois, Missouri, Arkansas, and Mississippi on the west; Florida on the south, and South-eastern Canada on the north, with collections all along the Atlantic sea-board (Fig. 1).

Although in New England the white pine is the most favored food, it is apparent that in a large part of the area trees other than white pine must be fed upon, due to the restricted distribution of the tree as shown by the accompanying map. From reports obtained, however, it seems to be true that the beetle is much more abundant in the white pine area, especially where frequent cuttings are being made.

NATURE OF DAMAGE

The adult beetles feed on the tender bark of coniferous seedlings, oftentimes entirely stripping the bark from the stem and side branches. The most characteristic injury, however, is the removal of the bark in irregular areas leaving numerous criss-cross ridges. The beetles are voracious feeders and will kill a three or four year old white pine seedling within a

very few days. As many as thirty beetles have been found around the base of a single seedling.

It has long been observed in New England that it is almost impossible to secure a reasonably pure stand of white pine reproduction promptly after the removal of older stands of

FIGURE 3. Typical Injury on Main Stem of Seedlings Showing Numerous Criss-Cross Ridges Left by Beetle.

pine, even though large numbers of seedlings may be present. Several causes have been suggested to account for the loss of these seedlings. It has been suggested that the young hardwoods already present, entirely crowd out the pine, or that extreme acidity of the soil, due to the decomposition of the leaf litter, does not favor the growth of the pine seedlings. These explanations do not, however, satisfy all conditions,

for damage is just as prevalent in grass covered areas, as was shown by Carter, such as pastures where limby pasture pines have been cut down to give the young seedlings a better chance to develop. In one case a broken stand of limby, pasture grown pine was removed from over a veritable carpet

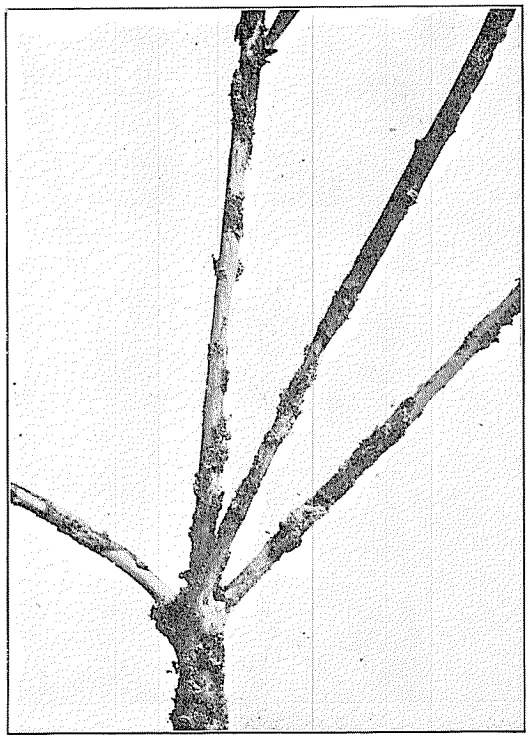

FIGURE 4. Typical Injury Showing Girdling Effect on Dead Seedling Killed by *Hylobius pales*.

of white pine seedlings, which were from two to six inches in height. Three years later there were left less than ten per acre of these thousands of young pines. In another case a stand of white pine was removed, the area cleared and set out as a nursery with white pine. The beetles were immediately attracted to the spot and completely ruined the nursery.

The beetles have been collected wherever a pine cut has been made.

As an example of how little cutting it takes to attract the pales weevil, a small white pine which was growing in a stand of gray birch was cut. The tree was about twelve feet in height with a stump diameter of four inches. All the slash was immediately removed, except for a few twigs that were placed on the stump and burned thoroughly so that the outer portion of the stump was completely charred. Fourteen white pine seedlings were then set out around the stump covering an area of about twelve feet in diameter. In two weeks from cutting eleven of the seedlings had been damaged by the beetle. The area where this experiment was carried on was more or less covered with scattered white pine seedlings, but none of these had been harmed previous to the cutting of the single white pine.

The beetles are attracted purely to areas where lumbering operations have been carried on, such as the felling of trees and the sawing and stacking of lumber, or to areas where trees have been destroyed in such a manner that the odor of pitch or sap is still apparent.

In order to ascertain the amount of damage and probable length of infestations, large numbers of counts were made covering approximately forty acres of cut-over pine lands. Included in this area were tracts which had been cut from one to five years previously. In making these counts typical areas varying from 225 square feet to areas of 3000 square feet, depending on the density of the pine seedlings, were marked off, and all of the seedlings counted and tallied under the heads of (1) Healthy, (2) Dead from Unknown Cause,(3) Killed by *Hylobius pales*, (4) Injured by *Hylobius pales*. Figure 5 shows a typical area as copied from the field diary. As much as possible these plots were so scattered in the areas that a general average could be obtained. The counts from the different tracts were then sorted according to age of the cut so that the figures, for example of the 1919

cut, could be averaged together. In this way the degree of infestation was obtained, for not merely one cut-over area, but for the general district around Petersham where the counts were made. See table on the following page.

It is apparent then, that damage occurs the first three years after a cutting of white pine, ninety-eight per cent of

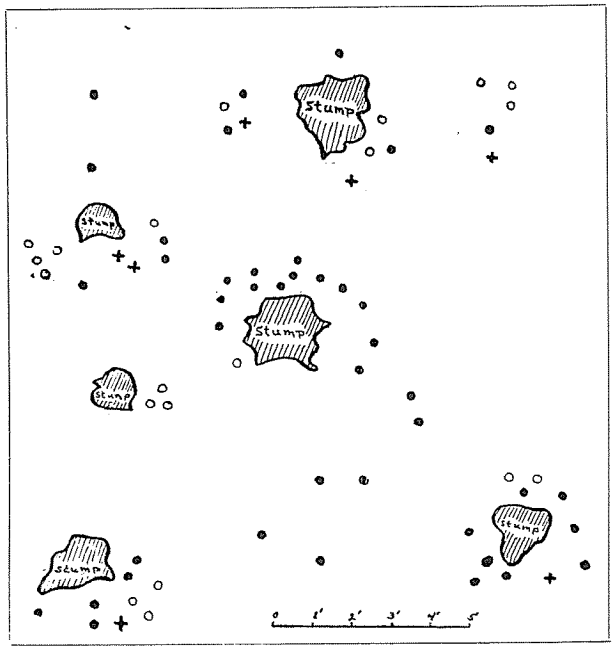

FIGURE 5. Typical First Year Infestation as Copied from Field Diary.
+ Healthy White Pine Seedlings, 28.2%.
o Seedlings Dead from Unknown Causes, 11.27%.
● Seedlings Killed by *Hylobius pales*, 60.53%.
None Merely Injured.

it occurring the first two years, and that after the third year no new injury is done.

In one location about one million feet of lumber were piled at one end of a pasture which was fast being reforested by natural pine seedlings. The lumber was largely white pine. The beetles were immediately attracted in large numbers and the succeeding infestation proved to be one of the most

SUMMARY OF COUNTS MADE IN OCTOBER, 1919

Date of Removal Cutting	Year of Infestation	Approx. Size of Areas Examined	Percentage of Trees Killed during Feeding Season
1918–1919	First	23.95 Acres	40%
1917–1918	Second	7.95 "	40% (Additional to above)
1916–1917	Third	13.7 "	2% " " "
1915–1916	Fourth	1.6 "	0%
1914–1915	Fifth	10. "	0%

severe in the locality. The center of the infestation proved to be the lumber, and from here the beetles worked out, killing practically all of the seedlings as the infestation spread. At the beginning of the second year of infestation there was hardly a live seedling to be found within five hundred feet of the lumber. Even the maturing twenty to thirty year-old white pines surrounding the pasture were attacked, the beetles feeding on the tender twigs. The large trees were by no means seriously damaged but most of the twigs fed upon were killed.

In a like manner experiments showed that freshly cut slash will attract the beetles even when carried a long distance from the cutting. Freshly cut pine logs when piled in an open pasture preparatory to sawing attracted thousands of the beetles.

Experiments carried on in the laboratory only emphasized the fact that the beetles are endowed with an exceedingly acute sense of smell. Especially arranged chambers with connecting galleries were used for testing their power of smell. A small freshly cut pine twig was placed in one chamber. The beetles liberated in another chamber soon sensed the odor and crowded over one another in their effort to get at the twig. The beetles had not been fed for a day, so that hunger undoubtedly hastened the reaction.

FOOD PLANTS

The beetle has a wide range of food plants and has been found feeding upon all of the coniferous species growing in the vicinity of fresh cuttings in Southern Maine and in Central Massachusetts. White pine is, without any question, the favorite food in these localities, but in the absence of this tree other coniferous seedlings are voraciously fed upon. In one place on the Harvard Forest a plantation of red pine, *Pinus resinosa*, was started on an area which had been cut over two years previously. The first year after the cutting, a heavy infestation of the beetle occurred, the majority of the white pine seedlings, which, due to proper forest management were reforesting the area, having been killed. The second year as there were comparatively few white pine seedlings present, the beetles attacked the red pine, which had just been set out, and either killed or injured approximately forty-eight per cent of the trees. These seedlings were five-year old stock, the bark of which is relatively rough and heavy.

The general susceptibility of the young seedlings seems to depend largely upon the nature of the bark. Those seedlings having relatively thin, tender bark, being favored for food. The exuding of pitch retards feeding to a noticeable degree. Injury likely to cause death is confined to trees under three feet in height. In the breeding cages, fresh white pine chips were the most favored food, but in the absence of other foods, even hardwoods were fed upon.

The following is a list of known food plants. Records have come to notice of the beetle having been found on plum and cotton, but no verifications have been obtained.

Pinus strobus L. White pine.
Pinus rigida Mil. Pitch pine.
Pinus resinosa Ait. Red or Norway pine.
Pinus ponderosa Laws. Western yellow pine.
Pinus sylvestris L. Scotch pine.
Larix laricina (Du Roi) Koch. American larch.

Larix larix (L) Karsten. European larch.
Picea rubra (Du Roi) Dietr. Red spruce.
Picea Abies (L.) Karsten. Norway Spruce.
Abies balsamea (L.) Mill. Balsam fir.
Tsuga canadensis (L.) Carr. Hemlock.
Pseudotsuga taxifolia (Lam.) Britton. Douglas fir.
Thuja occidentalis L. Arbor Vitae.
Juniperus communis L. Common juniper.
Juniperus virginiana L. Red cedar.
Betula populifolia Marsh. Gray birch.
Fraxinus americana L. White ash.

FEEDING HABITS OF ADULT

Extensive observations have shown that *Hylobius pales* is typically a nocturnal feeder, although a few beetles can practically always be found feeding during the day. These, however, are usually feeding on the underside of twigs or at the base of the seedling just below the surface of the ground. In the insectary one cage was kept dark by covering with a heavy manila bag. In this cage beetles could be found feeding at all times. In the field the beetles are rarely found feeding in the direct sunlight except after long, heavy storms, or during warm periods of weather which have been directly preceded by low temperatures.

The beetles start feeding soon after sundown and by midnight the majority of them are feeding, or at least are active. By sunrise the majority of the beetles have sought shade in the soil around the base of the seedlings. Many merely hide on the underside of fallen leaves. This habit was taken advantage of in collecting the beetles, pine chips being placed at the base of the infested trees, and the beetles collected from under these. It is a common occurrence to find from ten to fourteen beetles at the base of a single seedling, although their color and habit of feigning death tends to make them easily overlooked.

The beetles are hearty feeders and, when necessity demands, will feed on a great diversity of food. They are not gregarious in their feeding habits, seldom more than three

being found close together on the same twig. A favorite place of feeding is in the crotch of a twig and the main stem where the wood is particularly sappy. The new buds are also favored in some localities, although this does not seem to be general. Oftentimes seedlings may be entirely stripped, not a vestige of bark remaining. That portion of the seedlings from which the needles have fallen is usually attacked first.

Very often seedlings which appear healthy or even slightly yellow, and which show no signs of having been attacked above the ground, are found to have been girdled or partially girdled just below the undecomposed carpet of needles or other vegetation.

Moisture is an essential element in determining the degree of infestation. Seedlings growing amongst moss are especially favored, whereas those growing on exposed dry places are far less susceptible to attack. In order to further exemplify this point, which was quite apparent in different localities, four large plots were marked out and all seedlings on each plot counted and examined. The plots were adjacent to each other so that soil, temperature, and light conditions were as nearly identical as possible. On two of these plots the ground cover was entirely removed so that the bare soil was visible. As the soil was rich in humus there was little likelihood of the seedlings drying up. Although this experiment has been running only about ten weeks there is already a noticeable difference in the degree of infestation between the cleared and uncleared plots.

MIGRATION

Observations made in the field tend to show that the beetles are present in small numbers through the woods regardless of whether there have been recent cuttings or not, and that they are attracted from long distances to freshly cut areas. It is this habit of migrating that causes the beetle to be of

such economic importance for it concentrates its attacks on areas where the young seedlings are just coming up to replace the cut timber.

The adults are strong fliers, the majority of them apparently flying within twenty feet of the ground, as is shown by the fact that mature pines are seldom fed upon above this height. The beetles have been observed hovering about in the air for long periods. An examination of the wings shows a strong development. It is interesting to note that the European species, *Hylobius abietis*, is said by European entomologists not to fly, although the wings show a development similar to that in *H. pales*.

An interesting example of their migrating habits occurred on a tract where there was a fairly heavy infestation of the beetles in a red pine plantation, which bordered one of the main roads. Large numbers of white pine logs had been hauled into a field on the opposite side of the road, preparatory to sawing. As the infestation was in its third year, thousands of the beetles migrated to the log-piles. In order to reach these it was necessary for them to pass through a fringe of pine trees bordering the road. Large numbers of the beetles must have stopped here to feed, for fully half of the young twigs showed signs of having been fed upon, large numbers actually being killed.

SEASONAL HISTORY AND HABITS

The adult beetles emerge from hibernation during the period from the latter part of April to the latter part of May, depending upon climatic conditions. The majority become active at approximately the same time. They immediately begin feeding and remain near the place of emergence until the middle of June. It is at this time, that in the third year of infestation, the heaviest migration takes place. The beetles swarm to some locality where, preferably, a white pine logging operation has just taken place. During their

flight they may stop for a short time to feed on mature pine. On reaching the new breeding grounds they may feed for from one to two weeks, upon the pine chips, slash, or even upon the bark of pine logs, if no suitable seedlings are present.

The small, pearly white eggs are usually laid singly, either in freshly cut pine logs or in the roots of fresh cut pine stumps. The beetles make a small perforation in the bark and crowd the egg into this opening. When the breeding takes place in log piles the eggs are almost invariably laid on the lower side of the under logs, where they rest upon the ground. Other conditions being favorable the eggs are usually laid in the ends of the logs just beneath the bark, around areas where limbs have been cut off, or in areas where the bark is reasonably thin and smooth. Large numbers of eggs are usually laid fairly close together. When breeding takes place around stumps the beetles burrow down into the soil for a distance of from three or four inches to a foot or more, and lay their eggs in small perforations made in the roots. Apparently, they prefer the underside of the roots for egg laying.

The eggs hatch in from ten days to two weeks and the small, footless, white grubs immediately begin burrowing beneath the bark. Unlike bark beetles, they apparently follow no direction, merely going where the food may seem most tempting. The larvae are gregarious and loosen the bark over large areas. As is the case with many other bark borers, turning the infested logs so that the direct rays of the sun strike the areas being tunneled, soon kills the larvae, due probably, to lack of moisture. They require nearly two months to mature, at which time they have attained a length of approximately one centimeter.

About the first of September the larvae pupate beneath the bark in individual cells, penetrating about one-quarter inch into the sap-wood and covered over with frass. In this stage they remain until about the first of October, although

some adults may emerge as early as September fifteenth. The adult beetles, after emergence, begin feeding upon the nearest pine seedlings. It is at this time that the most severe damage is done. As one seedling is stripped of its bark the beetles move on to the next, so that in areas where the seedlings are not thickly carpeted, every seedling may be killed or damaged.

Beetles have been found feeding as late as November eighteenth in the vicinity of Petersham, Mass., and as late as the first of December in an out-of-doors cage in Boston, Mass., the difference in altitude being a thousand feet. At Petersham, the ground had been covered with a light fall of snow for nearly a week, and frost had penetrated the ground to a depth of three inches.

By the twentieth of October the majority of the beetles have gone into hibernation. The winter is spent, for the most part, in the soil at the base of the seedlings upon which the beetles have been feeding. They penetrate the ground to a depth of six inches, where there is a tendency for them to congregate in groups. Some pass the winter in hibernation beneath stones at a similar depth. The different stages overlap to a considerable extent, larvae having been found as late as October eighth. Some individuals undoubtedly pass the winter in the larval or pupal stage in stumps or logs.

DESCRIPTION

Hylobius pales Herbst.

Curculio pales Herbst. Käfer, vol. 7, p. 31 (1797).

Pissodes macellus. Germar, Coleop. Spec., p. 319 (1827).

Hylobius pales. Dejean, Cat. Coleop. Coll. Dejean (1837).

Hylobius americanus. Dejean. Cat. Coleop. Coll. Dejean (1877). (Later edition).

Hylobius pales. Schönherr, Gen. Sp. Curculionidum (1842).

Hylobius pales. Leconte and Horn., Proc. Am. Philos. Soc., vol. 15, p. 140. (1876).

Hylobius pales. Blatchley and Leng, Rhynch. No. Am., p. 186 (1916).

The Adult

The adult (Fig. 6) is an oblong, robust, dark reddish brown to black beetle. Length 7–10 mm. the elytra have scattered small tufts of rather long gray or yellowish hairs, those be-

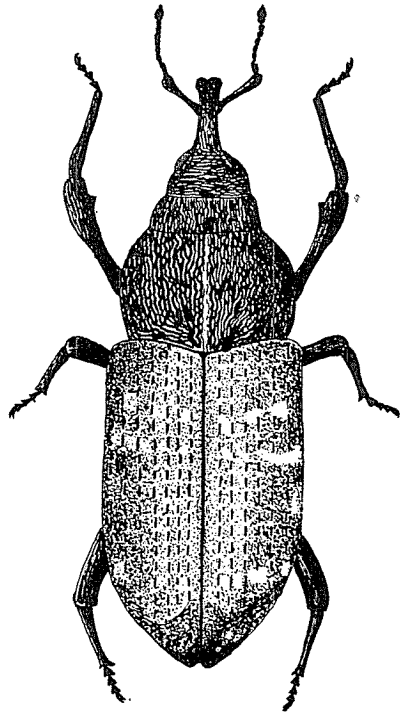

Figure 6. The Pales Weevil (*Hylobius pales*): Adult Greatly Enlarged.

hind the middle arranged to form two oblique cross bars. These, however, are not always distinct.

The *head* is sub-opaque, densely though not coarsely punctured. The *eyes* are large, coarsely granulated, transverse, separated by their own diameter, not contiguous beneath. The *antennae* are stout, more or less completely elbowed, the scape barely reaching the eye. Joints one and

two of the funicle are distinctly longer than the others, the first longer than the second, three to six moniliform, seven much broader, forming part of the club. The club is compact, oval, pointed, ringed, and wholly pubescent and sensitive. The antennae are inserted in front of the middle, their insertion being visible from above. The *beak* is free, stout, cylindrical, feebly curved, length approximating that of thorax. The beak is grooved for the reception of the antennae, the grooves being directed towards the lower part of the eyes. *Mouth parts.* Mandibles with two apical teeth, the lower one a little shorter than the upper and in addition having a little cusp on the inner edge so that they are in reality three toothed. The labial palpi are large, the mentum transverse.

The *thorax* is broader than long. The prosternum is broadly emarginate in front and fringed with long yellow hairs. The mesosternum is moderately long. The humeri are not truncated by protruding sides of mesothorax. The gular margin is prominent. The legs are stout, front coxae contiguous, femora club-shaped and strongly toothed. The tibia are rather slender, not narrowed towards tips, sinuate on the inner side, corbels narrow, terminal hook strong. The terminal edge of hind tibia is double. The third joint of tarsi is dilated, spongy beneath, claws simple, diverging.

The *abdomen* is sparsely and rather finely punctate. Lateral angles of first ventral segment covered by elytra, suture in front of second, broadly angulated at middle. The second and fifth ventral segments each as long as the third and fourth united. The male has an additional anal segment. The disc of elytra is distinctly flattened, striae with large, oblong punctures, intervals rather narrow, (flat, rugose-punctate).

The Egg

The egg is pearly white, slightly oblong, and is equally rounded at both ends. It is 1 mm. in length by .5 mm. in

diameter. The chorion is smooth, slightly glossy, and is of medium toughness.

The Larva

The larva (Fig. 7) is a white, robust, cylindrical, footless grub. The head is light brown. The spiracles are very prominent and are oblong in shape. When full grown the larva is approximately 12 mm. in length.

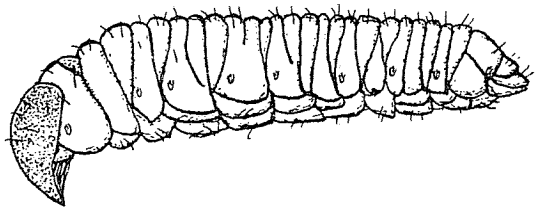

Figure 7. Larva of *Hylobius pales*. Greatly Enlarged.

The Pupa

The most characteristic point in identification in this stage is the pupal cell which is found beneath the inner bark of infested logs or stumps. The cell is made in the sapwood and is from one-quarter to one-half inch in depth, and is arched over with a thick cover of chips which the grub has chewed off. The pupa, which is approximately 10 mm. in length, is found beneath this cover of fine sawdust or chips. (Fig. 8.)

SIMILAR SPECIES

The Genus Hylobius includes about ten known species, of which *pales* and *confusus* are native to the United States.

Hylobius confusus Kirby, closely resembles small forms of *H. pales*. The head is more shining, less densely, and more coarsely punctured. Length of adult from 6–8 mm.

Pissodes strobi Peck, is probably the beetle most liable to be confused with the pales weevil. The simplest way of differentiating them from each other is to note the antennae.

In the pales weevil the antennae come out nearly two-thirds way down the beak, whereas in the white pine weevil the antennae are inserted about midway on the beak. The white pine weevil is smaller and generally of a reddish-

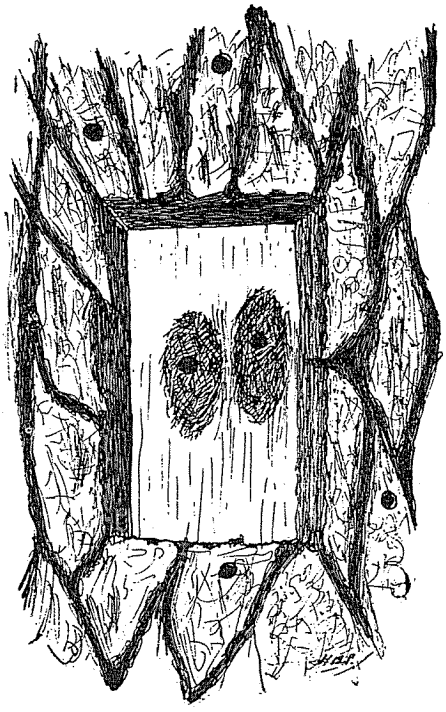

FIGURE 8. Pupa Cases of *Hylobius pales* Beneath Bark. Actual Size.

brown tinge with prominent light markings on the elytra. This beetle also feeds to a slight extent on the bark of white pine, prior to egg laying.

GENERAL BEHAVIOR AS AFFECTING CONTROL

In an effort to find a feasible method of controlling the beetle by the use of repellents, poison baits, or banding materials, experiments were carried on both in the field and

in the laboratory. It was essential that the cost of application be kept low, as will be explained under General Control Methods. Plots were treated with repellents such as borax, lime, and napthaline, others were treated with Tanglefoot.

Owing to the fact that the beetles thrive best in a rich humus soil it was suggested that the application of lime might prove of benefit in keeping the degree of infestation low. This, however, proved to be of no practical use as the beetles were in no wise repelled by the lime. More extensive experiments might prove otherwise, but this is doubtful.

Plots were also treated with borax and napthaline, the substances being placed around the seedlings in powdered form. The cost of application depends almost entirely upon the prevailing labor prices. Borax proved to be of no use. On the other hand napthaline has a negative chemotropic effect on the beetles. The degree of the repellence does not appear, however, to warrant the application of it on a large scale.

Tanglefoot acts as a decided barrier due entirely to the stickiness of the substance, the odor having nothing to do with its action. The Tanglefoot was placed in bands around the base of the seedlings on the main stem, about one-half inch from the ground level. The beetles will try again and again to cross a band of the substance, there being no hesitation until the first four legs are completely entangled. Numerous factors tend to discourage the use of banding materials on seedlings in the control of *Hylobius pales*. In the first place the effect upon the growth of the seedlings is yet to be worked out. The bark on a white pine seedling is very tender and would probably be penetrated easily by oils which would interfere with the growth of the tree. In the second place observations have shown that the beetles will feed on the stem beneath the soil and also that they are strong fliers, which latter characteristic would enable them to get above the band. The fact that the band must necessarily be near the surface of the soil means that the winds

and rains would tend to cover it with material from the ground cover and soil, that would permit the beetles to cross. Then there is the item of cost which would necessarily be quite large, due to the labor of treating the seedlings. This would immediately eliminate the treatment of natural seedlings. The labor involved in treating seedlings in plantations as they are being set out would not, however, be prohibitive. The seedlings can easily be bent "U-shaped" and dipped in the banding material just as they are being transplanted from the nursery.

The beetles proved to be positively chemotropic to odors arising from citrus fruits. This led to the idea that poison baits might possibly be used. Experimentation, however, proved that the attractive power of the fruit was easily offset by the presence of pine chips. As these latter are invariably present on cut-over areas, poison baits in which an aromatic oil is the basis, would prove of little or no avail. Other types of baits have not as yet been tried.

The habit of feigning death is highly developed in *Hylobius pales*. If disturbed when feeding, the beetles drop to the ground and crossing their tibiae assume a position as in death. If disturbed by jarring or by the breath while walking, they immediately become motionless in which state they will remain for some time after the apparent danger is past. This habit of feigning death, together with their natural soil-like color, make them easily overlooked when collecting, so that sifting of the soil or placing upon white paper was frequently resorted to. It was interesting to note that rubbing the tarsi, even with a dissecting needle, would invariably arouse the beetles to activity.

The instinct of self defence is decidedly lacking. When attacked by other insects, such as ants, the beetles offer no semblance of defence. An example of this was noticed when several mound building ants, *Formica exsectoides*, attacked one of the beetles. The pales weevil was immediately rolled over on its back, in which position it folded its legs and

antennae close to its body, in short, apparently feigned death. The ants were unable to reach any vital point due to the heavy chitinous coating of the beetle. They contented themselves with chewing off the tarsi, the beetle offering no resistance. This very apparent lack of ability to defend themselves, even against smaller enemies, is probably due to a long dependence upon their protective coloring and heavy chitinous coating which offers considerable protection.

The beetles are by no means weak, for they are able to move bodies weighing several times their own weight. Then again they are equipped with sharp, powerful mandibles with which they could inflict severe wounds upon insect enemies, if this strength were only supplemented with quicker actions.

NATURAL ENEMIES

The pales weevil has few natural enemies, and these cannot be relied upon to hold the pest in check. Up to the present writing no insect parasites have been bred from the larvae, although parasitic Diptera and Hymenoptera have been repeatedly taken in the vicinity of logs and stumps in which the weevils have been breeding. The beetle, however, is admirably protected from insect attack throughout its life.

A few of our native birds feed upon the adults, but as the latter come out in numbers only at night, few are killed. Woodpeckers often feed upon the larvae.

It is a common occurrence to find mole tunnels in areas where the infestation is heavy, and undoubtedly the moles feed upon the adults. A small snake has also repeatedly been found at the base of infested trees.

FUNGI

One of the imperfect fungi *Sporotrichum globuliferum*, undoubtedly plays an important rôle in the control of Hylobius pales, and often attacks other Coleoptera and Hemiptera. The fungus spores are wide-spread, diseased beetles or larvae

being found under a great variation of conditions. The maturation of the fungus, however, depends to a great extent upon an abundant supply of moisture.

The fungus appears as cottony masses breaking out through the intersegmental membranes, joints of the legs, and end of the beak. In advanced stages the beetles become practically covered with the mycelium and fruiting bodies. Stephens [1] describes the fungus as follows, "Hyphae widely spreading, much branched, conidiophores simple, short. Conidia acropleurogenous (born on sides of apex). Hyphae hyaline in more or less cottony masses." The mycelium may at times nearly fill the body cavity.

In an endeavor to study the possibilities of using the fungus as an artificial control measure, cultures were grown on potato agar. The fungus grows readily at ordinary room temperature. A study of germinating spores showed that branching begins to take place the fourth day. The growth is not rapid and care must be taken to prevent contamination, as molds quickly outstrip the fungus in growth. Colonies of the fungus from one to two square inches in size require approximately two weeks to grow.

In the majority of cases the beetles probably become infected through feeding, as this method of inoculation proved to be the most satisfactory in the laboratory, although dipping the beetles in a mixture of spores suspended in water gave satisfactory results. The beetles are killed within four days from inoculation. Checks were of course kept, and in no cases did these become infected. A mite was found in connection with the fungus which may possibly aid in carrying the spores.

Cultures of the fungus were transferred to a medium of boiled rice which was mashed so as to give a reasonably smooth surface upon which the fungus could easily be examined. Growth was noticed the day following inoculation. The growth on rice permits an easy dissemination of the

[1] "The Fungi which Cause Plant Diseases."

fungus in the field, the rice merely being spread broadcast around the base of pine seedlings. The rice apparently has no attractive power to the beetles, but merely serves as a spreading agent, the beetles becoming infected through actual contact.

Owing to the fact that the virulence of the organism depends almost entirely upon moisture, and that the fungus is

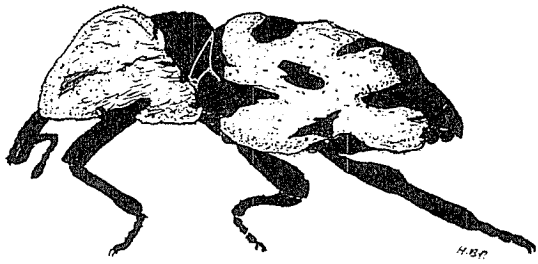

FIGURE 9. Beetle Infected with *Sporotrichum Globuliferum.*

apparently widespread, regardless of artificial dissemination, its use as a control method would hardly be worth while. Nevertheless it is true that under favorable conditions the fungus takes a heavy toll from the beetles. This fact was clearly presented in a breeding cage containing about one hundred and fifty adults. The cage was kept fairly damp and two or three diseased beetles left within. At the end of two months nearly all had succumbed to the fungus.

The conditions affecting the spread of the fungus amongst larvae, appear to be identical with those affecting the adult. Larvae feeding beneath the bark of round-edged lumber, or in logs which are exposed to dampness, become infected with the fungus. As the larvae are gregarious in their feeding habits the mortality is increased to a considerable degree.

METHODS OF CONTROL

The control of a forest pest must necessarily be carried on at a minimum of cost, and in the case of the pales weevil, practi-

cally devolves upon some form of forest management, other methods previously mentioned having thus far proved of little avail. There are two distinct types of infestation to be dealt with: First, that occurring on cut-over areas, and second, that occurring in pure stands of seedlings such as forest nurseries, plantations, and natural pine reproduction on open pasture land.

CONTROL ON CUT-OVER PINE LANDS

I. *In Natural Reproduction*

In view of the fact that the beetle destroys eighty per cent of the coniferous seedlings on a freshly cut area, it is obvious that if a large enough number of seedlings can be made available this damage can, to a great extent, be offset. If then, for example, a cut-over area could be started with ten thousand or more seedlings per acre, enough would remain, after the ravages of the beetle, to form the basis of a valuable mixed stand of hardwood and softwood.

Various methods of handling pine stands have been tried out on the Harvard Forest and these are explained in an article by R. T. Fisher and E. I. Terry entitled, "The Management of Second Growth White Pine in Central New England." [1] In brief it can be stated that the so-called shelter wood method has resulted in a reproduction of pine varying from three thousand to twenty-five thousand seedlings per acre. In order to obtain these results a thinning is first made to stimulate pine reproduction that will be available when a clear cut is made. If the clear cut is to be made during the fall or winter following a heavy fall of seed, a preliminary thinning is not necessary. After the cutting, the slash is burned in piles. The new crop on the cut-over areas is then weeded usually twice, depending upon the site. The first weeding is done when the reproduction is from three to five years old, and the second during the period between the

[1] Journal of Forestry, vol. xviii, no. 4, April, 1920.

eighth and tenth years. This method of management results in a good mixed stand in spite of the damage done by the pales weevil. It is well to bear in mind that the pure pine stand as found in Central New England is simply a transition type, which has encroached upon open pasture lands, and is being replaced after cutting by mixed hardwood, except upon thin-soiled or sandy areas, in which localities the soft woods thrive best. It is hardly worth while then to strive to obtain pure stands of pine on cut-over areas.

Year-old seedlings are seldom attacked. This is undoubtedly due to the small amount of sap which would be present. If a cutting is made in a seed year the young trees have that year to grow, very little damage resulting. As the beetles migrate to some extent in the fall, the infestation would be much lighter the second year, and by the third year would be almost a negligible quantity. Unfortunately it is not economically possible to cut only on seed years as these occur at intervals of three years, or if the climatic conditions are unsatisfactory a six-year period may elapse between heavy seed years, and in some cases an even longer time.

Owing to the fact that the beetles are attracted to cut-over areas by the odor given off by the pine stumps, slash, logs, or boards, it is advisable to eliminate as much as possible these agents from the area being reforested. New England lumbermen almost invariably leave the slashings resulting from logging operations in long windrows, which usually cover nearly one-third of the cutting, thus preventing the new forest from growing in this area. It is advised that this slash be piled over the pine stumps and thoroughly burned in the early spring. This not merely does away with the slash and its resulting odor of pitch but also chars the stumps which lowers their attraction for the beetles. This operation will not prevent an infestation, but will mitigate it.

Large adjacent cuttings made in consecutive years only tend to augment the primary infestation. This means that there will be an overflow of the beetles from the freshly cut

area on to the older cut, thus endangering the young coniferous growth that may have escaped the first infestation.

II. *In Plantations*

At the present writing it is not advisable to start coniferous plantations, using species native to New England, on cut-over pine lands during the first two seasons after cutting. The resulting plantations are sure to be seriously damaged and in some cases completely destroyed. A promising, inexpensive mode of entirely eliminating this loss is at present being worked out and it is hoped that by the end of another growing season satisfactory results will be available.

In brief, the idea being tried out is to burn all of the slash over the stumps in the early spring following the cutting, and to eliminate all coniferous seedlings on the cut-over areas by pulling them up and burning. It is taken for granted that the plantations are being set out due to the fact that the reproduction present on the area is either very scant or else unsatisfactory in other ways, so that the labor of eradicating the seedlings would be comparatively slight. If this is done in the early spring before the hardwoods leaf out, a man or boy can cover several acres in a day. When the adults emerge in the early fall from the pupal cells they are voracious feeders and if food is scant or absent they will migrate to some more favorable location, as observations in the field have shown. This means that the following Fall the plantation could probably be set out without loss from the beetles, or possibly the following Spring.

CONTROL ON OPEN LAND

It is a common occurrence in New England to see pasture land bordering pine woods literally carpeted with natural pine seedlings which are destined eventually to make pure pine stands. Oftentimes limby pasture-grown pines of considerable size may occur scattered over these areas. In order

to prevent loss to such beds of seedlings, which are a decided asset to the owner, certain policies must be adhered to.

In the first place the overtopping pasture pines must not be cut if seedlings are present until these reach a height of at least three and one-half feet. If cut then the slash should be burned over the stumps or carted away. In this way serious damage can be averted.

In the second place it is a common practice to stack the freshly sawed lumber in open pastures. The beetles being attracted by the odor from the lumber will swarm to the piles in great numbers, and if seedlings are present, as is often the case, the resulting damage is sure to be great. It is advised, then, that pine lumber be piled in areas where seedlings are not present. In a like manner it is sometimes customary to haul the logs out of the woods and to pile them in an open field near the mill site preparatory to Spring sawing. These pine logs serve as a breeding ground for thousands of the beetles, and if coniferous seedlings are present they are sure to be destroyed. If possible the logs should be sawed before the beetles emerge from hibernation in the spring. If this is not practical, turning the logs so that the sun will strike what was the under side, when the beetles deposited their eggs, will destroy the majority of the larvae. The beetles apparently prefer the logs at the outer edge of the piles, probably as they are the first ones reached, and are also less damp, so that turning over the bottom logs at the outer edges is decidedly worth while. In no case should the larvae be permitted to mature in the logs as this merely enhances and augments further infestations in the region.

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