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SOME OF THE PRINCIPAL INSECT ENEMIES OF CONIFEROUS  
FORESTS IN THE UNITED STATES.

BY

A. D. HOPKINS, PH. D.,

*In Charge of Forest Insect Investigations, Division of Entomology.*

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## SOME OF THE PRINCIPAL INSECT ENEMIES OF CONIFEROUS FORESTS IN THE UNITED STATES.

By A. D. HOPKINS, Ph. D.,

*In Charge of Forest Insect Investigations, Division of Entomology.*

### INTRODUCTION.

Within recent years the writer has made a preliminary survey of the principal forest regions of the United States, from southeastern Florida to northwestern Washington, from northern Maine to eastern Texas, and in the middle Appalachian region, the middle Rockies, and the Pacific slope, for the purpose of obtaining information relating to the principal enemies of the forests, the location and extent of areas of greatest depredation, and the possibilities of preventing losses.

It was found that among the many hundreds of insect enemies of forest trees observed and collected there are a few species which are of primary importance in their relation to widespread devastations. Indeed, it would seem that the most important enemies of coniferous forests in this country are restricted to a few species of a single genus of beetles. This genus was described by Erichson, of Berlin, Germany, in 1836, under the name *Dendroctonus*, which means "killer of trees." It is represented in Europe by only a single species, but in this country some eighteen species have been recognized. With few exceptions, they are all that the generic name implies, and the greater number are even more, for they are real devastators of forests.

One of the species of this genus, known as the spruce-destroying beetle, has been, according to published data, a menace to the Northern spruce forests during the past eighty years. Its work has from time to time taken the character of an invasion and destroyed many millions of dollars' worth of the best spruce timber in different sections, from New Brunswick to New York.

The destructive pine bark-beetle is another species which threatened the entire destruction of the pine and spruce of Virginia and West Virginia between 1890 and 1892, and before its ravages were checked it killed many millions of the best pine and spruce forest and shade trees in the two States.

The pine-destroying beetle of the Black Hills has been, within the past six or eight years, devastating the forests of the Black Hills Reserve in South Dakota. It has already killed some 600 million



fect of timber, and is threatening a like fate to the remainder. This involves not only the destruction of the timber, but also that of the great mining and other industries of that region which are dependent on the timber supply.

The records and available evidence show that these three species alone have demonstrated their ability, under specially favorable conditions, to devastate the pine and spruce forests of the entire country. Therefore they are worthy of general attention and the most detailed investigation.

The facts already determined by study of the insects and their work indicate plainly that most of the forests of the country which are available for the application of improved forest methods and systematic working plans can usually be protected from this and like dangerous enemies at a slight cost.

The prime requisites for success in combating this class of pests are: First, the prompt recognition of the commencement of a trouble; second, the determination of the insect causing it; and, third, the prompt application of the proper treatment before the depredations have spread like a conflagration.

It is the object of this paper to call attention to what are believed to be the worst insect enemies of coniferous forests, also to some of the characters of the insects and their work, by which they may be readily recognized, and to the peculiar methods of control applicable to each.

#### THE SPRUCE-DESTROYING BEETLE

(*Dendroctonus piceaperda* Hopk.)

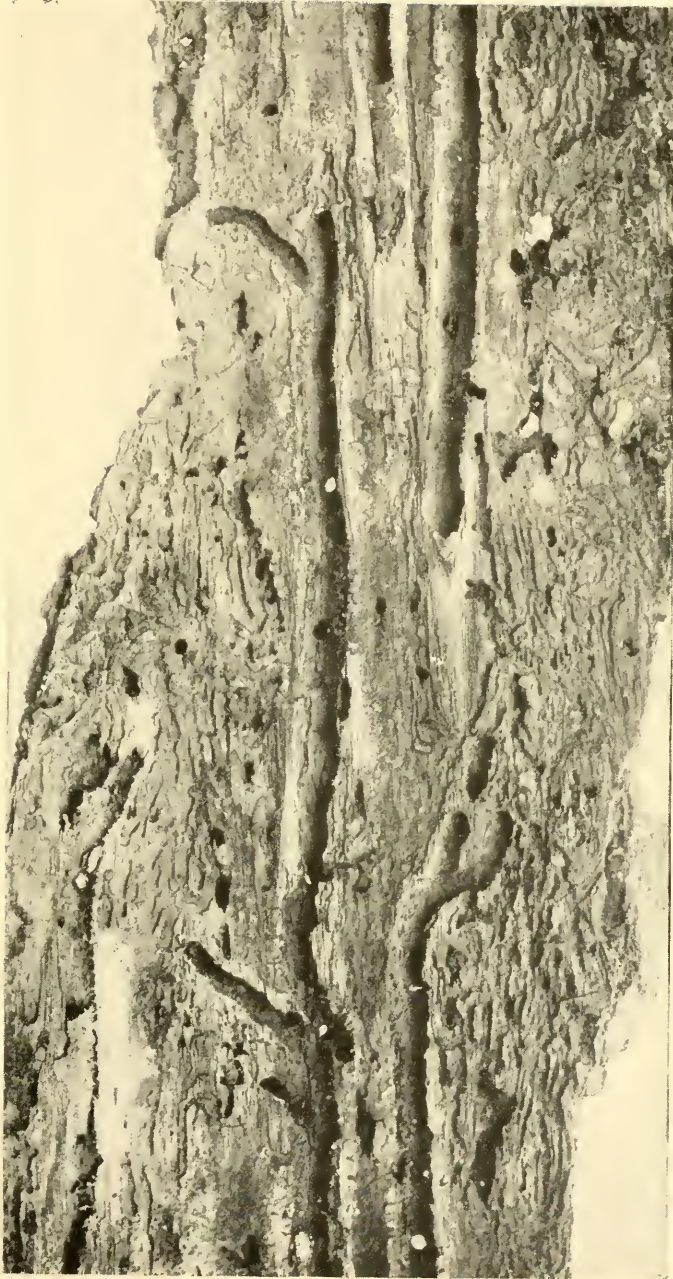
This insect was perhaps the first of its class to claim attention in this country, owing to its destructive invasions of the spruce forests of New England and New York from 1818 to 1900, as described by Peck, Hough, Packard, Fisk, and the present writer.

#### DESCRIPTION OF THE VARIOUS STAGES OF THE BEETLE.

THE ADULT (fig. 23, *a*) is a reddish brown to black beetle, varying in length from three-sixteenths to four-sixteenths of an inch (4.7 to 6.0 mm.). The body is sparsely clothed with rather long hairs, and has other distinctive characters, as shown in a general way in the illustrations.

THE EGG is a small, pearly-white object, scarcely to be distinguished from those of other bark beetles of the same size.

THE LARVA (fig. 23, *b*) when first hatched is a minute white grub, which increases in size until it is slightly longer than the beetle, and is distinguished from other larvae of the same class by a dark yellowish brown space on the upper surface of each of the last two abdominal segments.



WORK OF THE SPRUCE-DESTROYING BEETLE.

[Primary or egg galleries in inner portion of spruce bark, from dead tree. From photograph.]



THE PUPA (fig. 23, *c*) is nearly white, of the same size and somewhat the same form as the adult, but without free legs and wings, and is found in oblong cavities in the bark of trees where the broods develop.

HABITS OF THE ADULT AND LARVA.

Many pairs of beetles make a simultaneous attack on the lower half of the main trunk of medium-sized to large trees. They bore through the outer bark to the inner living portion, and through the inner layers of the latter they excavate long, irregular longitudinal galleries (Pl. XXVIII), and along the sides of these, at irregular intervals, numerous eggs are closely placed. The eggs soon hatch, and the larvæ at once commence to feed on the inner bark, and as they increase in size extend and enlarge their food burrows in a general transverse but irregular course away from the mother galleries (fig. 24, *d*). When these young or larval forms are full grown each excavates a cavity or cell at the end of its burrow and next to the outer corky bark.

The period of development from the egg to the matured larva varies from two or three to nine or ten months, depending upon the condition of the weather during growth. With the first hatched larvæ in June the period will

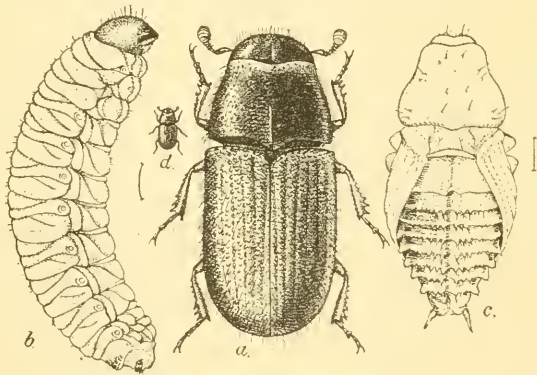


FIG. 23.—Spruce-destroying beetle: *a*, dorsal view of adult beetle; *b*, side view of larva; *c*, dorsal view of pupa—all greatly enlarged; *d*, natural size of beetle. (Original.)

be shorter, while those hatched later in the summer will not complete their growth until the next spring. Under the climatic conditions prevailing in northwestern Maine, eggs deposited about June 19 will develop to pupæ by September 1, and to adults by October 4, but will not emerge until the next spring. It appears that activity ceases about the middle of October, when all stages of the insect may occur in the bark of infested trees, where they, with probable exceptions of the eggs and pupæ, remain until about the first week in June. Activity then commences, the matured larvæ soon change to pupæ, and by the middle of June those that pass the winter in the adult stage emerge and commence to excavate galleries and deposit eggs. The adults, from hibernating larvæ of different stages, develop and continue to emerge from the last of June until the last of August. The eggs deposited by the late-developing beetles produce larvæ which do not complete their development until July or August of the next year, and consequently the period from the time the first galleries are excavated and eggs deposited until the broods of adults emerge is about

one year. Under different conditions of latitude and altitude these dates and periods will be different.

HOW THE TREES ARE KILLED.—The numerous primary or egg galleries penetrate the most vital parts of the tree (the cambium), where the principal activity involved in new growth takes place. This causes at once a loss of vitality and a weakened resistance. The exca-

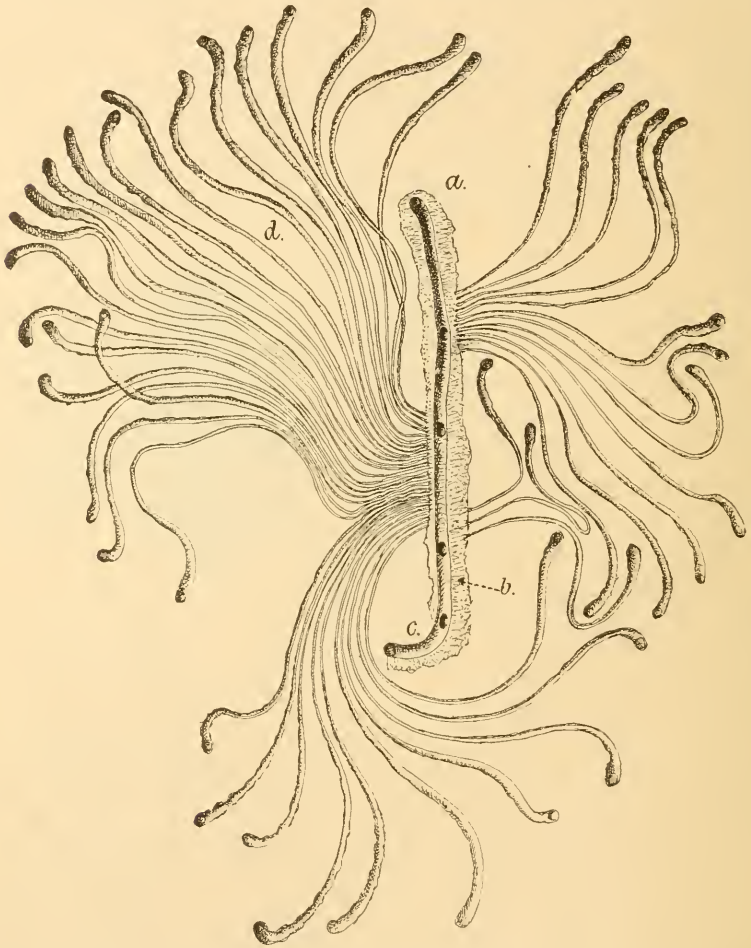


FIG. 24.—Work of the spruce-destroying beetle: *a*, primary gallery; *b*, borings packed in side; *c*, entrance and central burrow through the packed borings; *d*, larval mines—note how the eggs are grouped on the sides. (Original.)

vation of the primary galleries is immediately followed by the transverse burrowing operations of the young broods, which rapidly complete the destruction of all remaining life in the bark. Thus, the tree is completely and effectually girdled. This is followed some months later by the dying and falling of the leaves and the complete death of all parts of the tree. By the time, and even before, the leaves die and

fall the new broods of beetles emerge from the bark and migrate in swarms to other living trees, which in a like manner are attacked and killed.

AREA INVADDED.—The species extends from New Brunswick to New York and westward to the Black Hills of South Dakota; also northward into Canada. It attacks and kills the Red, Black, and White spruces, but only the larger trees. The amount of timber killed by it, as indicated by published accounts and the writer's observations, has been very great; certainly within the past half century several billions of feet of timber have been thus destroyed.

METHODS OF PREVENTING LOSSES FROM FUTURE DEPREĐATIONS.

A series of experiments conducted during the summer of 1900 and again in 1902 resulted in the determination of some important facts

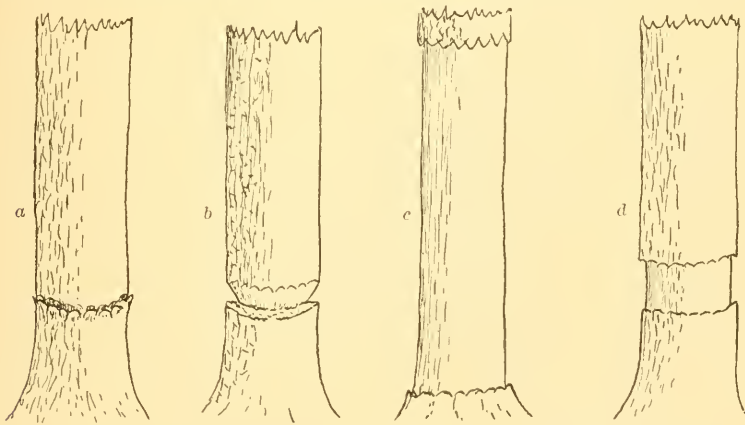


FIG. 25.—Different methods of girdling trees: *a*, hack girdled; *b*, girdled to heartwood; *c*, hack girdled and peeled; *d*, belt girdled. (From Bulletin No. 28, new series, Division of Entomology, U. S. Dept. Agr.)

in the life history of the insect, and in the discovery that if living spruce trees are hack-girdled (fig. 25) just before the pollen commences to fall from the Red Spruce and when it is falling from the birches, the conditions, as related both to the flight or swarming period of the beetles and to the physiological phenomena of the tree, will be most favorable for the attraction of the beetles to such trees; thus, the beetles may be made to concentrate their attack upon numerous girdled trap trees to be subsequently destroyed during the fall, winter, and early spring months, either by the ordinary lumbering operations, which insures the removal of the timber from the forests before the insects emerge, or by felling the trees and removing the bark from the lower two-thirds of the trunk, this method to be supplemented as far as possible by the felling and barking of such other trees as are found to be infested. By this means the number of the beetles may

be so reduced within large areas as to effectually protect the remaining living timber. It was also determined that the adoption of improved forestry methods, which require the intelligent harvesting of the matured crop of timber, is doubly beneficial to the forest. These methods involve the removal of the trees above 12 inches in diameter, which are the only ones attacked by the destructive beetle, and leave the younger growth, which is exempt from attack, to produce a future supply of timber.

#### THE DESTRUCTIVE PINE-BARK BEETLE.

(*Dendroctonus frontalis* Zimm.)

The devastation wrought by this beetle in the Virginias and adjoining States attracted general attention at the time, and was the subject of special investigation by the writer. This insect may be considered as one of the most destructive enemies of Southern pine forests. Published records of depredations by insects in the pine forests of the

Southern States within the past century indicate that it has been the cause of repeated widespread damage, similar to that resulting from its work in the Virginias.

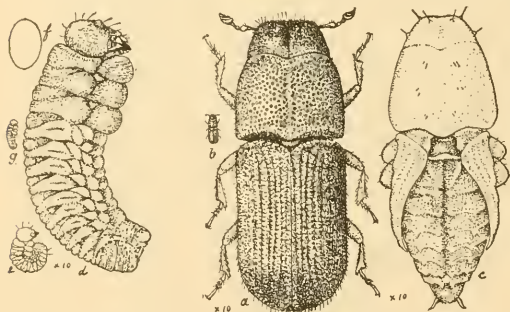


FIG. 26.—Destructive pine-bark beetle: *a*, adult beetle, enlarged; *b*, adult, natural size; *c*, pupa, enlarged; *d*, larva, enlarged; *e*, young larva, enlarged; *f*, egg, enlarged; *g*, larva, natural size. (After author, in Bulletin No. 56, West Virginia experiment station.)

#### DESCRIPTION OF THE VARIOUS STAGES OF THE BEETLE.

THE ADULT (fig. 26, *a*) is a small, rather slender, brownish to black beetle, varying in length from one-twelfth to one-sixth

of an inch (2.2 to 4.2 mm.). It is distinguished mainly by the very broad head and nearly parallel sides of the prothorax.

THE PUPA (fig. 26, *c*) also differs in having a proportionately larger prothorax, with sides less constricted in front.

THE LARVA (fig. 26, *d*) is strikingly different from that of the spruce-destroying beetle in the globular form of the curled-up, freshly hatched individuals (fig. 26, *e*) and in the much enlarged prothoracic segments; also in the last abdominal segments being truncated and unarmed.

## HABITS OF THE ADULT AND LARVA.

In this species the adults normally invade the bark of the middle trunk of medium to large pine and spruce trees and the middle to

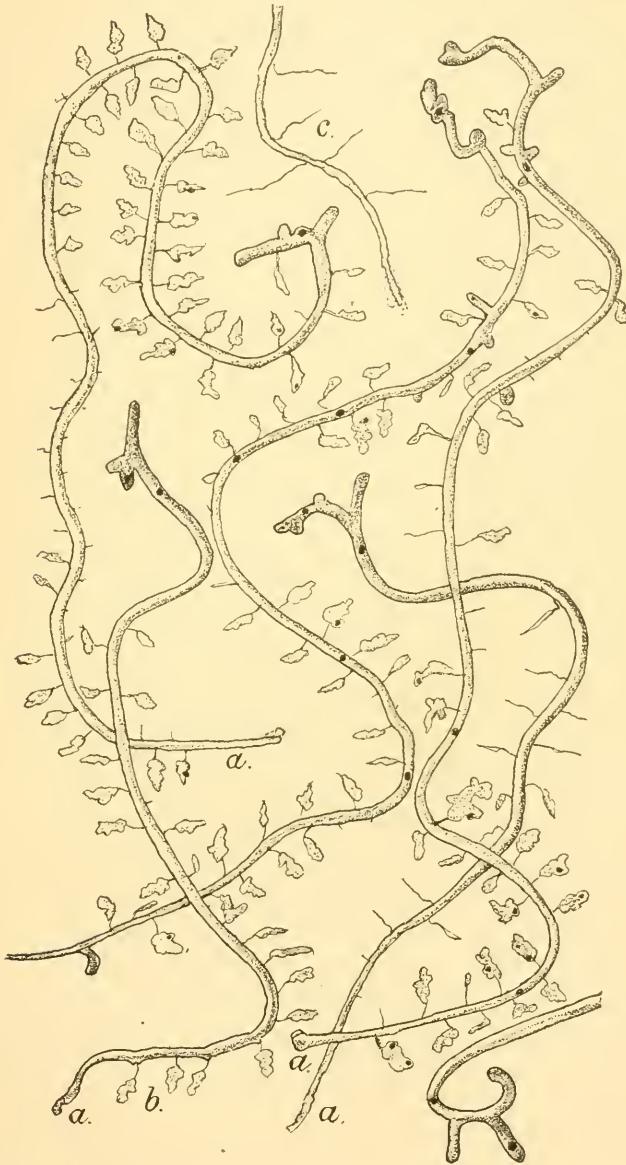


FIG. 27.—Work of destructive pine-bark beetle. *a, a, a, a*, characteristic forms of primary galleries; *b*, normal forms of larval mines, *c*, abnormal forms of larval mines—all slightly reduced. (Original.)

lower portion of the smaller ones. The habit of attack and methods of excavating galleries is similar to that of the spruce beetle, but the



character of the primary gallery is strikingly different. Instead of extending nearly straight up and down the tree it extends from the entrance in a transverse and tortuous course through the inner bark (fig. 27). Those of different pairs of beetles frequently cross each other, so that the many primary galleries, independent of the larval mines, serve to completely girdle the tree and kill the bark, thus causing a much more rapid death of the bark and foliage than when the primary galleries, like those of the spruce beetle and the pine beetle of the Black Hills, extend parallel with the elongated sieve tissues and cells through which the life-supporting and wood-forming liquids pass. The larval burrows are also quite different, being normally very short and broad. The pupal cells are usually excavated in the outer dry bark, while those of the spruce beetle are normally in the outer portion of the inner bark.

The time required for the development of a brood varies greatly with the season, latitude, altitude, etc. In West Virginia, at a medium altitude of 1,000 feet above tide, there appear to be two broods, one emerging in August and the other in September.

The winter is passed in the adult stage and in all stages of the larva, with possibly a few eggs and pupæ.

HOW THE TREES ARE KILLED.—The trees are killed by the girdling effect of the primary galleries in the bark of the middle portion of the trunk—which, as has been demonstrated, is the most vital part, or at least has less power of resisting injuries than the lower portion and base. Instead of the leaves of infested trees remaining green until the next season, as is the case with trees infested by the spruce beetle and the pine beetle of the Black Hills, all except those attacked late in the season commence to fade in a few weeks after the attack; so that trees attacked about the middle of July will be entirely dead and the leaves brown by the first of November or earlier, when all of the broods of beetles will have emerged. The trees infested with broods at the beginning of winter may present in the foliage all stages of color, from yellowish to perfect green.

KINDS OF TREES ATTACKED.—This beetle is known to attack the Shortleaved Yellow Pine, Pitch Pine, Scrub or Virginia Pine, Table Mountain Pine, and White Pine, and recent observation indicates that the Loblolly and Longleaf pines are also attacked and killed by it. It also attacks and kills the native Red Spruce and the introduced Norway Spruce.

DISTRIBUTION AND AREA OF PRINCIPAL DEPREDATIONS.—This species with its work has been observed by the writer in West Virginia, Virginia, Maryland, North Carolina, South Carolina, Texas, and the District of Columbia, and has been recorded by other writers from Georgia to Lake Superior, Florida, Colorado, Arizona, and California. The Western forms heretofore associated with it have, however, been

recently found by the writer to represent several distinct species. The destructive invasion in 1890-1892, as determined by the writer, extended from the western border of West Virginia through Maryland, Virginia, and the District of Columbia, and northward into southern Pennsylvania and southward into western North Carolina, an area of over 75,000 square miles, in which a vast amount of pine and spruce was killed by it. In many places in West Virginia and Virginia nearly all of the pine of all sizes, from a few inches in diameter to the largest trees, was killed on hundreds and even thousands of acres, while shade and ornamental trees within the same area suffered the same as those in the forest. The total destruction of the pine and spruce of the entire area was threatened, but the severe freeze of December, 1892, and January, 1893, together with natural enemies, exterminated the pest or so reduced its numbers that no more timber died after the summer of 1893, since when to the date of the present writing not a living example of the beetles has been found north of North Carolina.

#### PROBABLE BEGINNING OF A NEW INVASION IN THE SOUTH.

Recent investigation in the Southern Appalachian region has demonstrated the fact that the insect is living there, and that scattering clumps of trees are being killed by it as they were in the early stages of the great invasion of 1890-1892.

#### EVIDENCE OF AN OLD INVASION IN TEXAS.

It has also been recently determined that a great amount of timber died in the Longleaf Pine region of eastern Texas between 1882 and 1885, which, as evidenced by the dead beetles found preserved in the pitch and the characteristic galleries in the bark from the old dead trees, was probably due to the presence of this insect in destructive numbers at that time.

Knowing what devastations were wrought by this beetle in the Virginias within two or three years and what it evidently did in Texas within about the same length of time, we conclude that during a series of years of especially favorable conditions it is capable of devastating the entire pine and spruce forests of the South. Therefore, it presents, in the writer's opinion, the most important forest insect problem in this country, and one which demands immediate action to prevent a possible widespread invasion, which would be a real calamity to the South.

#### METHODS OF PREVENTING DESTRUCTIVE INVASIONS.

From what has been learned of the habits of this insect, it is known that it passes the winter in different stages in the inner and outer bark of trees attacked by the adult beetle in September to November. The trees so infested may be detected by the faded and yellowish foliage

of the dying trees, or by the pitch tubes and borings in the loose outer bark and at the bases of such infested trees as show no change in the foliage from the normal green. The principal infestation is in the bark of the main trunk of medium to large trees, and among the lower branches to the bases of small trees and saplings.

In order to effectually destroy the insect it is only necessary to fell the larger trees, remove the bark from the trunks, and burn it. It is entirely unnecessary to burn or otherwise destroy any part of the wood, because the destructive beetle does not enter the wood and rarely breeds in the bark of the tops and branches, but with this particular species it is necessary to burn the bark removed in the winter, because the matured larvæ, pupæ, and adults pass the winter in the outer dry bark, where they would otherwise survive and emerge in the spring to attack other trees.

The infested small trees may be felled and barked or burned, or the bark removed from the infested parts by means of suitable barking tools, as is sometimes done in European forests.

The summer broods of the insect can also be destroyed by felling and barking recently infested trees.

As an example of what may be accomplished by the cutting and peeling process, Mr. G. H. Warner, in March, 1902, cut the infested trees in four different widely separated clumps of from 1 to 2 acres each in the forest of the William Gillette place, near Tryon, N. C., and removed the bark and burned it. Examination of this place by the writer in July, and of the vicinity in November, of the same year, indicated that a sufficient number of the beetles and their broods had been thus killed to protect a very large area from further attack. At least no recently attacked trees were observed on the place or in the immediate vicinity.

It is well known by people in the South that if a pine tree standing in the midst of a healthy forest is girdled, struck by lightning, felled by ax or storm, or otherwise seriously injured, during the middle of the summer, it will cause the death of the other pine trees immediately surrounding it, over areas varying from a few rods to several acres. This is due to the fact that the destructive beetle breeds in such trees, and emerges in sufficient numbers to attack and kill the living timber. Such trees should be felled and have the bark removed, whenever practicable, soon after the leaves begin to fade.

It must be remembered that the bark and wood of trees dying or dead from the work of the destructive beetle are always infested by many other kinds of bark-beetles and wood-boring beetles, as well as bark-grubs and wood-boring grubs, the latter known locally as "bore worms" or "sawyers." Therefore, these must not be confused with the real destroyer. The destructive beetle and its characteristic galleries in the bark can be easily distinguished from the secondary enemies by

comparing them with fig. 24, *d*, and descriptions. It is a common mistake by the unentomological observer to conclude that some of these secondary enemies, especially the sawyer, are to blame for the death of the trees.

#### TRAPPING THE BEETLE AND ITS BROODS.

Some facts in the habits of the beetle in the present infested region recently determined by the writer indicate clearly that it can be easily trapped during the summer and destroyed by means of the well-known method of girdled and felled trap trees. It was found that the adults are attracted to storm-felled and otherwise felled and injured trees, and that such trees, if neglected, form a nucleus for the rapid multiplication of the insect and its spread to healthy standing timber. Therefore, if felled and girdled trees are provided at the proper time, so that the beetles will be attracted to them at the period of their greatest flight, they will attack such trees in preference to the living uninjured ones. Then, after they have entered the inner bark and the broods are partially developed, that is, before they have entered the outer bark, it will only be necessary to remove the bark to effectually destroy them, and thus protect the healthy timber. If, however, the removal of the bark is neglected until the broods have entered the outer dry portion, it will be necessary to burn it as soon as it is removed.

#### THE PINE-DESTROYING BEETLE OF THE BLACK HILLS.

(*Dendroctonus ponderosæ* Hopk.)

This beetle is now causing widespread destruction to the Bull Pine in the Black Hills Forest Reserve and is the subject of detailed investigation by the Department. The fact that it may spread through the entire Rocky Mountain region and cause general destruction of the pine and spruce renders it an insect of special interest and importance.

#### DESCRIPTION OF THE BEETLE AND ITS WORK.

**THE BEETLE** (fig. 28).—The fully matured adult is a stout dark-brown or black beetle, individuals of which vary in length from about one-sixth to one-fourth of an inch (4 to 7 mm.). It differs from the spruce-destroying beetle, with which it agrees in size, mainly in the absence of long hairs on the prothorax and elytra; and from the destructive pine-bark beetle in its much larger size, also in other specific characters which would require a technical description.

**THE EGG** differs but slightly from that of the spruce beetle.

**THE LARVA** (fig. 29) resembles that of *D. frontalis*, but differs in being of much larger size and in having the prothoracic segments much less enlarged.

**THE PUPA** (fig. 30) is scarcely to be distinguished by the ordinary observer from that of the spruce beetle.

CHARACTERISTIC FEATURES OF THE WORK OF THE BEETLE AND LARVA.—The attack of this beetle on living trees and the general features of its operation beneath the bark and method of killing the trees is similar to that of the two preceding; but it differs in the time of flight, character of galleries (fig. 31), and other minor details. It commences to emerge and fly during the last

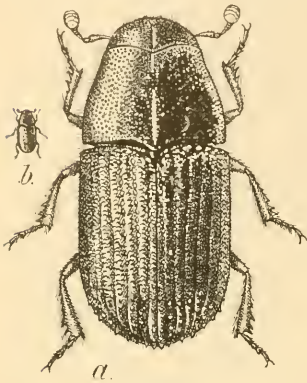


FIG. 28.—The pine-destroying beetle of the Black Hills: *a*, adult beetle, enlarged; *b*, adult beetle, natural size. (Original.)

half of July, and the adults, which subsequently develop from different stages of the hibernating broods, continue to emerge until in September. The main swarm, however, emerges during the last half of July and the first half of August and attack the living timber. They settle on widely separated clumps of trees, or invade the living timber adjoining that from which they emerged. The number of trees invaded in one locality varies from two or three to many hundreds, or even thousands. Each tree is attacked by a great number of pairs

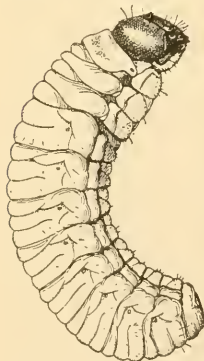


FIG. 29.—Larva of the pine-destroying beetle of the Black Hills.

of beetles, which enter the bark from near the base up to about the middle of the trunk of medium-sized to large trees, and on the lower portion of the main stem of the smaller ones. They then begin to excavate the entrance burrows, which are usually in crevices hidden by the flakes of the dry bark. The reddish sawdust-like borings thus produced fall to the ground or lodge in the flaky bark or the outer part of the trunk.

When the beetles enter the inner bark, or bast, the tree commences to exert its resistance to the enemy by throwing out pitch to fill and heal the fresh wounds in the living tissue (fig. 32). During the earlier attack the borings and pitch are pushed out by the beetles and formed into pitch tubes at the mouth of the entrance burrows; while later, in August, when the tree is apparently less able to exert resistance, pitch tubes are not necessarily formed, but the borings lodge in the loose bark and around the base of the tree.

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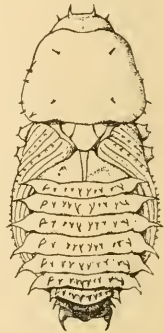


FIG. 30.—Pupa of the pine-destroying beetle of the Black Hills.

formed, but the borings lodge in the loose bark and around the base of the tree.

The inner bark is entered obliquely, or transversely to the cambium or outer portion of the wood, where a broadened cavity is excavated for the accommodation and temporary occupation of the parent beetle

until the principal flow of pitch is exhausted. The gallery is then extended transversely or subtransversely for a short distance, seldom more than an inch or two, and then longitudinally up or down the tree, varying in length from a few inches to over 2 feet (fig. 31). As soon as the gallery has been extended 1 or 2 inches from the entrance and basal cavity, small notches are excavated in the sides of the gallery, in each of which an egg is deposited, and so on until the gallery is completed.

As the eggs are deposited, the borings, instead of being thrown out at the entrance, are closely packed in the entrance burrow, basal cavity, and gallery, except near the farther end, which is kept open and enlarged or extended to one side or the other, as it is occupied by the parent beetles, after the work of constructing the egg galleries is completed, until they die.

The bark of an infested tree is usually occupied by one of these primary galleries every 1 to 6 inches of the circumference, from near the base to near the middle of the trunk; therefore they effectually check the normal movement of the sap, and the larval mines, which radiate from the primary gallery, destroy the intervening bark, and complete the girdling process. The larval mines are similar in character to those of *D. frontalis*, and quite different from those of *D. piceaperda*, as will be noted by comparing figs. 24 and 31. The larvæ undergo their transformation to the pupa in cells excavated in the inner bark at the end of the larval gallery.



FIG. 31.—Work of the pine-destroying beetle of the Black Hills: *a, a, a*, entrance and basal chamber; *b*, ventilating holes in roof of gallery; *c*, termination of gallery (larval mines extending from each side of primary galleries)—all much reduced. (After author, in Bulletin No. 32, new series, Division of Entomology.)

KINDS OF TREES ATTACKED.—So far as has been observed, this beetle attacks and kills the Bull Pine (*Pinus ponderosa*) and the White Spruce (*Picea canadensis*), but shows a decided preference for the pine.

DISTRIBUTION OF THE SPECIES AND EXTENT OF ITS DEPREDACTIONS.—The beetle has been reported by Professor Gillette from central Colorado, which indicates that it may be found throughout the central Rocky Mountain region; but, so far as determined, it has not proved so destructive anywhere else as in the Black Hills Reserve, where in

the past six years from 400 to 600 million feet of timber, according to various estimates, have been killed by it.

Recent investigations indicate that at least 80 per cent of the merchantable timber west of Spearfish Creek to the Wyoming line has been killed. There is a decided increase in the spread of the depredations by the beetle eastward and southward. It is threatening the large areas of healthy timber in the southern hills, and unless checked it will doubtless extend its destructive work in that direction, as it has northwestward.

The Black Hills Forest Reserve is recognized as one of the most important in the country, especially in its immediate relations to the support of great mining industries. The annual product of gold mined in the Black Hills amounts to about \$10,000,000. The methods of mining require the use of some 20 million feet of mine timbers each year. The process of extracting the gold from the ore requires

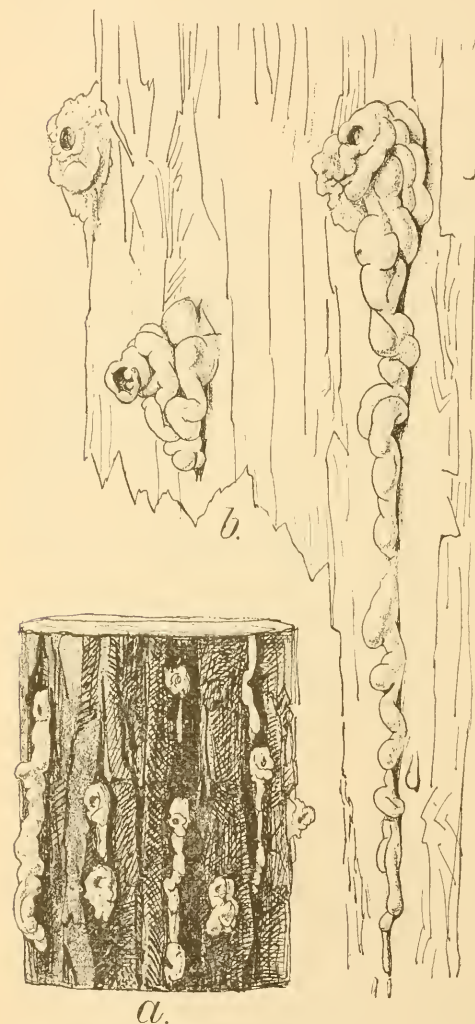


FIG. 32.—Work of the pine-destroying beetle of the Black Hills: *a*, pitch tubes on surface of bark, much reduced; *b*, same, two-thirds natural size. (Original.)

thousands of cords of wood for fuel. The average low grade of the ore and the expensive processes of mining and reduction require that the supply of such timber be readily accessible and procurable at a low price. The cost of transportation of timber from other reserves or other Western forests would prohibit its use. Therefore, as stated by the superintendent of one of the principal mines, "the mining interests

of South Dakota are dependent upon the limited timber resources of the Black Hills." The dying of the timber is threatening the life of the mining industry and of all the many other interests which depend upon it.

CHARACTERISTIC FEATURES OF THE INFESTED AND DEAD TIMBER.

The characteristic features which are of importance to the reserve officials, lumbermen, and residents in recognizing the presence and work of the pine-destroying beetle are as follows:

**BORINGS AND PITCH TUBES.**—The first indication of attack is the red dust or borings lodged in the loose outer bark or scattered upon the ground about the base of the tree. The next and a more conspicuous evidence is the presence of numerous small masses of pitch, or so-called pitch tubes, on the outer bark at the mouth of the entrance burrows (fig. 32).

**APPEARANCE OF THE LEAVES.**—The leaves of the trees attacked by the beetle in July to September in any year, for example, in 1899, retain their normal green until May of the next year, that is, till 1900. Then the leaves of the lower branches begin to fade and gradually change to yellowish. This condition rapidly spreads toward the top, until all are dead by the first or middle of August. The trees in this stage are designated by lumbermen as "sorrel tops." By the time, and often before, all the leaves are dead the broods of beetles have emerged and entered the living timber. After this the recently dead and vacated trees are of no further importance as sources of danger as breeding places for the pine-destroying beetle.

By the summer of the next year (1901) the leaves change to a reddish brown and commence to fall. The trees in this stage are referred to as "red tops."

By the summer of the year after that (1902) all of the leaves have fallen, and in this stage the trees are referred to as "black tops." Still later (1903-1904) most of the tops will break off. They are then called "broken tops."

The bark of the lower half or two-thirds of the newly infested trees usually dies within a few weeks after the primary galleries are completed, or by the middle to the last of September of the year in which the attack is made; and when thoroughly infested the bark may then be readily separated from the wood. The sapwood will then be found changed from the natural color to a bluish hue.<sup>a</sup>

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<sup>a</sup>BLUING OF THE WOOD.—According to information from Dr. Von Schrenk (who has made detailed investigations of the deterioration and decay of the wood of the beetle-killed trees), the bluing of the sapwood of the infested trees is due to a fungus which enters the burrows in the bark made by bark beetles and those in the wood made by timber beetles. The writer has determined that this blue wood trouble is not only associated with the recently excavated galleries of the destructive beetle, but also with those of the numerous other bark-boring and wood-boring beetles, which follow the attack of the former and excavate their primary galleries in the living bark and sapwood.



EVIDENCE OF THE WORK OF THE BEETLE ON THE SURFACE OF THE WOOD.—The peculiar grooves and marks in the surface of the wood made by the pine-destroying beetle during the process of excavating the primary or egg galleries, as seen on the barked surface of dead trees, sawlogs, railroad ties, mine timbers, etc., are always unmistakable evidence of its work (Pl. XXIX). While there are many other kinds of bark beetles and bark-boring grubs which follow the attack of the destructive beetle, and excavate each its peculiar kind of gallery or groove on the wood, none of these marks can be mistaken for the peculiar longitudinal grooves made by the destructive species.<sup>a</sup>

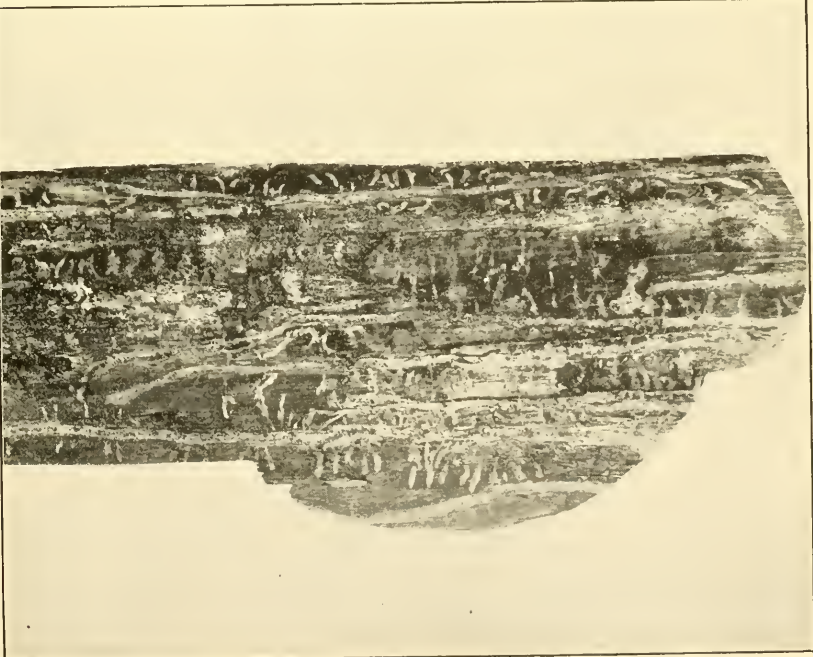
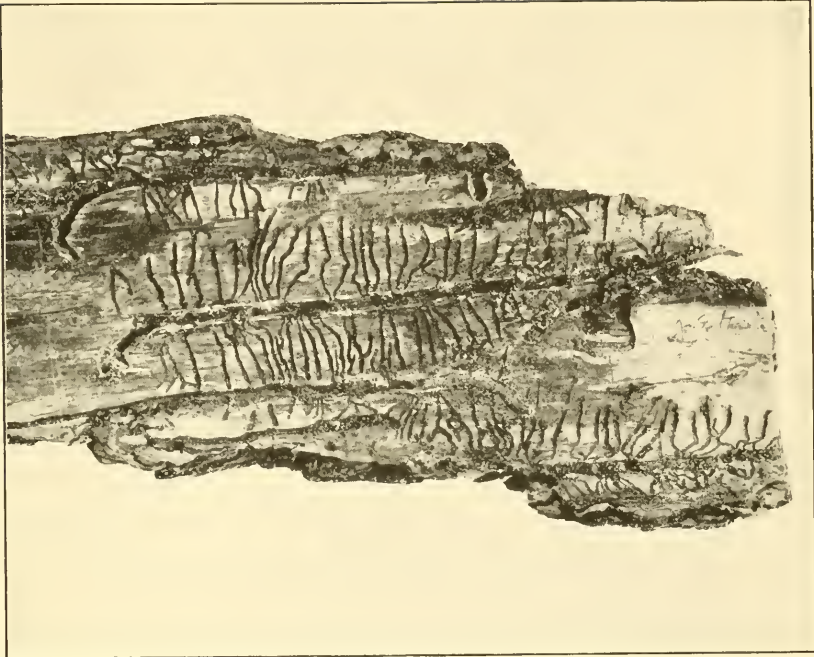
#### METHODS OF COMBATING THE PEST.

EXPERIMENTS WITH GIRDLED TREES.—Experiments with girdled and felled trees, to determine whether or not the trap-tree method would be practicable in dealing with the pine-destroying beetle in the Black Hills Reserve, seem to demonstrate, among many other important facts in the life history and habits of the beetle, that while some of the girdled as well as felled trees were infested, the near-by living and uninjured trees were equally attacked. Therefore, it would seem from the results of this season's work that the trap-tree method, which is so admirably adapted for the control of similar troubles by other kinds of bark beetles in this country and Europe, is not adapted to the conditions attending the Black Hills trouble. This is probably due to some peculiar characteristic of the species or variety of pine involved.

Further experiments, however, may show that while none of the several methods and dates of girdling and felling the trees are available in checking or controlling the insect in its present magnitude, some one or more of them may prove to be adapted to the prevention of its recurrence after it has once been brought under control by other methods.

CUTTING AND BARKING THE INFESTED TREES TO DESTROY THE YOUNG BROODS.—After a thorough study of the prevailing conditions in the Black Hills Reserve, both as regards the extent of the present depredations, the peculiar habit of the depredator, and the relative abundance of the several kinds of natural enemies which prey upon the parent beetles and different stages of its broods, the writer is convinced, as stated in his recommendations, that in order to destroy a sufficient number of the young stages of the beetles to render any special service toward checking or ending the depredations, it is necessary that the beetle-infested trees in all of the principal areas of new infestation throughout the reserve be cut and the bark removed from

<sup>a</sup> For illustrated forms of galleries made by secondary enemies of the trees, see "Insect enemies of the pine in the Black Hills Forest Reserve," Bulletin No. 32, new series, Division of Entomology, U. S. Dept. Agr.



WORK OF THE PINE-DESTROYING BEETLE OF THE BLACK HILLS.

[On left, primary galleries and larval mines in inner bark, from dying tree; on right, gallery grooves and marks on barked surface of chip from beetle-killed tree.  
From photograph.]



the infested parts of the trunks between the 1st of September (1902) and the 1st of May (1903).

It is also evident that if these principal areas of newly infested timber in the western and southern hills are cut over, the natural enemies, including insects and birds, will be able to so reduce the numbers of the beetles left in the scattering uncut infested trees as to prevent the continuation of their destructive ravages, and that the pest will thus be kept under complete control, especially if the future management of the reserve shall provide for the cutting of such newly infested clumps of trees as from time to time may be found. Recommendations to this effect have been submitted by the writer to the Bureau of Forestry and to the General Land Office for consideration in their future management of the forest and administration of the reserve.

#### OTHER DESTRUCTIVE SPECIES OF DENDROCTONUS.

The other species of the genus *Dendroctonus* which have been found by the writer to be specially destructive, but which for lack of space can not be described in this article, are four undescribed and two described species. One is destructive to the Silver or Mountain White Pine, in Montana and Idaho. Another destroys the Red Fir from Idaho to western Washington and Oregon. One of the described species (*Dendroctonus brevicornis* Lec.) kills the Western Yellow Pine in California and Oregon to western Idaho. The other described species (*D. approximatus* Dietz), together with two undescribed species, attacks and kills the Bull Pine in northern Arizona.

With a few modifications to suit local conditions and varying features in the habits of these species, the same recommendations for dealing with troubles caused by *D. piceaperda*, *D. frontalis*, and *D. ponderosae* may be adopted.

#### SUMMARY.

The principal destructive enemies of coniferous forests in this country belong to the *Dendroctonus* genus of bark beetles.

THE SPRUCE-DESTROYING BEETLE has killed billions of feet of spruce timber in the Northern spruce forests in the past seventy-five or eighty years. It can be controlled by cutting the infested trees during the fall, winter, or early spring months, and removing the bark from the infested parts of the main trunks. It can also be attracted to trap trees hack girdled during the last week in May or first week in June, and subsequently destroyed by felling them and removing the bark in the summer after the broods are partially developed, or during the following winter.

THE DESTRUCTIVE PINE BARK-BEETLE destroyed millions of dollars worth of pine and spruce forest and shade trees in an area including

West Virginia, Virginia, Maryland, and the District of Columbia between 1890 and 1892.

The natural home of the species is evidently in the Southern Appalachian region, where it is now at work, and is a menace, not only to the pine and spruce of that region, but to the coniferous forests of the entire Southern and Eastern United States.

If taken in time, this pest can be controlled by felling the infested trees and removing the bark from the infested parts of the trunks and burning it; also by means of trap trees.

THE PINE-DESTROYING BEETLE OF THE BLACK HILLS has killed many hundreds of millions of feet of pine timber in the Black Hills Forest Reserve within the past six or seven years, and is at the present time threatening the destruction of the remaining timber of the reserve, together with the great mining and other industries which depend upon the forest resources.

In order to check the ravages of this beetle and protect the remaining living timber, it is necessary to cut and bark all of the principal clumps and bodies, or an aggregate of at least 50 per cent of trees which were attacked by the beetle during the summer of 1902—a remedy which has been recommended by the writer and has been adopted by the General Land Office to be applied so far as it is possible and practicable to do so.

#### GENERAL RECOMMENDATIONS.

It is of the greatest importance that the commencement of deprecations similar to those described in this article, as indicated by isolated clumps of dying trees in the pine or spruce forests of any section of the country, should be reported to the Department of Agriculture as soon as discovered, in order that the matter may be investigated and prompt information given on the proper course to pursue in each particular case to prevent the widespread deprecations which may follow neglect.

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